The Influences of Design Reflection on Creative Problem Solving

Wen-Dih Yeh

National Taipei University of Technology, wyeh@ntut.edu.tw

Abstract: In the process of learning, reflection is an important mechanism which contributes to progress. The reflection course contains the significant experiences from the past to the present. In fact, the students' accumulation of design experience is highly valued in the industrial design education. In the design courses of the domestic industrial design departments, the design teams of students for practicing design projects are mostly composed of the students of the same grade. Since one's reflection is closely related with his/her experiences, will the reflection of an individual change if he/she works in a design team that the team members are with diverse experiences? The goal of the current study is to investigate the relationship between the reflection of the beginner and the existence of the expert in the same design team. In this research, the design teams which are composed of design students with various design experiences are asked to conduct a same design assignment. The video tapes recording the design process of each design team, the reflection diary and the self evaluation of the learning reflection of the beginner team members, and the sketches that the design team accomplishes for their design assignment are collected and analyzed. The impacts of the interaction of the design reflection and the design leadership on the process and the results of the creative problem solving of the design team are further compared.

Key words: Design Team, Novice, Expert, Leadership Role, Design Reflection

1. Introduction

During the learning process, reflection is an important mechanism of enhancing progress. The reflection course includes the previous and the current important experiences. In the development of industrial design learning, it is emphasized to accumulate students' design experience. According to Jonathan, Alan and Alice (2006), the course of new product development should be established on Kolb's (1984) experiential learning model in which there are four learning stages following from each other. In addition, reflection is a key link of this learning model. In Taiwan's design education, most of the design teams established in the courses of design project are built with design students of the same year, therefore the team members are at the similar design mastery level. Since one's reflection is related with his/her past experience, will one's reflection content be different if he/she is in a design team built with the members of different design experiences? If a design novice works as a team member with a design expert, what will be the reflection regarding to his/her design learning? The above issues are explored in this study.

1.1 Team and Team Heterogeneity

A team comprises a group of people linked in a common purpose (Shonk, 1982). In a team, a group of people with a full set of complementary skills required to complete a task, job, or project (Quick, 1992) Team members share authority and responsibility for self-management and are accountable for the collective performance (Guzzo, Salas & Associates, 1995). Management theory tends to advocate team heterogeneity as beneficial to firm performance (Amason et al. 2006; Bantel & Jackson 1989; Beckman et al. 2007; Ensley et al. 1998; Roure & Keeley 1990; Ruef, 2000; Wiersema & Bantel 1992; Zimmerman 2008). The team heterogeneity may be evaluated by the seniority, profession, or education background of team members (Mohammed & Angell, 2004).

1.2 Novice to Expert

The Novice to Expert Theory first proposed by Dreyfus and Dreyfus (1980) as the Dreyfus Model of Skill Acquisition. The Dreyfus brothers (1986) developed the model in which there are five levels of development from Novice to Expert. They start from the bottom rung at the Novice level and move upward through Competent, Proficient, Expertise and Mastery. Each level builds on the level before it as the learner advances from a neophyte level then gains knowledge, skills, perceptions, intuition, wisdom and most important of all, experience in their given field of practice.

Each of the five levels of skill acquisition has distinguishing behaviors and traits (Benner, 1984): (1)Novice: A novice does not know anything of the subject he/she is approaching and has to memorize its context-free features. The novice is then given rules for determining an action on the basis of these features. (2)Advanced Beginner: An advanced beginner is still dependent on rules, but as (s)he gains more experience with real life situations, (s)he begins to notice additional aspects that can be applied to related conditions. (3)Competent: the competent person grasps all the relevant rules and facts of the field and is able to bring his/her own judgment to each case. (4)Proficient: The learner progresses from the step-by-step analysis and solving of the situation to the holistic perception of the entirety of the situation. (5)Expert: An expert's collection of experienced situations is great that each specific situation immediately determine an intuitively appropriate action.

1.3 Kolb's Learning Styles

Kolb (1984) indicated that "Learning is the process whereby knowledge is created through the transformation of experience." From his learning styles model, Kolb developed his learning style inventory. According to Kolb, learning involves the acquisition of abstract concepts that can be applied flexibly in a range of situations and the drive for the development of new concepts is provided by new experiences.

