Developing Creativity Competency of Engineers

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Developing Creativity Competency of Engineers

Abstract

The complete agreement of all stakeholders on the importance of developing the creativity competency of engineering graduates motivated us to undertake this study. We chose a senior-level course in Software Testing and Quality Assurance which offered an excellent platform for the experiment as both testing and quality assurance activities can be executed using either routine or mechanical methods or highly creative ones. The earlier attempts reported in literature to develop the creativity competency do not appear to be systematic i.e. they do not follow the measurement ->action plan ->measurement cycle. The measurements, wherever done, are based on the Torrance Test of Critical Thinking (TTCT) and the Myers Briggs Type Indicator (MBTI). We found these tests costly and decided to search for an appropriate alternative that led us to the Felder Solomon Index of Learning Style (ILS). The Sensing / Intuition dimension of the ILS, like MBTI, is originated in Carl Jung's Theory of Psychological Types. Since a number of MBTI studies have used the dimension for assessing creativity, we posited that the same ILS dimension could be used to measure the competency. We carried out pre-ILS assessment, designed and delivered the course with a variety of activities that could potentially enhance creativity, and carried out course-end post-ILS assessment. Although major changes would not normally be expected after a one-semester course, a hypothesis in the study was that a shift from sensing toward intuition on learning style profiles would be observed, and indeed it was. A paired t-test indicated that the pre-post change in the average sensing/intuition preference score was statistically significant ($p = 0.004$). While more research and direct assessment of competency is needed to be able to draw definitive conclusions about both the use of the instrument for measuring creativity and the efficacy of the course structure and contents in developing the competency, the results suggest that the approach is worth exploring.

Keywords: Creativity, Index of Learning Styles (ILS), Active Learning, Wikipedia

Introduction

The engineering field is becoming increasingly complex across all its branches - from the traditional civil engineering to the modern computer, space, and genetic engineering. The complexity has increased even more due to a growing interdependence among disciplines and the emergence of a wide range of new technologies.To manage this situation, engineers who can keep pace with new technologies and think laterally when developing new applications, and engineers who are creative and capable of abstract thinking are required. It has been observed that recent engineering graduates are lacking in these competencies; and the traditional and still dominant engineering curriculum at most universities, especially in developing countries, makes little provision for developing them [1-3]. These observations prompted us to design a course to remedy that deficiency.

We chose a course in Software Testing and Quality Assurance (STQA) that offered a possibility of adding 'developing creativity competency' as another course objective. The course - being a part of the emerging discipline of Software Engineering - offered varied opportunities for critical thinking. We inferentially assessed the creativity competency by measuring students' preference for sensing or intuition using Felder-Solomon Index of Learning Style (ILS) [4] that is based on Felder-Silverman Model of Learning Style[5]. It has been well established that creativity is correlated with a preference for intuition[6], and it has also been observed that on an average engineering undergraduates show a preference for sensing[7]. The student cohort in this study was no exception and provided the required opportunity to bring them to a point of better balance. Towards that, we designed the course with elements like active learning, open book examination with thought-provoking questions, Wikipedia assignments, etc. Students' work on them accounted for a significant percentage of the final course grades, which was a major departure from the prevalent practices of having course grades depend on one or two examinations. We also conducted a day-long creativity and innovation workshop. We administered ILS assessment at the beginning and the end of the course and determined pre-post changes with the hypothesis that the course would lead to a shift toward intuition. The hypothesis was validated. While that result by itself would not be conclusive evidence of a gain in creative thinking and problem-solving competencies, it would suggest the possibility that the new course had that effect and would lead to the development of other courses along similar lines.

The main contribution of this paper is in formulating a systematic approach to develop creativity competency of engineering students. Towards that aim, it describes an experiment of using the Index of Learning Styles (ILS) to infer creativity competency and dwells on varied pedagogical techniques to develop the competency.The rest of the paper presents possible creativity measurement instruments including learning styles, details of the course design and its results, and ends with concluding remarks.

Creativity

National Academy of engineering in its report [8] states that Creativity (invention, innovation, thinking outside the box, art) is an indispensable quality for engineering, and given the growing scope of the challenges ahead and the complexity and diversity of the technologies of the 21st century, creativity will grow in importance. Brumm, et al.[9] have identified fourteen workplace competencies required for professional engineers; innovation (and creativity) being one of them. Amabile, et al. [10] found that creativity results from formation of a large number of associations in the mind followed by a selection of associations that may be particularly interesting and useful.

Creativity fuels and is a mainstay of innovation that has been defined by Richard Lyons, the chief "learning officer" at Goldman Sachs, [11] as fresh thinking that delivers value to customers. There are many researchers who use the two terms – creativity and innovation - interchangeably. We argue that academic environments have to start with developing creativity and then take on value delivery leading to innovation.

