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Comparison Between Characteristics of Creativity in Physics Practical Work and Physics Innovative Project Among Pre-service Physics Teacher

Lilia Ellany Mohtar[a*], Fatin Aliah Phang[a]

[a]*Department of Educational Science, Mathematics and Multimedia Creative, Faculty of Education UTM*

*Corresponding author: lilia@utm.my

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Abstract

This research is intended to study the characteristics of creativity in two practical-based physics learning activities which are physics practical work (PPW) and physics innovative project (PIP) among pre-service physics teacher at Universiti Teknologi Malaysia (UTM). The study was conducted in one semester among 12 physics education undergraduates from the Faculty of Education, UTM. Two sets of survey questionnaires were used to collect data on characteristics of creativity in PPW and PIP respectively and the data was analyzed using descriptive analysis. The result of the study shows that six characteristics of creativity are highlighted more when the pre-service physics teachers performed PIP except openness which are the same in both activities. Based on the findings, it is found that activities like inquiry based learning such as PIP can encourage more characteristics of creativity compared to PPW that is guided by manual books. Therefore, it is suggested that activities like PIP should be delivered to the pre-service teachers as one of the exercises to generate creative teachers.

Keywords: Creativity; pre-service physics teachers; physics practical work; physics innovative project

Abstrak

Kajian ini bertujuan mengkaji perbandingan ciri kreativiti dalam dua aktiviti pembelajaran fizik berasaskan kerja amali iaitu dalam latihan amali fizik (PPW) dan projek inovasi fizik (PIW) dikalangan bakal guru fizik di Universiti Teknologi Malaysia (UTM). Kajian telah dijalankan selama satu semester dikalangan 12 orang pelajar Sarjana Muda Penidikan Fizik daripada fakulti pendidikan, UTM. Kaedah pengumpulan data yang digunakan adalah kaedah tinjauan iaitu dengan menggunakan dua set soal selidik sebagai alat kajian. Data daripada jawapan soal selidik dianalisis secara deskriptif. Keputusan kajian menunjukkan, enam ciri kreativiti didapati lebih cenderung ditonjolkan semasa bakal guru fizik menjalankan PIW kecuali ciri keterbukaan yang menunjukkan keseimbangan antara kedua-dua aktiviti. Berdasarkan dapatan kajian, didapati bahawa aktiviti yang berbentuk inkuiri penemuan seperti PIW lebih dapat menggalakkan ciri kreativiti berbanding PPW yang berpandukan buku manual. Oleh itu, dicadangkan agar aktiviti seperti PIW diberikan kepada bakal guru sebagai salah satu latihan untuk menghasilkan guru yang kreatif.

Kata kunci: Kreativiti; bakal guru fizik; latihan amali fizik; projek inovasi fizik

1.0 INTRODUCTION

Torrance (1970) stated that creativity is an element that can be developed through the teaching and learning process. This reinforces the fact that the teachers take great responsibility to train their students to practice creativity. If teachers failed to instill creativity among the students, the desire to produce creative and innovative talent will not be achieved. Creativity can be nurtured in an active environment of teaching and learning. Active learning generally refers to any method of teaching that involves students in the learning process (Prince, 2004). According to Haigh (2007), active learning can be practiced by conducting laboratory activities and it is a compulsory learning activity in science subjects, including physics. Normally, laboratory activities that are carried out are like doing experiment, hands-on activities and project-based learning such as designing and innovative projects (Hong & Kang, 2009).

Active learning such as PPW that is said to foster creativity also raised a lot of criticisms because of its *'recipe book'* (Vidal, 2010). However, it is believed that students can improve their thinking and experimenting skills if they are given the opportunity to experience and learning new disciplines (Vidal, 2010). The method gives students the opportunity to fully use their mind's ability to leave the conventional learning practices including to follow the instruction of *'recipe'* in the textbook. If the experiment or practical work can not help in generating creativity among the students, then science projects such as PIP is expected to provide that opportunities to the students. Furthermore, innovative projects

are more rational if the educational system desired to produce workforces that are capable to have excellence skills exspecially in experimenting process (Forest & Faucheux, 2011). This is because students are more likely to generate a lot of ideas, new ideas, new paradigms and new learning culture (Forest &Faucheux, 2011). With this approach, students are expected to be able to show their creative behaviors (Hong & Kang, 2009).