Kolb (1984) theorized that four combinations of perceiving and processing determine four learning styles that make up a learning cycle. The four stage learning cycle (Figure 1) includes (1) Concrete Experience - a new experience of situation is encountered, or a reinterpretation of existing experience. (2) Reflective Observation – Reflective observation of the new experience and any inconsistencies between experience and understanding is of particular importance. (3) Abstract Conceptualization -Reflection gives rise to a new idea, or a modification of an existing abstract concept. (4) Active Experimentation - the learner applies them to the world around them to see what results.

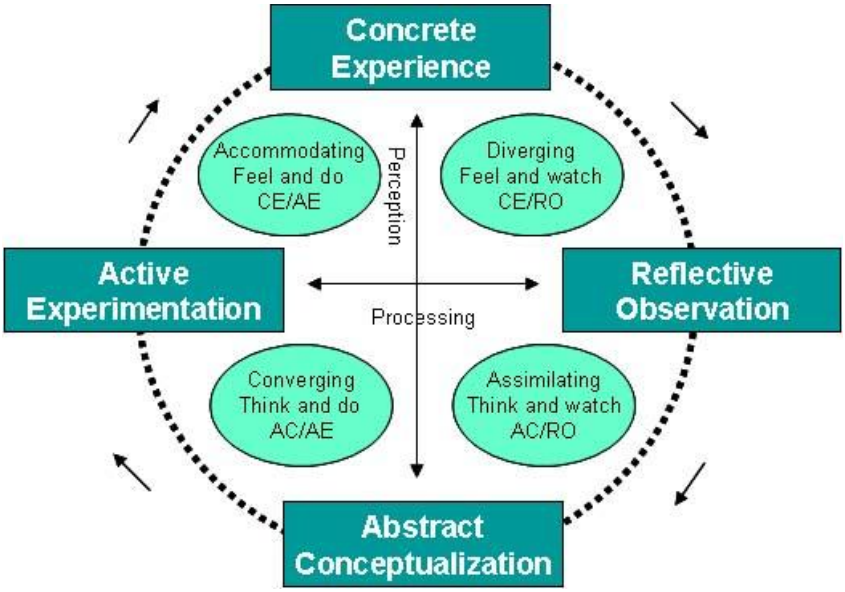

Figure 1. Kolb's Learning Styles

Kolb's learning theory (1976) sets out four distinct learning styles**,** which are based on a four-stage learning cycle: (1)Diverging (concrete, reflective) – They emphasize the innovative and imaginative approach to doing things. They are generally influenced by other people and like to receive constructive feedback. They like to learn via logical instruction or hands-one exploration with conversations that lead to discovery. (2)Assimilating (abstract, reflective) - Assimilators have the most cognitive approach, preferring to think than to act. They like to reason inductively and create models and theories. They like to design projects and experiments. (3)Converging (abstract, active)- Convergers think about things and then try out their ideas to see if they work in practice and they like decision-making, problem-solving, and the practicable application of ideas. They prefer technical problems over interpersonal issues. (4)Accommodating (concrete, active) - Accommodators have the most hands-on approach, with a strong preference for doing rather than thinking. They are good at adapting to changing circumstances; solves problems in an intuitive, trial-and-error manner, such as discovery learning. Also they tend to be at ease with people.

1.4 Reflection

Reflection is perhaps the most powerful resource that individuals possess and advancing reflective practices is of key importance. The issue of reflection in education is frequently ascribed to John Dewey (e.g., Hatton & Smith, 1995; Williams, 2001), who contended that true learning occurs only after one has been through a learning experience and then taken the time to ‘‘weave meaning among the threads of experience’’ (Rodgers, 2002). Dewey defined the phases of reflective thinking in several different models. One he states involves: (1) a state of doubt, hesitation, perplexity, mental difficulty, in which thinking originates; and (2) an act of searching, hunting, inquiring to find material that will resolve doubt, dispose of perplexity (Dewey, 1933, p. 12).

