An evaluation of the thinking preferences of engineers to assist in their personal and professional development.

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Abstract

This paper reports the preliminary results of a ongoing research programme into the development of personal and team working skills of engineers. The aim of the work was to raise the self-awareness of the engineers as an aid to assist them in group work and team building tasks that are essential to the professional. This was achieved through the use of a newly developed psychometric instrument known as Thinking Styles®(1). This psychometric test was used to produce personal profiles for 30 postgraduate engineering students and a group of 10 academic and industrial engineers based in Greek Institutions. The paper briefly presents an insight into the design and development of this psychometric instrument and describes the evolution of the tool from the concepts within Neuro Linguistic Programming (NLP)(2). The paper then examines a range of other indicators; Myers-Briggs Type Indicator (MBTI), Kolb's Learning Style Model, Herrmann Brain Dominance Instrument (HBDI), Honey and Munford's Learning Style questionnaire and the Felder-Silverman Learning style models, that have been used in Engineering Education, before presenting the results of a pilot study. The benefits of such an evaluation are discussed and compared with the results from other indicators as a means of increasing the self-awareness and flexibility of the engineers thinking.

1. Background to the development of the new instrument

Thinking Styles® measures twenty-six conceptually independent cognitive styles sub-divided into three categories: sensory, people and task focus. The instrument has its roots in Neuro Linguistic Programming (NLP). The NLP tool of modelling involves sub-dividing techniques and strategies down into their smallest constituent parts and carefully recording them so that they can be copied rather like a blueprint. In this way, if you want to be an excellent motorist for example, you find an excellent car driver and study them, modelling exactly what they do so that you can replicate it. Of course this is an over-simplification of a complex technique, and NLP now includes many more tools, models and ideas than those originally expressed by its developers. (2)
The original conceptual idea for a commercially developed psychometric instrument specifically designed to provide information to people about the ways in which they think evolved from the NLP concept of 'meta-filters' (3). NLP suggests that these meta-filters are conceptual categories that serve to assist individuals in the receipt, sorting and dissemination of information. A critical point to make is that these filters are 'perceptual' filters. For example, an issue that one person perceives as 'easy' to resolve may be perceived as 'difficult' to resolve by another person, yet both people are being presented with the same issue.

1.1 Design and Development

The development of the Thinking Styles® as a psychometric instrument took eight years from the initial concept in 1993 through the beta test phase to the current Version 2 that is supported by statistical data, and became commercially available in 2001. The twenty-six independent dimensions are listed in Appendix 1. The instrument has achieved good levels of internal reliability with all dimensions demonstrating values between .60 and .95, as shown in Table 1. These figures provided evidence that the dimensions are independent scales. The initial statistical analysis has been done in order for the instrument to be recognised as statistically valid and reliable, (1) more work remains to be done such as congruent validity studies with other instruments. The next section looks at the applications of such instruments.

1.2 Applications

Many researchers such as Sternberg, (4, 5,and 6), and Zang (7) have focused on the academic and educational applications of cognitive style and meta-cognitive awareness as opposed to exploring their benefits and applications within the areas of the human resources. This particular research has been to pilot the Thinking Styles® questionnaire within the area of Engineering Education. Recent research into student learning has recognised the complexity and temporal nature of student motivation (8). There is a real need to encourage engineering students to adopt a deep approach to their learning (9). Heavy workloads, high-class contact and content laden course material can detract from a deep approach and positive action has been proposed to address the balance (10). There is a real need for staff delivering engineering courses to take account of individuals thinking and learning styles and to concern themselves with the personal and professional development of their students. It is well known (11) that students have different learning styles characteristic strengths and preferences in the ways they take in and process information. Some students tend to focus on facts, data, and algorithms; others are more comfortable with theories and mathematical models. Some respond strongly to visual forms of information, like pictures, diagrams, and schematics; others get more from verbal forms written and spoken explanations. Some prefer to learn actively and interactively; others function more introspectively and individually.

An objective of education should be to help students to understand how they think and learn and to develop an overall flexibility. This greater understanding of themselves and others leads to real personal and professional growth and independence. In the field of engineering education five indicators have been used to assist students in understanding their learning and thinking styles; these are discussed in the next section.