Creativity Measurements

Drucker [12-13] stresses that every organization needs to measure and improve its creative and innovative performance. Organizational performance broadly depends on its processes and people. The literature survey in the area led us to believe that the people part – unlike the process one –did not attract adequate attention of either the researchers or the practitioners. We argue that organization leaders need to track individual performance and competency measurements in the area. In fact, we believe that such measurements should be initiated in colleges. Young students have enormous creative potential, have yet to start their long professional life and can benefit significantly by developing the competency. We, therefore, looked for a cost-effective mechanism to measure and develop the competency of students.

Creativity has attracted many experimenters but only a few of them have ventured to measure it [14-15]. They perhaps, have concurred with Eisenberg's argument that creativity cannot be viewed from a deterministic lens[16]. Those who have measured have relied on the Myers Briggs Type Indicator (MBTI) [6] and the Torrance Test of Critical Thinking (TTCT) [14, 17].

MBTI

The Myers Briggs Type Indicator was developed in the 1940s by Isabel Myers and Katharine Briggs, based on Carl Jung's Theory of Psychological Types[18-19]. The test is administered by accredited trainers and measures personal preferences about how people perceive the world and make decisions. It does so by measuring personality preferences using the four scales - Extroversion/Introversion (EI), Sensory (or practical)/Intuitive (SN), Thinking/Feeling (TF) and Judging/Perceiving (JP). Extroverts focus on the outer world and introverts on their own inner world. Sensors prefer the basic information they take in and intuitive people interpret, look beyond and think through, and add meaning. Thinking individuals look at logic and consistency and Feeling ones first look at people and their special circumstances. In dealing with the outside world, Judging individuals prefer to get things decided and Perceiving ones prefer to stay open to new information and options. There are more than 25 studies involving the MBTI instrument which have proved the correlation between the preference of intuition and creativity [19]. Thorne and Gough [20] have developed a Creativity Index based on the instrument that rates preference for intuition three times higher than any other factor. The MBTI is the most widely used personality assessment tool across the globe and is validated by many researchers [21-23]. Even so, some psychologists have criticized the instrument for lack of convincing validity [24-25].

TTCT

The Torrance Tests of Creative Thinking (TTCT) was developed by Dr Paul Torrance in 1966 and has since been re-normalized four times. There are two parts to the test: Figural and Verbal - each having two forms: Form A and Form B. The test has a wealth of information available on it and requires little time for its administration. It seems to be more researched and analyzed than any other creativity instrument and is proven to be reliable and valid except the latest i.e. 1998 normalized version. The test has to be administered by qualified scorers –those who have undergone training by the Torrance Center of Creativity and Talent Development at The University of Georgia and Scholastic Testing Service, Inc.[17].

Thus, both MBTI and TTCT tests are reasonably well proven but costly. Interestingly, there is an instrument that is developed on the lines of MBTI with respect to Intuitive / Sensing type - the type that is highly correlated with creativity [19]. We decided to use that instrument i.e. Felder Solomon Index of Learning Style (ILS) [4-5]. It is available free of cost to academic organizations.

Learning Styles

Learning styles are relatively stable preferences that students have for ways to receive and process information. Close to a hundred different learning style models have been formulated and instruments to assess preferences on some of those models are available either from open sources or from commercial vendors with millions of users accessing them each year. While there are many supporters and detractors of the styles [26, 27, 28], we agree with the observations made by Felder [29] that they are useful descriptions of common behavior patterns and have been used frequently and successfully to help teachers design effective instruction, to help students better understand their own learning processes and to help both teachers and students realize that not everyone is like them and the differences are often worth celebrating.

Index of Learning Styles (ILS)

The Felder-Soloman Index of Learning Styles (ILS) is one of the most popular learning style instruments[4-5]– especially in engineering education. It is based on Felder and Silverman's model and assesses preferences on four bipolar dimensions: Active-Reflective, Sensing-Intuitive, Visual-Verbal, and Sequential-Global. Active learners prefer doing things, particularly in groups. Reflective learners work better alone, with time to think about the task before doing it. Sensing learners like facts, data, and experimentation and work well with detail. Intuitive learners prefer ideas and theories, particularly when they get to grasp and generate new ideas. Verbal learners like to hear information and engage in discussion, particularly when they can speak and hear their own words. Visual learners like words, pictures, symbols, flow charts, diagrams, and reading books. Sequential learners prefer linear reasoning, step-by-step procedures, and material that comes to them in a steady stream. Global learners are strong integrators and synthesizers making intuitive discoveries and connections to see the overall system or pattern[26]. Both innate personality traits and prior experiences may influence preferences on each of these scales.