Schön (1983) advocated the concept of reflective practice as a critical process in refining one's artistry. He recommended that novices could use reflective practice as a way to recognize consonance between their own experiences and those of successful practitioners. He believed that it was the ability to reflect both during and after

an activity that distinguished the effective practitioner from less effective professionals. Shön has made the distinction between reflection-in action and reflection-on action. Reflection-in action is described as a process during learning engagement that leads to adjustments in action and reflection-on action described as reflection that happens after an act is completed.

Within the Questionnaire for Reflective Thinking , Kember *et al* (2000) have identified four constructs that cover a broad spectrum of reflective thinking. These comprise: habitual action, understanding, reflection and critical reflection. These four levels are highlighted below. (1) Habitual action — Habitual action occurs when a procedure is followed without significant thought about it. (2) Understanding — The concepts are understood as theory without being related to personal experiences or real-life applications. (3) Reflection — At this level, people not only have accurate understanding, they reflect on that understanding and are able to relate it to personal experiences, or they can make practical applications. (4) Critical reflection — This highest level of reflection implies the transformation of a perspective.

2. The Empirical Study

The aim of this study is to investigate that will the reflection of an individual change if he/she works in a design team that the team members are with diverse experiences? The goal of the current study is to investigate the relationship between the reflection of the beginner and the existence of the expert in the same design team. The type of sampling procedure used in this research is "Non Probability Sampling." Further in non-probability sampling, it is judgmental and convenience sampling. Ten teams of design students participated in this study. Each team is composed of three team members. There is one expert design student (graduate students of design, at least with three experiences of team design competition) in eight teams. And the other two teams are both composed of three novice design students (sophomore, half year learning of design, general sketch ability). Each team is asked to accomplish a three-process design task of USB Hub design: goal setting, concept proposing, and final design. During the design task which lasts for twelve days, each participant writes a reflection diary in which there are seven questions regarding the reflections on design goal, design work, design achievement, design attitude, observation of team members, feedback of team members, and self evaluation. The video tapes recording the design process of each design team, the reflection diary and the self evaluation of the learning reflection of the beginner team members, and the sketches that the design team accomplishes for their design assignment are collected and analyzed.

3. Data Analysis and the Results

3.1 Quantity of Reflection

The calculation of the quantity of reflection is based on the data collected from the video tapes and reflection diary. Each verbal or written sentence is count as one. The quantity of reflection at the time point of "reflection in action" is 71.57 for the experiment team, and 55.67 for the control team (Table 1). The quantity of reflection at the time point of "reflection on action" is 23.67 for the experiment team, and 23.86 for the control team (Table 1). The quantity of reflection at the time point of "goal setting", "concept proposing", and "final design" is respectively 36.43, 23.57, and 35.43 for the experiment team and 26.5, 13, and 36.5 for the control team (Table 2). Regarding the quantity of reflection of the seven reflection items of design goal, design work, design achievement, design

attitude, observation of team members, feedback of team members, and self evaluation is respectively 29.07, 46.71, 7.29, 1.07, 20.43, 23.43, 0.36 for the experiment team and 12.17, 27.67, 1.33, 0.67, 7.33, 6.50, 0.00 for the control team (Table 3). It is found the quantity of reflection of the experiment team is higher than the control team in almost every comparison. The results of t-test indicate that the experiment team has significantly higher quantity of reflection on "team member feedback" ($t=-3.03$, $p<0.05$) and "self evaluation" ($t=-3.87$, $p<0.05$).

Table 1 Reflection Quantity of the Two Reflection Time

Time	Group	Average
Reflection in Action	Control Team	55.67
	Experiment Team	71.57
Reflection on Action	Control Team	23.67
	Experiment Team	23.86

Table 2 Reflection Quantity of the Three Design Stages

Design Stage	Group	Average
Goal Setting	Control Team	26.50
	Experiment Team	36.43
Concept Proposing	Control Team	13.00
	Experiment Team	23.57
Final Design	Control Team	36.50
	Experiment Team	35.43