Creative behavior can be seen through creative features highlighted by a person. There are many characteristics of creativity that can demonstrate a creative personality. Even though not all of the characteristics of creativity can be owned by an individual, what is certain, creativity is a potential and ability that can be highlighted (Bryon, 2009) especially in an encouraging environment. Among the characteristics of creativity that often being studied and considered dominant in the study of creativity are like divergent thinking, problem solving, imagination, uniqueness, openness, curiosity and confidence (Treffinger, 1992; Cropley, 2001; Cheng, 2004; Sriraman, 2004; Aboukinane, 2007: Hong and Kang, 2009; Pedersen & Burton, 2009).

2.0 OBJECTIVE OF THE STUDY

The objective of the study is to identify the differences of characteristics of creativity that are highlighted by pre-service physics teacher in PPW and PIP. It is known that PPW and PIP are active learning activities that can instill creativity among pre-service physics teachers but the effectiveness is being argued. Thus, a study is conducted to identify the comparison of characteristics of creativity that are exposed by the pre-service physics teachers in Faculty of Education, UTM while performing these two physics learning activities. This study allows the researchers to discover how these physics learning activities that are based on practical work can foster creativity among the pre-service physics teachers through seven characteristics of creativity as mentioned earlier.

3.0 METHODOLOGY OF THE STUDY

A survey research method was employed in this study by using two sets of questionnaire. The respondents involved are third year students in the program of Bachelor of Science and Computer with Education (Physics) at Faculty of Education, UTM. All of the students in this program are the subjects of the study which are five males and seven females.

This study involved two physics learning activities that are conducted in the course of Physics Practical Work II (SPN 3231) as the medium for data collection. In this course, the respondents performed two learning phases which are PPW selected by the lecturers based on Form Five KBSM Physics practical textbook, and PIP. For the PPW, the pre-service physics teachers conducted six experiments in accordance with the manual instructions outlined in the Form Five Physics textbook, while PIP, the teachers performed to produce an innovative eksperimen which mean the other way to do the experiment that can achieve the same objective as in the textbook.

4.0 RESEARCH INSTRUMENT

There are two sets of questionnaire which have been constructed for the purpose if this study, namely Questionnaire of Creativity in PPW which is to identify the characteristics of creativity in PPW and Questionnaire of Creativity in PIP to identify the characteristics of creativity in PIP. The two sets of questionnaire were distributed to all 12 respondents at two different occasions. The first was after the respondents performed the PPW and the second was after the respondents completed the PIP. Each questionnaire consists of two sections which are Part A and Part B. Part A requires the respondents to fill in their name while Part B consist 29 items related to the characteristics of creativity. The name of respondents in each questionnaire is only intended as labelling but for the analysis purpose and reporting the findings, all names were labeled with specific codes.

(i) Part A: Background of the Respondent

This section requires respondent to fill in their name. Names in each questionnaire is only intended to facilitate the researchers to identify the owner of the questionnaire responses. For the purpose of findings analysis and report, the names will be labelled by using specified codes.

(ii) Part B: Characteristics of Creativity

In this section, there are 29 items related to the characteristics of creativity which is being studied. All of the items in the questionnaire form have been set up by the researcher himself by adapting questions from previous studies (Foursight Consulting Group, 2004; Sriraman, 2004; Hamza & Griffith, 2006; Aboukinane, 2007; Pedersen & Burton, 2009; Nor Fadila & Mohd Fairul, 2010; Rabari *et al.*, 2011a). The items are prepared together with the five scales option or Likert scale. Likert scales that are used are strongly disagree, disagree, neutral, agree and strongly agree

5.0 DATA ANALYSIS

The data from the survey was analyzed using descriptive analysis and presented as frequencies and percentages. The distributions of the respondents' answers for each item were totalled-up and divided into two categories of responses which are (1) negative feedback; and (2) positive feeback. The negative feedback consists of respondents' answers that opted for Strongly Disagree, Disagree and Neutral while positive feeback consists of respondents' answers that opted for Agree and Strongly Agree. This categorization is made based on data analysis conducted by Aboukinane (2007) in his PhD thesis which also reviews the characteristics of creativity among students at Texas University. The comparison between the characteristics of creativity in PPW and PIP among the pre-service physics teachers was being made based on the average percentage of the positive feeback of the respondents.