2. Models in Engineering Education

2.1 The Myers-Briggs Type Indicator (MBTI).

This model classifies students according to their preferences on scales derived from psychologist Carl Jung's theory of psychological types. The classification resulting from this model is provided in Appendix 2 (12)

Many thousands of engineering students and hundreds of engineering academic staff have taken the MBTI as part of a research study conducted by a consortium of eight engineering schools in USA (13). One example of MBTI as a diagnostic tool is its use for students having academic difficulties. If the descriptions seem accurate to the students, staff assist the students in devising tasks that capitalize on their strengths as well as addressing weaknesses. Letting the students assess the accuracy of the descriptions is essential. Like all other assessment instruments, the MBTI provides clues, not labels; the student is the ultimate judge of his or her behaviour patterns.

2.2 Kolb's Learning Style Model.

This model classifies students as having a preference for
either a concrete experience or abstract conceptualisation (how they take information in) or an active experimentation or reflective observation (how they internalise information). The four types of learners in this classification scheme are given in Appendix 3 (14)

The Kolb Learning Style Inventory has been administered widely within the engineering education (15,16) One specific example is in assisting chemical engineers to develop technical communication skills. Used to assess their learning style, the students kept journals in which they described conflicts and accomplishments within their lab groups, relating them to the group members' learning styles. It was found that teaching students about learning styles helps them learn the course material because they become aware of their thinking processes. The major success is the development of interpersonal skills that are critical to success in any professional career (17).

2.3 Herrman Brain Dominance Instrument (HBDI).

This method classifies students in terms of their relative preferences for thinking in four different modes that are based on the task-specialized functioning of the physical brain. These are given in Appendix 2 (18)
Lumsdaine and Voitle (19) studied the HBDI types of the college's students and faculty. They found that many engineering students and professors were left-brain thinkers logical, analytical, verbal, and sequential. The data also indicated a strong attrition rate among right-brain thinkers, with many dropping out despite earning top grades in analytical courses. The described an inhospitable learning climate in engineering, which does not accommodate right brain thinking preference, even though voices in industry are increasingly demanding engineers with precisely those thinking skills.

Students worked in teams formed by the professors to provide balance in HBDI types. Student performance levels and attitudes to the course improved considerably because of these changes.

2.4 Felder-Silverman Learning Style Model.

This model classifies uses an Index of Learning styles (ILS) to classify students on four or five of the learning types as given in Appendix 2 (11)
Work has shown engineering staffs on average are strongly Quadrant A dominant and would like their students to be that way as well.
ILS has been used to assess the learning styles of engineering faculty members and first-year and fourth-year engineering students at university. It was found that staff members were significantly more reflective, intuitive, and sequential than the students. material), and global learners (providing the big picture, showing connections to related material in other courses and to the students' experience (20)

2.5 Honey and Mumford Learning styles Evaluation

This questionnaire directly assesses the four basic types of style in Kolb's model, as shown in Appendix 2 (21). This simple analysis has been used widely through business and education and most recently as a basis for selecting groups on an undergraduate engineering course. (22)

The vast majority of research conducted with engineers using any of the five tools mentioned is reported to provide a positive intervention. Three of the tools have only four reporting functions and professional engineers and staff are consistently found to be left brain, logical, procedural, Quadrant A, sequential, theoretical whereas their students and industry require greater flexibility and variety of thinking and learning preference. The authors were attracted to the Thinking Styles® questionnaire (1) because of the breadth of the dimensions and the fact that the instrument measured and individuals preference for thinking in a certain way but also an individuals dislike of that method of thinking. It was consider there was scope to use such a tool to assist engineers in developing a flexibility of thought as well as self-awareness and understanding of others.

2. The Thinking styles pilot study

The Thinking Styles questionnaire measures cognitive and linguistic preferences as well as the flexibility of thinking. It does not measure intelligence or ability it simply provides a listing of an individuals preference for thinking in a certain way. The questionnaire when analysed provides a personal profiles of the twenty-six dimensions as given in Appendix 1. A unique feature of this tool is that as well as identifying and measuring the way in which a candidate likes to think it also measures the degree to which a certain style of thinking is disliked. As such the range presents a flexibility of thinking.