The Index of Learning Styles provides scores showing the strengths of an individual's preference for one category or the other on each of the four dimensions. The instrument is a 44-item questionnaire[4] that requires choosing one of two options that focuses on some aspect of learning. The choices result in a score of 1, 3, 5, 7, 9 or 11 for each of the preferred categories, with a 1 signifying a very slight preference for the category and an 11 a very strong one.

Research Design

Our study introduces a systematic approach in measuring and developing the creativity competency and informs stakeholders that appropriate pedagogical methods and techniques can possibly bring in changes in the competency. The overall research design is as outlined in figure 1.

Objective, Scope and Type

"Complexity, Complexity, Complexity" was the response of Ivar Jacobson, a leading software engineering researcher, when informally asked about the changes in engineering field. That resonates well with employers' demand for handling complexity from engineering graduates. They are required to think of different creative and innovative solutions to today's complex engineering problems. That becomes challenging in the wake of our K-12 education system requiring students to follow only set or pre-defined methods. Engineering education has to play a transformative role, develop creative competency of its students and meet the employers' requirements of handling complexity.

We chose a senior course in Software Testing and Quality Assurance (STQA) for the experiment. It provides an excellent platform for experimentation as both testing and quality assurance activities require creativity. The course is a part of Software Engineering which is a young engineering discipline. In fact, some critics do not even recognize it as an engineering discipline [30]. These disagreements provide varied opportunities for debate and developing critical thinking making the choice of the course cogent. Our research is diagnostic, cross sectional and field setting.

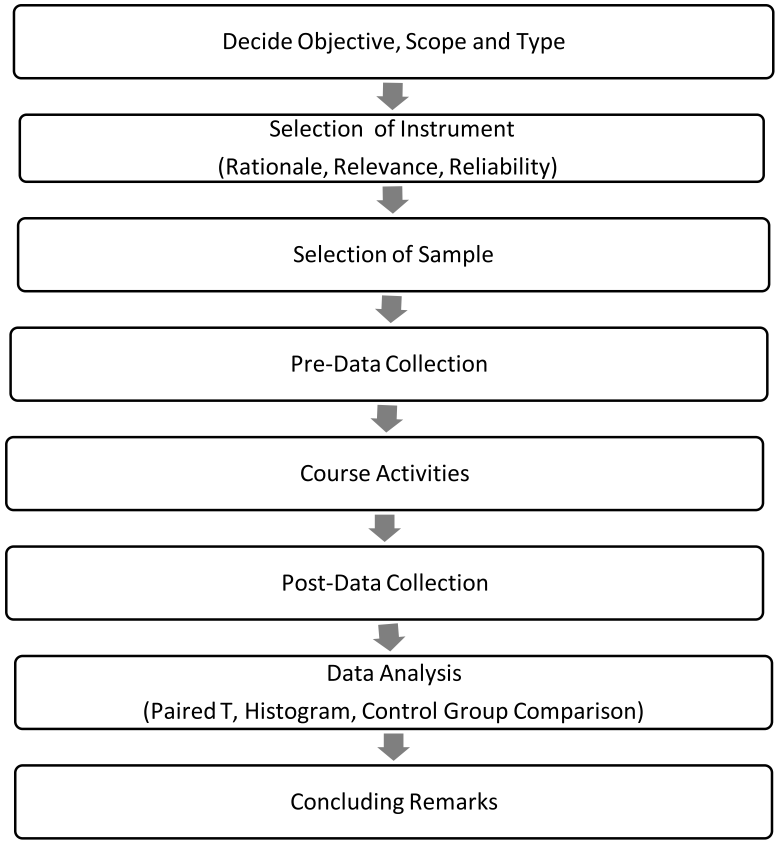

Figure 1 Research design

Selection of Instruments

This is a critical step as it maps research problems to a mathematical domain. There are a few reported studies on developing and / or measuring the competency. Tan [31] proposes a theoretical framework to explain how managers can foster and sustain creativity in their organizations using a total systems approach but does not seem to use any measurements. Thorne and Gough[20] have developed a Creativity Index based on the MBTI instrument. Higuchi [32] explains analysis of empirical experiment for measuring effect of creativity improvement before and after the Idea Marathon System training for about a 3 months period, for R&D and laboratories staff using TTCT Figural tests. There are some efforts in developing the competency at colleges. Putkonen, et al.[33] have proposed pedagogy and concluded that the context of working life offers better opportunities for inculcating innovative (creative) skills. They have not used any specific measures, though. Jiazeng, et al.[34] have introduced a separate course on Creative Studies and used TTCT to prove that creativity can be improved through education. While they have provided pre measurements; they seem to have relied on qualitative feedback to assess the improvement. The authors have not provided details of the cohort like their course, level, etc. While, there are a large number of creativity tests that have been developed [1,6], their use at workplaces has been far lesser [35-36]. Engineering education seems to be treading far behind. We found only one study that has compared creative thinking of American and Japanese students using TTCT[37]. Overall, the academic organizations measure knowledge level and not key transferrable competencies like creativity and teamwork.