6.0 RESULT OF THE STUDY

Table 1 shows the comparison between percentage of positive feeback from Questionnaire of Creativity in PPW and percentage of positive feeback from Questionnaire of Creativity in PIP for each item. It showed that the percentage of positive feeback from the respondents is more favourable to PIP where out of 29 items in the questionnaire form, there are two items that show the percentage of positive feeback for PPW is higher than PIP which are from openness characteristics. In other hand, four items show the percentage of positive feeback is similar for both activities which is one item from imagination, one item from openness and two items from confidence characteristic.

In order to show the differences between the seven characteristics of creativity in PPW and PIP, all items have been grouped according to their characteristics and the average

percentage of positive feeback was calculated for each characteristics. Table 2 shows the average percentage of positive feeback for characteristics of creativity in both PPW and PIP.

Based on Table 2, it is found that the average percentage of positive feeback by the respondents is more prevalent on the characteristics of creativity in PIP. This is proven when six out of seven characteristics of creativity for PIP which are divergent thinking, problem solving, imagination, uniqueness, curiosity and confidence showed the average percentage of positive feeback is higher than average percentage of positive feeback for PPW. Openness characteristic in PIP is equal to the average percentage of positive feeback with PPW. From the value of average percentage for both PPW and PIP, it is found that divergent thinking showed the highest average percentage difference which is 50.1% followed by problem solving and curiousity with difference value of 33.3%. Average percentage difference for unique is 20%, followed by imagination (14.6%) and 12.7% for confidence. Openness does not show any difference and this show that there is a balance of openness highlighted by respondents while performing PPW and PIP. The average value of this difference also shows that divergent thinking is a characteristic of creativity that was highlighted the most during PIP than PPW.

Table 1 Comparison of positive feeback for characteristics of creativity in PPW and PIP

Code of Question	Characteristics of Creativity	% of Positive Feedback By the Respondent	
		PPW	PIP
PD1	Divergent Thinking	58.3	100
PD2	Divergent Thinking	58.3	100
PD3	Divergent Thinking	25	91.7
PD4	Divergent Thinking	41.7	91.7
MM1	Problem Solving	50	91.7
MM2	Problem Solving	33.3	83.3
MM3	Problem Solving	58.3	91.7
MM4	Problem Solving	75	83.3
I1	Imagination	58.3	91.7
I2	Imagination	75	83.3
I3	Imagination	58.3	75
I4	Imagination	58.3	58.3
U1	Uniqueness	41.7	50
U2	Uniqueness	58.3	91.7
U3	Uniqueness	50	75
U4	Uniqueness	66.7	75
U5	Uniqueness	50	75
RIT1	Curiosity	50	91.7
RIT2	Curiosity	50	91.7
RIT3	Curiosity	66.7	91.7
RIT4	Curiosity	66.7	91.7
B1	Openness	66.7	91.7
B2	Openness	100	91.7
B3	Openness	100	100
B4	Openness	100	83.3
Y1	Confidence	58.3	58.3
Y2	Confidence	41.7	58.3
Y3	Confidence	58.3	91.7
Y4	Confidence	58.3	58.3

Table 2 Average percentage and differences of positive feeback for characteristics of creativity in PPW and PIP

Characteristics of Creativity	Average % of Positive Feedback by the Respondent		
	PPW	PIP	Differences
Divergent Thinking	45.8	95.9	50.1
Problem Solving	54.2	87.5	33.3
Imagination	62.5	77.1	14.6
Uniqueness	53.3	73.3	20.0
Curiosity	58.4	91.7	33.3
Openness	91.7	91.7	0.0
Confidence	54.2	66.7	12.7

7.0 DISCUSSION

The average percentage of positive feeback shows that divergent thinking is the most significant difference characteristic between PIP and PPW. It is shows that the majority of the pre-service physics teachers generated more ideas while performing works in PIP than in PPW. This is in line with the findings of Cheng (2004) which has proven that divergent thinking was the most highlighted characteristic by the pre-service physics teachers as compared to other characteristics of creativity. This was due to challenging works and requirement to produce something innovative. Rabari *et al*. (2011a) have found that divergent thinking showed significant correlation with the creative behaviour and critical thinking. This is to more ideas would be generated through challenging activities (Rabari *et al*., 2011a).