2.1 The pilot group

The questionnaire (1) was issued to 30 postgraduate engineering students and a group of 10 academic and industrial engineers based in Greek Institutions. Personal profiles were produced for all participants and a brief summary of the results is presented.

2.2 Results

Figures 1, 2 and 3 show the average results for the whole cohort for all twenty-six dimensions. The results are split up in terms of the Sensory, People and Task focus dimensions and the average of all the preferences compared. The initial examination is in terms of the highest preference exhibited by both the postgraduate student engineers and the professionals. A positive preference greater than 60% was required to be classified as having a high thinking preference for that dimension.

Firstly examining the Sensory thinking preferences:

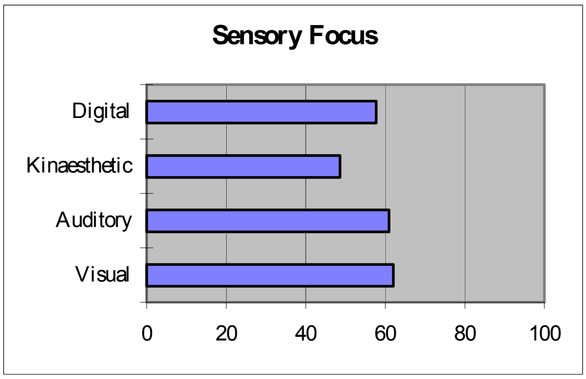

Figure 1 Average Sensory results of the whole group of engineers

Figure 1 shows a higher thinking preference for the 'Visual and Auditory dimensions those involved with diagrams and figures as well a preference for discussion and the use of words rather than for the 'Kinaesthetic. Dimension' which would involve feelings, emotions and intuition. Next looking at the People focussed dimensions:

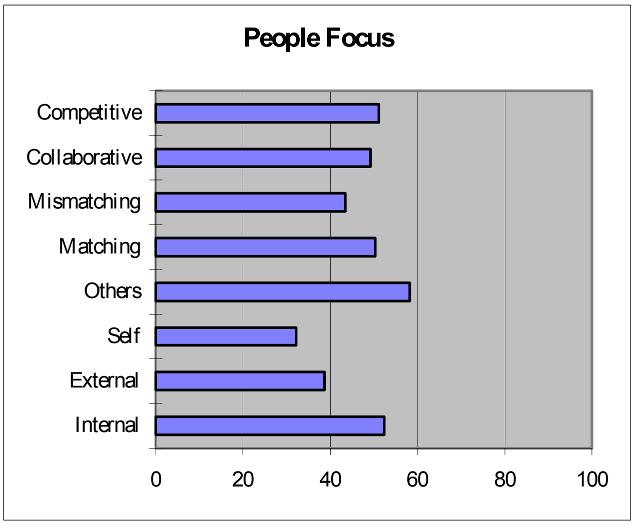

Figure 2 Average People focussed results for the whole group of engineers.

Figure 2 shows no high preferences for the people focussed dimension, although the significant difference between the greater preference for the 'Others dimension' being responsive to the needs of others and willing to help compared with the 'Self dimension' that of putting ones own needs first is interesting. This difference was present in most profiles and overall the data had some of the smallest standard deviations.

The final Figure 3 provides the Task focussed dimensions:

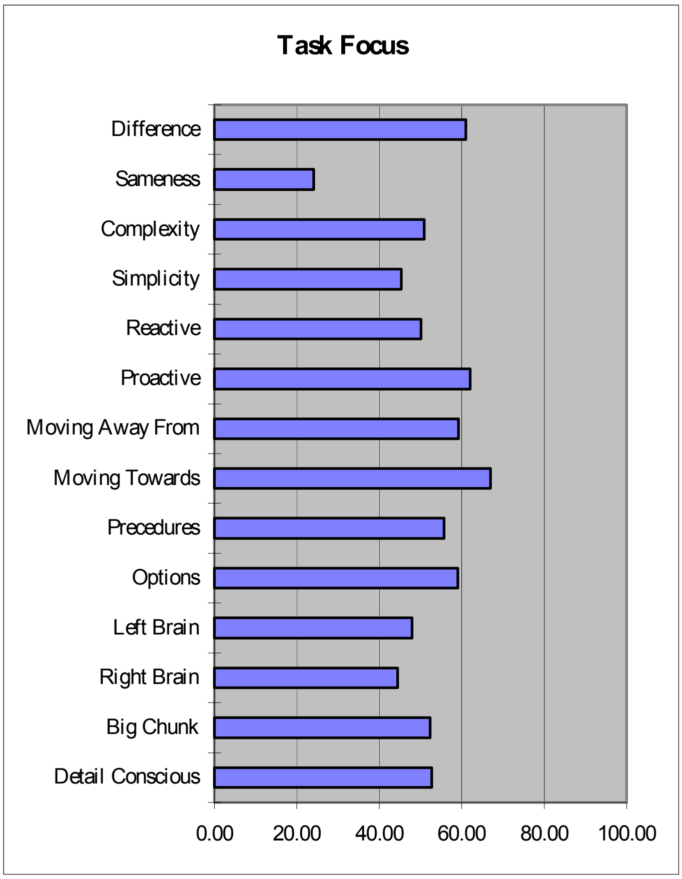

Figure 3 Average Task focussed results for the whole group of engineers.

Figure 3 indicates that the highest thinking preference from the group was the 'Towards dimension' indicating a focus towards goals and targets a positive attitude and clear purpose. This was followed by the 'Proactive dimension' an indication of getting on with things and the 'Difference dimension' which suggests a high capacity for change.

Comparing the results of the professional engineers and the postgraduate student engineers, Table 2 indicates the slight variation in the highest thinking preferences.

Professional Engineers	**Postgraduate Engineers**	**Thinking preference**
Visual	Towards	1 (Highest)
Proactive	Visual	2
Digital	Auditory	3
Away from	Proactive	4
Auditory	Difference	5
Towards	Away from	6
Professional Engineers	**Postgraduate Engineers**	**Thinking preference**
Sameness	External	24
External	Sameness	25
Self	Self	26

Table 2 A Comparison of the highest and lowest thinking preferences of the group

The similarity between the preferences of the professional and the students is interesting with the only difference being that the postgraduate engineers have a higher capacity for change and the professional engineers are more digital. However in this preliminary analysis only the highest and lowest thinking preferences have been examined as an average of the group. The next section looks specifically at two dimensions that of the left and right brain preferences of all individuals in the study and demonstrates the potential for this instrument. This is included as an example of the scope of the full analysis, which will be the topic of a later paper.

2.3 Left brain/right brain thinking preferences for the engineers

The engineers participating in this trial showed either a right brain preference or a left-brain preference or had a similar preference for both. The averaging (Figure 3) obliterates these differences, which have been highlighted in Table 3. The table shows a comparison between professional engineers and the student engineers in terms of the percentage whose preference was dominated by their right, left or both sides.

Thinking preference	Professional Engineer	Postgraduate Engineer
Left brain	20%	30%
Right Brain	10%	20%
Both sides	70%	50%

Table 3 A comparison of the left/right brain thinking preferences

The majority of the postgraduate and professional engineer had a preference for using both sides of the brain and this was particularly noticeable in the professionals compared to the students. Only 10% of the professional engineers had a preference for the right brain whereas this was 20% in the students.

3 Discussion

This paper has reported the preliminary findings of a newly developed thinking styles questionnaire, which has been used with engineers in Greece. All researchers (6, 7, 9, 11, 15, 19, and 22) engaged in this aspect of engineering education, have found a positive benefit and raised levels of self-awareness through the application of such instruments. All the assessment instruments discussed in this paper provide clues, not labels to help the participant understand their behaviour and how they relate and work with other people. Such models are useful in both an academic and business setting to support the development of interpersonal, team building and communication skills. In this respect the thinking styles questionnaire could be seen as simply another tool, however, the detail provided by the twenty-six dimensions (1) allows a much fuller self and peer analysis to take place and this questionnaire potentially offers a much more powerful psychometric instrument.