Table 3 Reflection Quantity of the Seven Reflection Items

Reflection Item	Group	Average
Design Goal	Control Team	12.17
	Experiment Team	29.07
Design Work	Control Team	27.67
	Experiment Team	46.71
Design Achievement	Control Team	1.33
	Experiment Team	7.29
Design Attitude	Control Team	0.67
	Experiment Team	1.07
Observation of Team Members	Control Team	7.33
	Experiment Team	20.43
Feedback of Team Members	Control Team	6.50
	Experiment Team	23.43
Self Evaluation	Control Team	0.00
	Experiment Team	0.36

3.2 Level of Reflection

While analyzing the level of reflection, it is found that it is very difficult to distinguish the reflection level of "habitual action" and "understanding" by the data collected from video recorded during "reflection in action." Therefore, the data collected at the problem stage is used for the coding of the reflection level and it is basically based on the data collected by the reflection diary.

The emergence number of reflection level at the three design stages is described in Table 4. It is found that for both the experiment group and the control group, the emergence number of the "understanding" level is the highest. Regarding the emergence number of reflection level for the seven reflection items is described in Table 5.

Table 4 Reflection Level of the Three Design Stages

Design Stage	Group	Emergence Number			Sorting
		Understanding (U)	Reflection (R)	Critical Reflection (CR)	
Goal Setting	Control Team	4.67	2.83	0.33	U>R>CR
	Experiment Team	7.43	4.29	0.29	U>R>CR
Concept Proposing	Control Team	4.67	3.17	0.33	U>R>CR
	Experiment Team	8.5	2.86	0.14	U>R>CR
Final Design	Control Team	5.5	2.5	0	U>R>CR
	Experiment Team	9	2.64	0	U>R>CR

Table 5 Reflection Level of the Seven Reflection Items

Reflection Item	Group	Emergence Number			Sorting
		Understanding (U)	Reflection (R)	Critical Reflection (CR)	
Design Goal	Control Team	6.33	2.33	0	U>R>CR
	Experiment Team	19.33	4.67	0	U>R>CR
Design Work	Control Team	2.67	3.67	0	R>U>CR
	Experiment Team	5	4.33	0	U>R>CR
Design Achievement	Control Team	7.33	2	0	U>R>CR
	Experiment Team	9.67	2	0	U>R>CR
Design Attitude	Control Team	2.33	1.67	0.67	U>R>CR
	Experiment Team	4.67	4	0	U>R>CR
Observation of Team Members	Control Team	5	5.33	0	R>U>CR
	Experiment Team	29.67	5.67	0.33	U>R>CR
Feedback of Team Members	Control Team	2.67	1	0	U>R>CR
	Experiment Team	2.67	1.33	0	U>R>CR
Self Evaluation	Control Team	1.67	0.33	0.33	U>R=CR
	Experiment Team	12.00	5.67	1.67	U>R>CR

It is found that for both the experiment group and the control group, the emergence number of the "understanding" level is the highest for all of the reflection items except the items of "design work" and "feedback of team members" for the control team. In addition, there are emergences of the "critical reflection" for the control team on the item of "design attitude" and "self evaluation," and for the experiment team on the item of "observing team members" and "self evaluation."

3.3 Design Results of the Design Task

Three design experts are invited to evaluate the teams' design results of the design task (Figure 2-Figure10). The evaluation criteria are "aesthetics," "creativity," and "fulfillment of the design requirement." The evaluation scores are shown in Table 6. The results of t-test indicate that the two groups are not significantly different on all the seven evaluation criteria.