The characteristics of problem-solving and curiosity also show a margin of difference between the two practical activities. The participation of students during the learning process is a great way to foster students' creativity through education because they are able to stimulate their thinking, especially during problem solving (Fasko, 2001). The PIP and PPW may foster problem solving because the learning activities require the pre-service teachers to work with problems. However, based on the obtained result, it shows that PIP may foster more problem solving characteristic than PPW. This indicates that the pre-service teachers are successfully produced the innovative experiment in PIP and gave them apportunity to solve the problem compared to PPW.

Curiosity in PIP is more prevalent than PPW among the pre-service teachers. These findings are consistent with the findings of Wood (2006) who has found that students were more interested in open-ended experiment because they were able to deal with real problems and had an opportunity to solve problems by using their own ideas. PIP is an experimental activity that is open in nature which give freedom for student to produce innovative products. This causes the pre-service teachers to show more curiosity while performing PIP than PPW due to the fact that they can plan and implement the plan with no limit. In addition, PIP demands the pre-service teachers to improve the existing experiments. This is supported by Latumahina (2010) who claimed that without curiosity, a person could not and there would be no way to make things better.

Uniqueness is the most difficult characteristic to be demonstrated by an individual because it requires high-skill and knowledge. However, the findings of this study show that uniqueness is possessed by the pre-service physics teachers while performing both practical-based physics learning activities. Based on the average percentage of positive feeback, uniqueness is more prevalent in PIP as compared to PPW. During PIP, the pre-service teachers are assigned to produce an innovative product. Therefore, it is possible for the teachers to come up with something that meets the uniqueness. Uniqueness is not producing something that has never been created before but it can be produced by a combination of new ideas or connecting one existing idea with another idea (Byron, 2009). Moreover, PIP do not have a manual book for reference. Torrance (1970) has defined uniqueness as an extraordinary characteristic and out of normal thought. The absence of the manual book allows the pre-service teachers challende themselve. In addition, the pre-service teachers were trying to get the best results of innovation as it will be evaluated by the lecturers. This situation also contributes to the uniqueness. According to Villalba (2008), something that has been found by someone with their own efforts was considered unique.

The percentage of positive feeback for imagination also is in favor with PIP eventhough the difference is (14.6%). The study found that more pre-service physics teachers were applying imagination when performing PIP than PPW. Based on the analysis of item 9 in the survey question, 91.7% of the pre-service teachers have stated that they used imagination while completing PIP as compared to 58.3% of the pre-service teachers who used imagination during performing PPW. These differences prove that PIP gives rise to the pre-service teachers to use more of their imagination in performing their work. This finding is in line with the statement of Sefertzi (2002) who has stated that imagination was not purposely expected to produce variety of ideas but it was an important mean to be creative. This finding is sufficient to prove that the PIP will encourage the pre-service teachers to be creative.

The difference in the percentage value of positive feeback for confidence in PIP and PPW is small (12.7%) which is in favor of PIP. This finding indicates that the PIP has succeeded to foster positive attitudes like dare to take risk, capable to produce something on their own, dare to express and manipulate ideas and confident with every action taken. This is in line with studies done by Aboukinane (2007) who has suggested that confident person was an individual with ability to face any eventuality and criticism, self-reliant, hold independent thinking, and knowing their self-direction.

The potential of openness among the pre-service physics teachers do not show any differences either in PPW or PIP. According to Jolly (2009), an active learning integrated the use of various sources to provide experiences that involved hands-on and minds-on activities. Although PIP are more challenging and require critical thinking, its knowledge and experience acceptance is similar with PPW. The findings show that the difference in terms of implementation and pressure in different tasks does not affect maturation of the pre-service teachers to carry out their work in innovation projects and practical work (Aboukinane, 2007). Pre-service teachers prove that they do not have problem to accept and give opinions, ideas and criticism even willing to accept a challenge as new knowledge and experience. This is in line with the statement of Dacey (1985) and Aboukinane (2007) in which openness refers to the individual's flexibility which is not awkward in accepting comments, opinions, ideas and new experiences and knowledge. Moreover, the openness that is balance between physics practical work and innovation projects may also be caused by the factors of teamwork where both activities in this study are conducted in groups of two people in each group. According to Aboukinane (2007), work in groups can help to generate more ideas and students can interact and share ideas with each other while working in groups. Students were also seen to spend time to listen to other people, demonstrate mature behaviour and not make decisions in a hurry and this is an openness attitude of an individual.