We decided to use Felder Solomon Index of Learning Style (ILS) to infer creativity competency of students. The sensing/intuition dimension of the instrument that is originated in Carl Jung's Theory of Psychological Types like the MBTI (Myers Briggs Type Indicator) Instrument appeared to provide the requisite measure.

Reliability Assessment

It is important to conduct a thorough measurement analysis on the survey instrument and be assured that the findings reflect accurate measures and the results are trustworthy. Test reliability indicates the extent to which individual differences in scores can be attributed to 'true' differences in the characteristics under consideration and usually decided by Cronbach's coefficient alpha, which is an average of all possible split pair correlations of responses. Litzinger, et al.[38] studied reliability and found that ILS had internal consistency reliability ranging from 0.55 to 0.77 across the four learning style scales. Felder and Spurlin[7] have quoted four studies in which alpha for each of the four dimensions exceeded 0.5, except in one study where global-sequential value fell slightly below 0.5, indicating that the instrument has satisfactory internal consistency and reliability. Tuckman [39] and Sekaran [40] propose a minimum alpha value of 0.5 for assessments of preferences such as those done by the ILS. Further, based on the assessments at ten engineering institutes, they have found that students consistently showed active, sensing, visual, and sequential preferences. Only at one institute, a batch of students was found to be a little more global than sequential. So, the above studies helped us assure reliability and validity of the ILS instrument.

Further, we also explored the validity of using ILS to infer creativity competency. We found that Rosati [41] has studied ILS and MBTI assessment of 622 students and found that the sensing students on the ILS are also significantly more sensing on the sensing/intuition scale of the MBTI. There are numerous MBTI studies that show strong correlation between its sensing dimension and creativity[19]. We, therefore, posit that the sensing dimension of ILS can be used to infer creativity competency.

Sampling

Our sample consisted of 78 undergraduate students of the Software Testing and Quality Assurance course (N=78). While most of them were admitted to the four year Undergraduate (UG) engineering program after twelve years schooling, a few of them (12) had lateral entries in the second year of the program after ten years of schooling followed by three years of engineering diploma. While the college is considered to be the best in the state and attracts bright students, there was noticeable variation in performance of the students at the entrance examinations and in the prior courses of the engineering program.

Data Collection (Pre)

We started the course by explaining the fundamentals of learning, details of Index of Learning Styles and its use to become better learners. We did not bring in the aspect of creativity competency in the discussion. We then administered the ILS assessment and helped them interpret its results. Overall ILS profiles of the students were found to be comparable with the Felder and Spurlin[7] study indicating that the sample under study was representative. Table 1 shows category-wise percentage division of Learning Style Preferences and Table 2 shows average score on all four dimensions. The average was computed by mapping the preferences to -11 to 11. For example, in case of S/N dimensions the S preference was taken as positive and N was taken as negative. So 11(S) became +11 and 11(N) became -11. We found that the cohort was reasonably balanced on active-reflective and sequential-global dimensions and was out of balance on sensing-intuitive and visual-verbal dimensions.

Active	**Sensing**	**Visual**	**Sequential**
55 %	68 %	92 %	61 %

Table 1: Category wise % division of Learning Style Preferences (Pre)

ACT-REF	**SNS-INT**	**VIS-VRB**	**SEQ-GLO**
0.6	2.0	5.6	0.9

Table 2: Average of Learning Style Preferences (Pre)

(The average was computed by mapping the preferences to -11 to 11. For example, in case of S/N dimensions the S preference was taken as positive and N was taken as negative. So 11(S) became +11 and 11(N) became -11)

We carried out a survey – two months after the assessment - to ascertain the efficacy of the ILS. We asked the participants about usage of the assessment results, benefits thereof and their recommendation to use the assessment for other students. The survey was taken up by 48 students and received a positive response as showed in Figure 2. We found that 45 out of 48 students, who took the survey, recommended the assessment to other students.

Since we had to use the sensing-intuition dimension, we further analyzed it. We have presented the result in Figure 3 below. The X axis has score on the S/N dimension where 1(S) means score of 1 on sensing dimension and 1(N) means score of 1 on intuition dimension and so on. The Y axis has a number of students with that particular score. The class was indeed highly sensing.