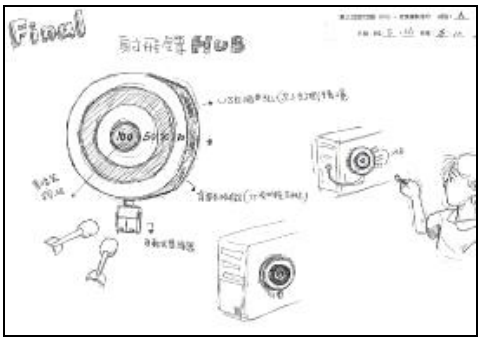

Figure 2 The Design Result of the Control Team A

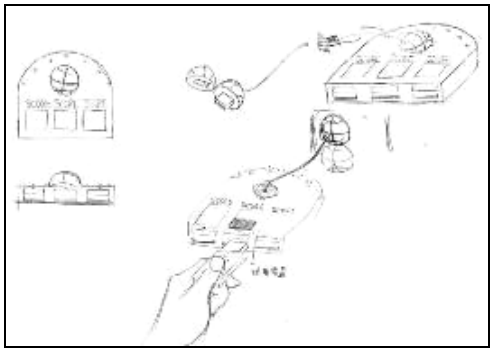

Figure 3 The Design Result of the Control Team B

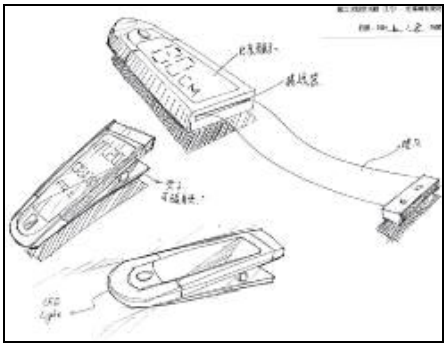

Figure 4 The Design Result of the Experiment Team C

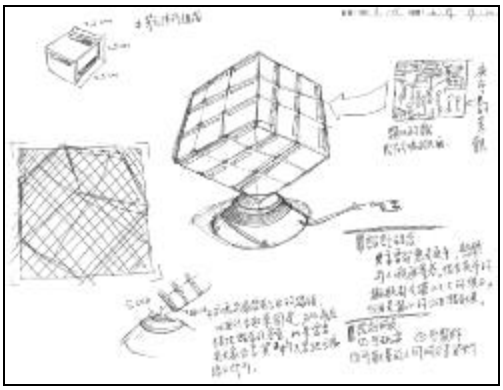

Figure 5 The Design Result of the Experiment Team D

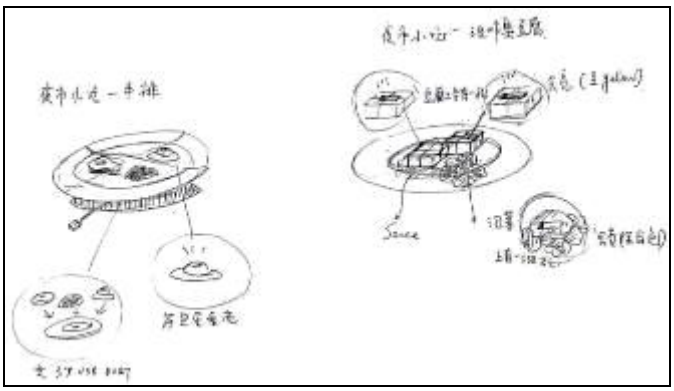

Figure 6 The Design Result of the Experiment Team E

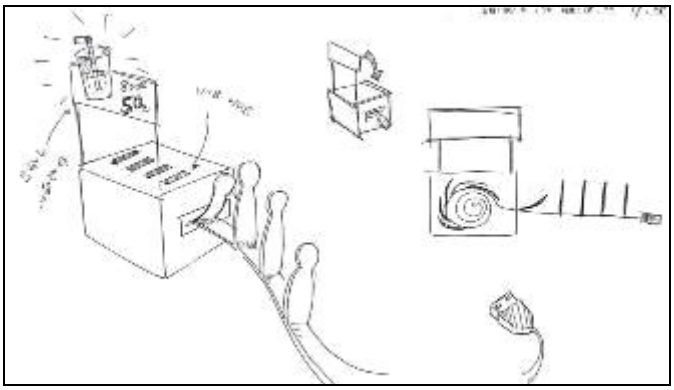

Figure 7 The Design Result of the Experiment Team F

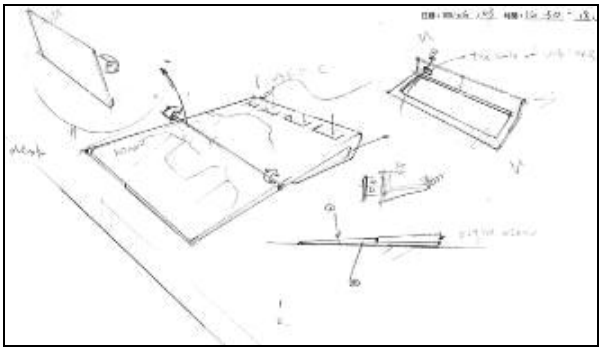

Figure 8 The Design Result of the Experiment Team G

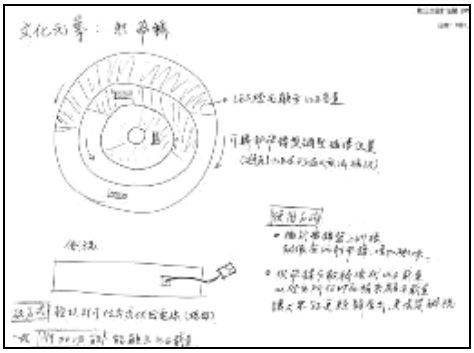

Figure 9 The Design Result of the Experiment Team H

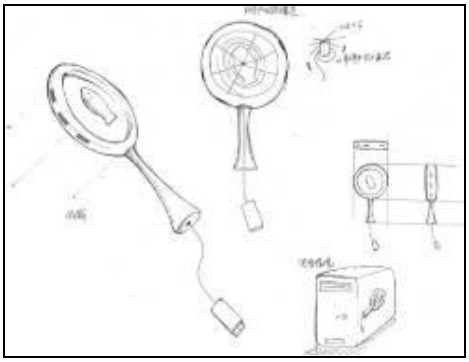

Figure 10 The Design Result of the Experiment Team I

Table 6 Evaluation of the Design Results of the Design Task

Evaluation Criteria		Groups									
		The Control Team	The Experiment Team								
		A	B	C	D	E	F	G	H	I	J
Aesthetics		4.67	4.33	3.33	5.33	4.33	6.00	4.00	4.67	6.00	4.33
Creativity		6.00	6.00	4.67	6.33	5.33	6.67	4.67	5.00	6.67	4.67
Design Requirement	Night market element	4.67	4.67	2.67	5.33	7.00	6.33	3.00	4.67	7.00	5.00
	Storage	4.67	4.67	4.33	4.67	2.00	5.67	4.67	5.00	5.67	4.33
	Small Size	3.00	4.00	2.00	3.00	3.33	5.00	3.33	3.33	3.67	2.67
	Use	4.67	5.00	3.67	4.33	3.00	5.67	5.33	5.33	5.00	4.00
	Establishment	4.00	4.33	5.00	4.33	2.33	4.00	4.33	4.33	5.33	3.67
Average		4.53	4.71	3.67	4.76	3.90	5.62	4.19	4.62	5.62	4.17
Group Average		4.62					4.57				

4. Conclusion