Based on the discussion above, PIP has proven to be a good example of the active learning of physics that can foster creative culture. Hong and Kang (2009) have supported that project-based learning can encourage creativity among students. PIP will promote the pre-service physics teachers to enhance their characteristics of creativity. This is supported by Forest and Faucheux (2011) who have suggested that innovative project was more relevant activity if the educational system desired to generate capable workforces that possess excellent thinking skills and experimenting process. This is because the students are more likely to produce a lot of new ideas, new paradigms and new learning culture (Forest & Faucheux, 2011). Furthermore, the more challenging innovative projects put into practice, the more forces will be applied for the teachers to be creatively compete, consequently gives positive impact to inculcate creativity (Torrance, 1970).

Characteristics of creativity in PPW can still be demonstrated by the pre-service teachers but the numbers are less than PIP. There is no doubt that the PPW is considered as an important component in teaching and learning physics either in schools or universities (Sneddon *et al*., 2009). However, it is certainly raises a lot of criticism as the PPW is said to be a *'recipe book'* (Abu Hasan Husin, 2004). According to a study conducted by Haryanti (2009), the learning process that entirely dependent on textbooks might result a 'dry idea' among students. They were incapable to build something new and hard to explore the nature (Haryanti, 2009). Thus, manual book is considered to be the factor that cause the characteristics of creativity are hard to be demonstrated by the teacher in PPW.

■8.0 RECOMMENDATIONS

Practical work has raised a lot of criticism because of *'recipe book'* and being argued because of its less effective to foster creativity among the pre-service teachers eventhough it is known as one of active learning activities (Shaharudin Ali, 2007; Vidal, 2010). Based on the results, PIP are proven to be able to demonstrate the characteristics of creativity among pre-service physics teachers in UTM as compared to PPW. Therefore it is suggested that pre-service physics teachers should be trained with inquiry-based learning like PIP than activities through *'recipe book'* like PPW.

■9.0 CONCLUSION

The result of the study shows that six out of seven characteristics of creativity which are divergent thinking, problem solving, uniqueness, imagination, curiosity and confidence are in PIP than PPW. Briefly, the results of the study indicates that PIP has successfully fostering characteristics of creativity among pre-service physics teacher. This shows that learning environment involving mind-challenging tasks like PIP is more suitable to be conducted if the learning objective desires to encourage creativity.

References

Aboukinane, C. 2007. *A Qualitative Study of Creative Thinking Using Experiential*. Doctor Philosophy, Texas A&M University.

Abu Hassan Husin. 2004. *Status Makmal dan Pelaksanaan Amali Fizik Di Sekolah-Sekolah Daerah Kuala Pilah, Jelebu dan Jempol (KPJJ)*. Research Project Report, Universiti Teknologi Mara.

Byron, K. 2009. *The Creative Researcher*. United Kingdom: Careers Research and Advisory Centre (CRAC) Limited.

Cheng, V. M. Y. 2004. Developing Physics Learning Activities for Fostering Student Creativity in Hong Kong. *Asia-Pacific Forum on Science Learning and Teaching*. 5(2): 1–15.

Cropley, D. & Cropley, A. 2010. Recognizing and Fostering Creativity in Technological Design Education. *International Journal Technology Design Education*. 20(1): 345–335.

Dacey, S. J. 1985. *Fundamentals of Creative Thinking.* San Francisco: Jossey-Bass.

DeHaan, R. L. 2009. Teaching Creativity and Inventive Problem Solving in Science. *CBE Life Science Education.* 8(3): 172–181.

Fasko, D. J. 2001. Education and Creativity. *Creativity Research Journal.* 13(3): 317–327.

Forest, J. & Faucheux, M., 2011. Stimulating Creative Rationality to Stimulate Innovation. *Creativity and Innovation Management.* 20(3): 207–212.

Foursight Consulting Group Inc., 2004. How Would You Rate Your Creativity? Retrieved on Sepember 12, 2011 from http://www.foursightconsulting.com.

Haigh, M. 2007. Can Investigative Practical Work in High School Biology Foster Creativity? *Research in Science Education*. 37(2): 123–140.

Hamza, M. K. & Griffith K. G. 2006. Fostering Problem Solving & Creative Thinking in the Classroom: Cultivating A Creative Mind! *National Forum of Applied Educational Research Journal-Electronic*. 19(3): 1–30.

Hanif, M. Sneddon, P.H., Al-Ahmadi, F. M. & Reid, N., 2009. The Perceptions, Views nd Opinions of University Students about Physics Learning During Undergraduate Laboratory Work. *European Journal of Physics*. 30(1): 85–96.