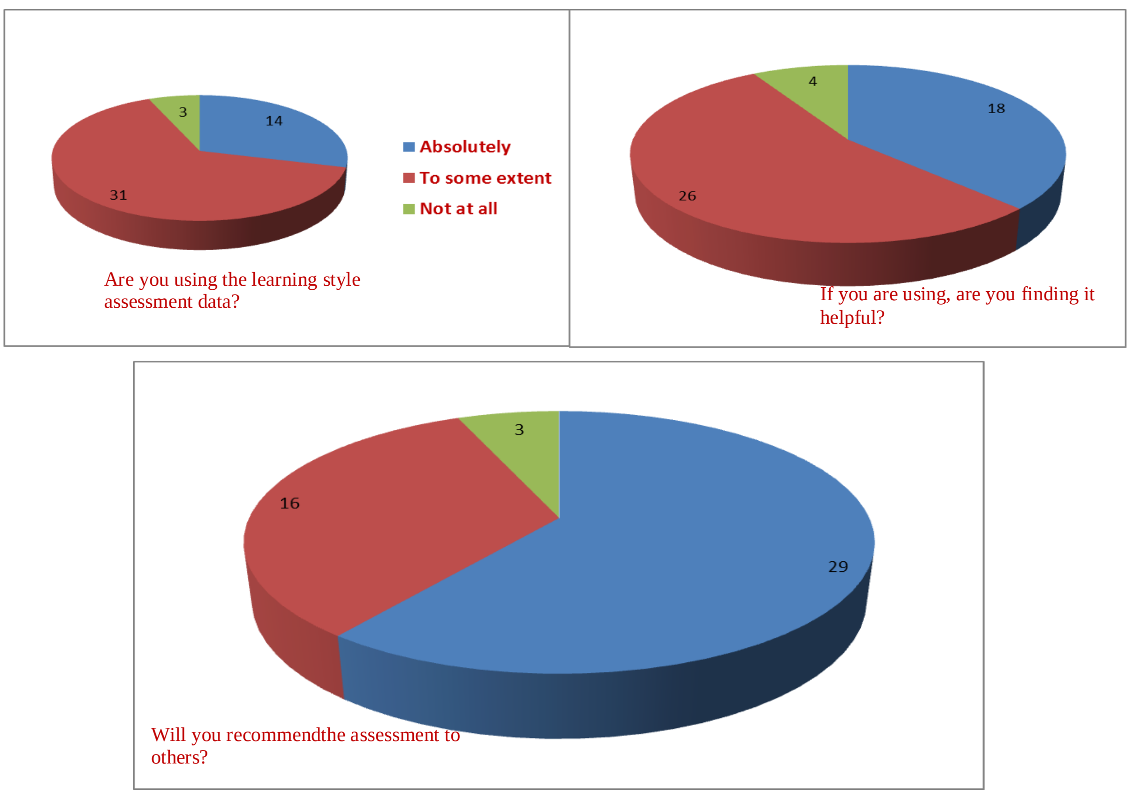

Figure 2: Survey on the usage of ILS Instrument

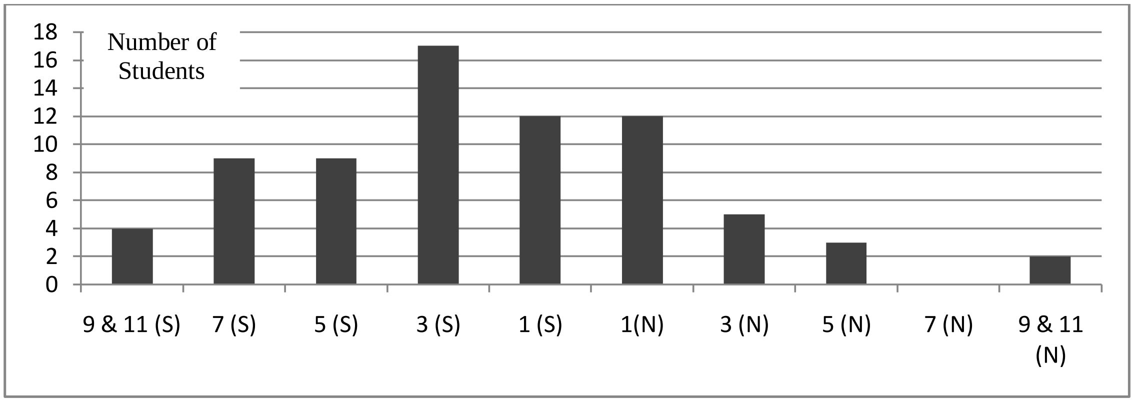

Figure 3: Sensing-intuitive Learning Style Preferences (Pre)

(X(S) means score of X on sensing dimension and X(N) means score of X on intuition)

Activities

As discussed earlier, the Software Testing and Quality Assurance course provided an excellent platform for the experiment. We included many thought-provoking problems during the course and facilitated their solutions. The open-book weekly and end-semester examinations also offered similar problems. The class was assigned to write wiki articles; it underwent a daylong creativity and innovation workshop and used many active learning techniques. We did not want to neglect sensing skills altogether and included activities like manual testing and use of various tools towards that. The focus, however, considering the profile of the class, was on developing creativity competency. More detailed description of different activities of the course is provided in the following sub-sections.