Since one's reflection is closely related with his/her experiences, this study investigate that will the reflection of an individual change if he/she works in a design team that the team members are with diverse experiences? The goal of the current study is to investigate the relationship between the reflection of the beginner and the existence

of the expert in the same design team. It is found that (1) Regarding the quantity of reflection, the number of the experiment team id higher than the control teams in all the comparisons of the reflection time (reflection-in-action, reflection-on-action), the design stage (goal setting, concept proposing, final design), and the reflection items (design goal, design work, design achievement, design attitude, observation of team members, feedback of team members, and self evaluation); (2) Regarding the level of reflection, both team groups' reflection are mostly at the "understanding" level. The reflection level distribution of the control group is "understanding" 60%, "reflection" 35%, and "critical reflection" 3%. The reflection level distribution of the experiment group is "understanding" 71%, "reflection" 28%, and "critical reflection" 1%. It seems that the existence of the expert in the design team may make the novice team member "understand" more but "critically reflective think" less. (3)Regarding the evaluation of the design results of the design teams, it is found that the score of the control group (4.62) is slightly higher than the experiment group (4.57) but they are not significantly different. It is observed that the interaction between the expert team member and the novice team members are quite different among the experiment group. It is suggested that the future research may consider to investigate the impact of the leadership style of the expert member on the reflection of novice team members.