Haryanti Mohd Affandi. 2009. *Ketekunan, Kreativiti dan Inovasi Di KalanganPelajar UTHM.* Master, Universiti Teknologi Malaysia.

Hong, M. & Kang, N. H., 2009. South Korean and the US Secondary School Science Teachers' Conceptions of Creativity and Teaching for Creativiti. *International Journal of Science and Mathematics Education.* 8(1): 821–843.

Jolly, P. 2009. Research and Innovation in Physics Education: Transforming Classrooms, Teaching, and Student Learning at the Tertiary Level. *The 3rd IUPAP International Conference on Women in Physics*. 1119(1): 52–58.

Latumahina, D. 2010. *4 Reasons Why Curiosity is Important and How to Develop It*. Retrieved on November 13, 2011 from http://www.lifehack.org/articles/ productivity/4-reasons-why-curiosity-is-important-and-how-to develop-it.html.

Nor Fadila Mohd Amin & Nik Mohd Amir Nik Abd Aziz. 2010. *Faktor Yang Mempengaruhi Kreativiti Pelajar Tingkatan 4 Dalam Mata Pelajaran Reka Cipta*. Research Project Report, Universiti Teknologi Malaysia.

Nor Fadila Mohd Amin & Mohd Fairul Mohamad Nawawi. 2010. *Amalan Penyelesaian Masalah Secara Kreatif Di Dalam Mata Pelajaran Reka Cipta Di Kalangan Pelajar SPH*. Research Report, Universiti Teknologi Malaysia.

Norhidayah Mohamad. 2006. *Amalan Dan Prestasi Dalam Perolehan Elektronik.* Master, Universiti Teknologi Malaysia.

Pedersen, E. L. & Burton, K. L. 2009. A Concept Analysis of Creativity: Uses of Creativity in Selected Design Journals. *Journal of Interior Design.* 35(1): 15–33.

Prince, M. 2004. Does Active Learning Work? A Review of the Research. *Journal of Engineering Education*. 93(3): 223–231.

Rabari, J. A., Indoshi, F. C. & Omusonga, T. O. 2011a. Correlates of Divergent Thinking Among Secondary School Physics Students. *International Research Journals*. 2(3): 982–996.

Rabari, J. A., Indoshi, F. C. & Okwach, T. 2011b. Differences in Divergent Thinking among Secondary School Physics Students *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS).* 2(4): 216–227.

Roisum, D. R. 2000. Creative Problem Solving. Retrieved on September 4, 2011 from http://www.roisum.com/documents/ CreativeProbSolve.pdf

Sahlberg, P., 2009. Creativity and Innovation Through Lifelong Learning. *Lifelong Learning in Europe*. 14(1): 53–60.

Sefertzi, E. 2000. Creativity. Full Report: EC Funded Project.

Shaharudin Ali. 2007. *Persepsi Pelajar Terhadap Kerja Makmal (Laboratory Work) Di Jabatan Fizik, UPSI Menggunakan Pendekatan Sisihan-Q (Q-Sort Approach).* Grant Research Report, Universiti Perguruan Sultan Idris.

Sneddon, P. H., Slaughter, K. A. & Reid, N. 2009. Perceptions, Views and Opinions of University Students about Physics Learning During Practical Work at School. *European Journal of Physics*. 30(1): 1119–1129.

Sriraman, B. 2004. The Characteristics of Mathematical Creativity. *The Mathematics Educator*. 14(1): 19–34.

Sternberg, R. J. 2006. The Nature of Creativity. *Creativity Research Journal.* 18(1): 87–98.

Treffinger, D. J., Isaken, S. G. & Firestein, R. L. 1992. Theoretical Perspectives on Creative Learning and Its Facilitation: An Overview. *The Journal of Creative Behaviour*. 17(1): 9–17.

Torrance, P. E. 1970. *Creative Learning and Teaching*. New York: Harper and Row.

Vidal, R. V. V. 2010. Creative Problem Solving: An Applied University Course. *Pesquisa Operacional.* 30(2): 405–426.

Villalba, E. 2008. *On Creativity: Toward an Understanding of Creativity and its Measurements*. Luxembourg: European Communities.

Wood, C. 2006. The Development Of Creative Problem Solving In Chemistry. *Chemistry Education Research and Practice.* 7(2): 96–113.