Wiki

Education in general, and engineering education in particular, has steadily adopted newer paradigms of student-centered learning as opposed to traditional lecture-oriented learning [42-43]. The new paradigms are well supported by Web 2.0 technologies that allow development of student-centered personalized learning environments [44] around blogs, wikis, and discussion forums. A special and perhaps the most popular instance of wiki is the online encyclopedia, Wikipedia. It can be used to engage students in authentic collaborative writing activities. Forte and Bruckman[45] have given guidelines to develop curricula to support learning among student authors in the Wikipedia environment. Moy, et al. [46] have successfully used Wikipedia to enable students to work collaboratively, explore advanced concepts in Chemistry, and learn communicating science to a diverse audience, including the public. Cole [47] has reported her failed experiment at a graduate-level class project that was centered on editing Chemistry-related entries in Wikipedia. She inferred that in an educational context, social technologies are perceived differently as compared with ordinary personal use which may have caused the failure.

While we identified a number of topics in the subject area for writing Wiki articles, we also encouraged students to come up with their own topics. They presented their ideas and we supplemented them with our ideas, wherever required, and converged on a topic for each student. We incentivized students by announcing bonus marks for completing the assignment. Out of 78 students, 69 attempted to write articles, and 60 students' articles were approved and uploaded. Many of the articles were appreciated by experts in the field. Some of the articles like test data generation (written by user Gakiwate) and testing high performance applications (written by user belapurerv08) appear at the top in Google search results even today.

Creativity and Innovation Workshops

The workshop used definition of innovation as 'fresh thinking that delivers value to customers' [11] and explained its criticality in today's circumstances through problems in various spheres at both global and national levels. Further it established the fact that an individual can make a difference by watching audio-visual clips of famous innovators like Steve Jobs, Ratan Tata, etc. as well as other not-so-famous innovators. The clips were discussed in the class to ensure uniform learning. The workshop also covered a range of creativity techniques such as, 5 whys, brainstorming, random inputs, associating, provocation, and introduced TRIZ. The participants analyzed and presented an assortment of case studies. The challenges in value delivery were elaborated with insightful case studies like the Dvorak keyboard. The participants were encouraged to choose challenges they felt passionate about. They were expected to ideate solutions and implement them. The workshop was very well received and earned a rating of 4.75/5 from participants and excellent qualitative feedback, some of which is reproduced below.

It was a great workshop. I think this is one activity that we enjoyed the most in college. I would appreciate if you could conduct this workshop for other students, too.

I really feel fortunate that I attended the Innovation workshop on Sunday. It really made some difference in our thinking process. I appreciate such programs and assure you that repeated exposure to such workshops will really magnify our innovation quotient. I feel honored to have an enthusiastic professor like you.

I was not able to come to yesterday's workshop due to some personal problems, and I apologize for that. I heard about the workshop from my friends and they said they liked it very much. I certainly seem to have missed a very good thing in my life yesterday.

Active Learning

Extensive research has been done on the efficacy of active learning in engineering education. Lamancusa, et al. [48] argue that personal experience on real problems develops skills and knowledge that are far more memorable and transferable than passive lectures, and quote Albert Einstein who said "the only source of knowledge is experience". Michigan State University professes active learning to be one of its six guiding principles. Cognizing all these benefits, we used many active learning techniques. Some of them are discussed in the next few paragraphs.

Our course sessions were designed to be highly interactive wherein we posed many questions and encouraged students to answer them. Most of the questions were open-ended with clear instructions that they were not being asked to simply recall from memory but to think and answer. We took extra efforts to develop better rapport with students irrespective of their academic performance,which helped increase their participation. We applauded thoughtful answers and regularly emphasized the fact that students who participate actively learn the most.

We identified various controversial issues in the subject area for discussion. These included 'organization's progress on CMM / ISO certification does not have any value', 'manufacturing QA processes cannot be applied to IT', 'testing should not be done by developers', 'increase in computing power has decreased productivity', etc.. We explained the brainstorming principles, formed random groups, and initiated discussion sessions.

Students were also asked to prepare and deliver short presentations on varied topics. There was a student who at the beginning just could not utter a single word from the dais. So, we asked him to read Rudyard Kipling's poem 'If' to the class. He did that and since then has been eagerly looking out for speaking opportunities. Owing to its benefits, we used peer evaluation process, for evaluating presentations [49].

We invited many international guest speakers who delivered insightful speeches – either in person or over the Internet. Speakers who visited were hosted by students who thus got the opportunity to interact with the luminaries and learn many things beyond technical areas. The better performers among the students were asked to teach some topics.