5. Acknowledgement

This study received financial support from the National Science Council of the Republic of China, under Grant No. NSC 99-2410-H-027-012.

5. References

[1] Amason, A., R.C. Shrader and G.H. Tompson (2006), Newness and novelty: relating top management team composition to new venture performance, Journal of Business Venturing 21, 125– 148.

[2] Bantel, K.A. and S.E. Jackson (1989), Top management and innovations in banking: does the composition of the top team make a difference?, Strategic Management Journal 10, 107–124.

[3] Beckman, C.M., D. Burton and C. O'Reilly (2007), Early teams: The impact of team demography on VC financing and going public, Journal of Business Venturing 22, 147–173.

[4] Benner, P. (1984). *From novice to expert: Excellence and power in clinical nursing.* Menlo Park, CA: Addison-Wesley.

[5] Dewey, J. (1933). *How we think.* New York: Houghton Mifflin.

[6] Dreyfus, H. & Dreyfus, S. (1980). *A Five-Stage Model of the mental activities involved in direct skill acquisition.* Operations Research Center Report. University of California, Berkeley.

[7] Dreyfus, H. & Dreyfus, S. (1986). *Mind over machine: the power of human intuition and expertise in the age of the computer*. Oxford: Basil and Blackwell.

[8] Ensley, M.D., J.W. Carland and J.C. Carland (1998), The effect of entrepreneurial team skill heterogeneity and functional diversity on new venture performance, Journal of Business and Entrepreneurship 10(1),1-14.

[9] Guzzo, R. A., Salas, E. & Associates (1995), *Team Eeffectiveness and Decision Making in Organizations*, Jossey-Bass, San Francisco.

[10] Hatton, N., & Smith, D. (1995). Reflection in teacher education: Towards definition and implementation. Teaching and Teacher Education, 11(1), 33–49.

[11] Jonathan, H. H., Alan, P. V. P. & Alice, M. A. (2006). Analysis of Student Reflections from a Multidisciplinary New Product Development Class. *International Design Engineering Technical Conferences & Computers and Information in Engineering Conference*, pp 10-13.

[12] KEMBER, D., LEUNG, D., JONES, A. & LOKE, A. Y. (2000) Development of a Questionnaire to measure the Level of Reflective Thinking. *Assessment and Evaluation in Higher Education,* 25**,** 380-395.

[13] Kolb, D. A. (1976). *Learning Style technical manual.* Boston: Mcber and Company.

[14] Kolb, D. A. (1984). *Experiential learning: Experience as the source of Learning and Development,* Englewood Cliffs, Prentice-Hall, New Jersy.

[15] Mohammed S., & Angell L. C. (2004). Surface- and deep-level diversity in workgroup: Examining the moderating effects of team orientation and team process on relationship conflict. *Journal of Organizational Behavior*. 25(8), 1015-1039.

[16] Quick, T. L. (1992). *Successful Team Building.* American Management Association, New York.

[17] Schön, D. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

[18] Shonk, H. (1982). *Working in Teams: A Practical Manual for Improving Work Groups,* New York: AMACPM.

[19] Rodgers, C. (2002). Defining reflection: Another look at John Dewey and reflective thinking. Teachers College Record, 104(4), 842–866.

[20] Roure, J.B. and R.H. Keeley (1990), Predictors of success in new technology based ventures, Journal of Business Venturing 5, 201-220.

[21] Ruef, M. (2000), Strong ties, weak ties and islands: structural and cultural predictors of organizational innovation, Industrial and Corporate Change 11(3), 427-449.

[22] Wiersema, M.F. and K.A. Bantel (1992), Top management team demography and corporate strategic change, Academy of Management Journal 35, 91–121.

[23] Williams, B. (2001). Developing critical reflection for professional practice through problem-based learning. Journal of Advanced Nursing, 34(1), 27–34.

[24] Zimmerman, M.A. (2008), The Influence of Top Management Team Heterogeneity on the Capital Raised through an Initial Public Offering, Entrepreneurship Theory & Practice, 1042-2587.