All of the other instruments have found that most academic engineers are digital, left brain, detail, towards, visual, procedures and auditory whereas undergraduate engineering students can show more flexibility and right brain creativity. This study has not indicated such wide disparity between the professionals and postgraduate students in that both groups had similar high and low thinking style preferences. This could be due to the fact that most other studies have been on undergraduate engineers whereas in this cohort all have ready graduated. However this is research in progress and represents a very small sample group from which it would not be appropriate to draw firm conclusions. Another interesting aspect is the individual analysis of the left and right brain thinking preferences, which showed (Table 3) that the majority of engineers had a preference to use both sides of the brain. Again this may be due the students being postgraduate and the majority of the professional engineers being industrially based. In that within a business environment all engineers need to exhibit a flexibility of thinking style and ability to work with others. It may also be a cultural aspect that needs further investigation.

One final observation from the data is that overall the engineers in this study show stronger thinking preferences for the sensory and task focused dimensions as opposed to the people focused category. This aspect is only revealed because of the detail that the thinking styles questionnaire produces and provides an indication of the potential self-development aspects of the tool.

More research needs to be carried out within business and academia in Greece and in other countries to establish the full potential of this instrument.

4. Conclusions

- An evaluation of the thinking styles of engineers has shown a preference for sensory and task focused dimensions. It has raised self-awareness and can be used to develop people focused skills if required.

- The thinking styles questionnaire provides full details with regard to the thinking likes and dislikes of individuals as well as an individuals thinking flexibility.

- The student and professional engineers in this study were more similar in their thinking preferences than had been previously found, but a much larger sample size in needed before firm conclusions can be drawn.

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Sensory Focus	Internal Reliability Data
Visual	0.86
Auditory	0.68
Kinaesthetic	0.78
Digital	0.73

People Focus	Internal Reliability Data
Internal	0.68
External	0.64
Self	0.73
Others	0.90
Match	0.66
Mismatch	0.72
Collaborative	0.89
Competitive	0.60

Task Focus	Internal Reliability Data
Detail Conscious	0.85
Big Chunk	0.82
Left Brain	0.65
Right Brain	0.71
Procedural	0.88
Options	0.76
Away From	0.73
Towards	0.80
Reactive	0.68
Proactive	0.76
Sameness	0.73
Difference	0.66
Simplicity	0.62
Complexity	0.95

Table 1 Internal Reliability Data of the thinking style dimensions

Appendix 1: Thinking Styles

Definitions for each of the cognitive styles:

Sensory focused dimenions exploring sensory representational syste*ms:*

1. **Visual thinking:** the use of pictures, diagrams and visual imagery.
2. **Auditory thinking:** a focus on words and language, listening and talking.
3. **Kinaesthetic thinking:** the use of feelings, emotions, intuition and physical exercise.
4. **Digital thinking:** involves a focus on the facts, and/or the use of data and statistics

People focused dimensions; exploring interactions with people:

5. **Internal thinking:** relies on own judgements and standards, believes oneself to be right, ignores feedback.
6. **External thinking:** relies on feedback from others, believes that others are right.
7. **Self referenced thinking:** puts their own needs first and ignores the needs of other people.
8. **Others referenced thinking:** responsive to the needs of others and willing to help other people.
9. **Matching thinking:** wants to fit in, dislikes confrontation and takes a non-challenging approach.
10. **Mismatching thinking:** dislikes being told what to do, will challenge and confront.
11. **Collaborative thinking:** involves others, shares information, prefers a team environment.
12. **Competitive thinking:** wants to win and better either the competition or ones' own performance.

Task focused dimensions; exploring approaches to tasks and problem solving:

13. **Detail Conscious thinking:** believes details are important and attends to detailed information.
14. **Big Chunk thinking:** focuses on general principles and summary information often in terms of key points.
15. **Left Brain thinking:** processes systematically and in sequence, ordered, completes one task at a time.
16. **Right Brain thinking:** creative, naturally multi-tasks, has an untidy workspace, works backwards starting from the end.
17. **Procedural thinking:** procedures are important, follows instructions and the correct way of doing things.
18. **Options thinking:** explores opportunity and possibility, seeks choice and alternatives, adds to work previously done.
19. **Moving Away From thinking:** focuses on problems, makes contingency plans, may worry.
20. **Moving Towards thinking:** focuses on goals and targets, says what they want, has a positive attitude.
21. **Reactive thinking:** waits, analyses and plans, reviews all the relevant information and considers consequences.
22. **Proactive thinking:** initiates action, gets on with things, proactive approach.
23. **Sameness thinking:** seeks stability and the familiar, prefers gradual change, notices similarities.
24. **Differences thinking:** notices what is different, seeks variety, has a high capacity & tolerance for change.
25. **Simplicity filter:** often simplifies complex issues and prefers things to be easy.
26. **Complexity filter***:* enjoys the challenge of difficulty and of complex issues.