Grading Method

We had twelve weekly tests and chose the best eight test scores towards 25 % of the final course grade. The Wiki assignment counted for 20 % of the grade. Since wiki assignments were difficult, 20 % bonus marks were announced for acceptance of articles. Since we followed relative grading, the bonus marks scheme did not make any material difference; it just created a positive conducive atmosphere. There was also an open-time and open-book final examination that covered the entire course material. It counted for 30% of the grade and classroom participation and paper assignments counted for the remaining 25 % of the grade.

Data Collection (Post)

At the end of the course, we again administered the assessment and captured changes in the preferences for styles. The survey findings with respect to sensing-intuition dimension are presented as a histogram in figure 4. Tables 3 and 4 provide category-wise percentile division of Learning Style Preferences and average score on all the four dimensions, respectively.

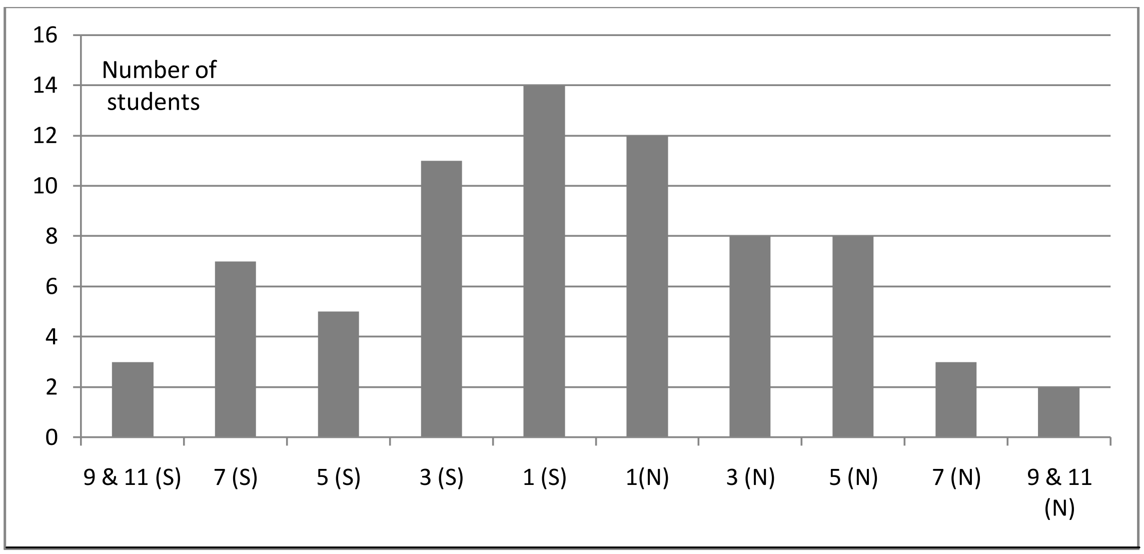

Figure 4: Sensing-intuitive Learning Style Preferences (Post)

(X(S) means score of X on sensing dimension and X(N) means score of X on intuition).

Active	**Sensing**	**Visual**	**Sequential**
68 %	55 %	92 %	45 %

Table 3: Category wise % division of Learning Style Preferences (Post)

ACT-REF	SNS-INT	VIS-VRB	SEQ-GLO
1.2	0.5	6.2	-0.7

Table 4: Average of Learning Style Preferences (Post)

(The average was computed by mapping the preferences to -11 to 11. For example, in case of S/N dimensions the S preference was taken as positive and N was taken as negative. So 11(S) became +11 and 11(N) became -11)

We could see changes in the sensing-intuitive dimension. The paired t test informed us that they are statistically significant (p value 0.004).

Control Group

We compared results of the above group with a control group – the group that consisted of 79 undergraduate students from the same college who were studying Software Engineering course (N=79) in the second term of their junior year. The pre assessment of the group provided us the class profile as given in table 5 and 6 below. For all practical purposes, both the groups were comparable.

Active	Sensing	Visual	Sequential
51 %	67 %	84%	62%

Table 5: Category wise % division of Learning Style Preferences (Pre for Control Group)

ACT-REF	SNS-INT	VIS-VRB	SEQ-GLO
0.22	1.81	4.41	1.08

Table 6: Average of Learning Style Preferences (Pre for Control Group)

(The average was computed by mapping the preferences to -11 to 11. For example, in case of S/N dimensions the S preference was taken as positive and N was taken as negative. So 11(S) became +11 and 11(N) became -11)

For various reasons, we could not conduct the creativity and innovation workshop, nor could we arrange wiki assignments for this group. We had no guest speakers and open book examinations. We retained the interactive nature of the class and organized a couple of group discussion sessions and student presentations. We carried out the post assessment that provided us the class profile as given in table 7 and 8 below.