Appendix 2

Myers-Briggs Type Indicators

Participants may be:

extroverts (try things out, focus on the outer world of people)

introverts (think things through, focus on the inner world of ideas)

sensors (practical, detail-oriented, focus on facts and procedures)

intuitors (imaginative, concept-oriented, focus on meanings and possibilities)

thinkers (sceptical, tend to make decisions based on logic and rules)

feelers (appreciative, tend to make decisions based on personal humanistic considerations)

judgers (set and follow agendas, seek closure even with incomplete data)

perceivers (adapt to changing circumstances, resist closure to obtain more data).

The MBTI type preferences can be combined to form 16 different learning style types. For example, one student may be an ESTP (extravert, sensor, thinker, perceiver), and another may be an INFJ (introvert, intuitor, feeler, judger).

Kolb's Learning Style Model. (15)

The four types of learners in this classification scheme are

Type 1 (concrete, reflective). A characteristic question of this learning type is "Why?" Type 1 learners respond well to explanations of how course material relates to their experience, their interests, and their future careers. To be effective with Type 1 students, the instructor should function as a motivator.

Type 2 (abstract, reflective). A characteristic question of this learning type is "What?" Type 2 learners respond to information presented in an organized, logical fashion and benefit if they have time for reflection. To be effective, the instructor should function as an expert.

Type 3 (abstract, active). A characteristic question of this learning type is "How?" Type 3 learners respond to having opportunities to work actively on well-defined tasks and to learn by trial-and-error in an environment that allows them to fail safely. To be effective, the instructor should function as a coach, providing guided practice and feedback.

Type 4 (concrete, active). A characteristic question of this learning type is "What if?" Type 4 learners like applying course material in new situations to solve real problems. To be effective, the instructor should stay out of the way, maximizing opportunities for the students to discover things for themselves.

Herrmann Brain Dominance Instrument (HBDI) (16)

The four modes or quadrants are:

Quadrant A (left brain, cerebral). Logical, analytical, quantitative, factual, critical;

Quadrant B (left brain, limbic). Sequential, organized, planned, detailed, structured;

Quadrant C (right brain, limbic). Emotional, interpersonal, sensory, kinaesthetic, symbolic;

Quadrant D (right brain, cerebral). Visual, holistic, innovative.

Felder-Silverman Learning Style Model.

This model classifies students as:

Sensing learners (concrete, practical, oriented toward facts and procedures)

Intuitive learners (conceptual, innovative, oriented toward theories and meanings);

Visual learners (prefer visual representations of presented material pictures, diagrams, flow charts)

Verbal learners (prefer written and spoken explanations);

Inductive learners (prefer presentations that proceed from the specific to the general)

Deductive learners (prefer presentations that go from the general to the specific);

Active learners (learn by trying things out, working with others)

Reflective learners (learn by thinking things through, working alone);

Sequential learners (linear, orderly, learn in small incremental steps)

Global learners (holistic, systems thinkers, learn in large leaps).

Honey and Mumford Learning styles Model

The model classifies students as:

Activists – Kolb – Type 1 (concrete, reflective). A characteristic question of this learning type is "Why?" Type 1 learners respond well to explanations of how course material relates to their experience, their interests, and their future careers.

Reflectors – Kolb – Type 2 (abstract, reflective). A characteristic question of this learning type is "What?" Type 2 learners respond to information presented in an organized, logical fashion and benefit if they have time for reflection.

Theorists – Kolb – Type 3 (abstract, active). A characteristic question of this learning type is "How?" Type 3 learners respond to having opportunities to work actively on well-defined tasks and to learn by trial-and-error in an environment that allows them to fail safely.

Pragmatists – Kolb – Type 4 (concrete, active). A characteristic question of this learning type is "What if?" Type 4 learners like applying course material in new situations to solve real problems.