Active	Sensing	Visual	Sequential
67 %	59 %	87 %	48 %

Table 7: Category wise % division of Learning Style Preferences (Post for Control Group)

ACT-REF	SNS-INT	VIS-VRB	SEQ-GLO
1.54	1.33	5.04	0.08

Table 8: Average of Learning Style Preferences (Post for Control Group)

(The average was computed by mapping the preferences to -11 to 11. For example, in case of S/N dimensions the S preference was taken as positive and N was taken as negative. So 11(S) became +11 and 11(N) became -11)

We could see changes in the sensing-intuitive dimension. However, the paired t test informed us that they are not statistically significant (p value 0.31).

Concluding Remarks

Intuitive style that connotes creative and abstract thinking is vital for today's engineers as they have to work on increasingly complex problems. Our K-12 education system has been pushing students towards more sensing style and the engineering education has to bring in the shift. Our experiment of designing the course to bring in the shift toward intuition on the distribution of preferences on the sensing/intuitive scale of ILS seems to have worked well. The sensing style moved from the average of 2.06 to 0.46. Using paired t test we confirmed that the change is significant (p value 0.004). We have compared both pre (hollow) and post (solid) preferences in a histogram in figure 5 that depict movement of the cohort from sensing to intuition preference. Interestingly, the sequential-global dimension also had a statistically significant change. The paired t test indicated that the 0.7 to -0.9 shift is significant with p value of 0.002. The change does help in enhancing the creativity competency and complements the better balance in the sensing intuitive dimension.

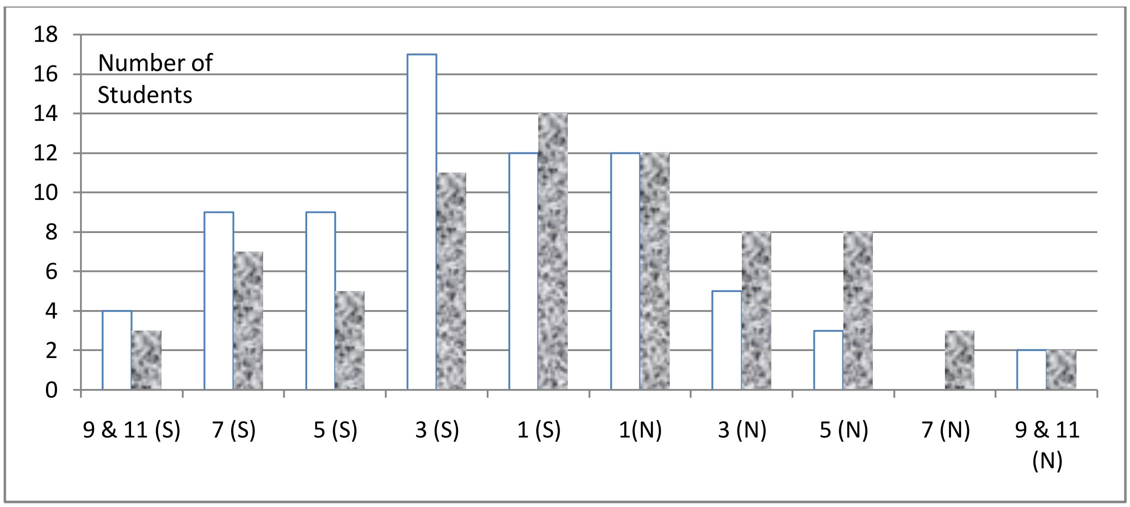

Figure 5: Sensing-intuitive Learning Style preferences Pre (hollow) and Post (solid). (X(S) means score of X on sensing dimension and X(N) means score of X on intuition)

The course had many novel elements such as, the use of Wiki assignments, significant involvement of students in the course proceedings through various active learning techniques, deviating from traditional examination and grading methods, and a day-long workshop -all of which seem to have worked synergistically.

We compared the result with a control group that was studying a similar course. The control group only used a few active learning techniques. We found that the group did see some change in their intuitive learning preferences but is not statistically significant.

The S/N dimension has been adapted by the ILS authors from Carl Jung's Theory of Psychological Types. The theory asserts that the types are innate and do not change over time. Our experiment is precisely looking at what seems to be contradictory – changing the types. The missing point is that the Jungian theory also says that the type assessment is a complex exercise and gets muddled due to conditioning of individuals. The original type may get masked due to social, family, and educational environments. We believe that must have been happening in K12 education system. It may have been conditioning students to sensing type and may require such assessment, awareness and interventions to help them discover their true type or uncondition / reverse condition them.

While we believe that our experimental results suggest that the approach has some merits and is worth exploring further, we do not claim it to be conclusive evidence of a gain in developing creativity competency. We only suggest the possibility that the new course may have that effect and lead to more definitive course development and assessment. We agree that we have to fortify our claims by carrying out more experiments on a larger population covering different cultural and geographic settings. We also think that planning the measurements and early interventions in the engineering curriculum could have a positive effect on producing better employable engineers and reducing attrition.

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