Pakistan Journal of Social Sciences 6 (5): 297-303, 2009
ISSN: 1683-8831

Effects of Learning Environmental Education Using the 7E-Learning Cycle with Metacognitive Techniques and the Teacher's Handbook Approaches on Learning Achievement, Integrated Science Process Skills and Critical Thinking of Mathayomsuksa 5 Students with Different Learning Achievement

Sutee Sornsakda, Paitool Suksringarm and Adisak Singseewo
Faculty of Environmental and Resource Studies, Mahasarakham University,
Mahasarakham 44150, Thailand

Abstract: This research aimed to investigate and compare the effects of learning environmental education using the 7E-learning cycle with metacognitive techniques and the teacher's handbook approaches on learning achievement, integrated science process skill and critical thinking of 93 Mathayomsuksa 5 (grade 11) students with different learning achievements, They were randomly selected by the cluster random sampling technique in the first semester of an academic year 2008. This students were assigned to an experimental group with 45 students and a control group with 48 students. The instruments for the study included: five plans of learning organization using the 7-E learning cycle with 3 metacognitive techniques: intelligibility, plausibility and wide-applicability for the experimental group and 5 plans of learning organization using the teacher's handbook approach for the control group, each plan for 2 h of learning in each week, the learning achievement test, the test on integrated science process skills and the critical thinking test. The paired t-test and the F-test (Two-way MANCOVA) were employed for testing hypothesis. The major findings revealed that the whole students, the high achievers and the low achievers indicated gains in learning achievement, integrated science process skills in general and in 3-5 subscales and critical thinking in general and in each subscale from before learning ($p<0.05$). The experimental group evidenced more learning achievement, integrated science process skills in general and in each subscale and critical thinking in general and in the interpretation subscale than the control group ($p<0.05$). The high achievers showed more learning achievement, integrated science process skills in general and in 4 subscales and critical thinking in general and in 4 subscales than the low achievers ($p<0.05$). Statistical interactions of learning model with learning achievement were found to be significant ($p<0.05$) in learning achievement, integrated science process skills in general and in 4 subscales and critical thinking in general and in 3 subscales.

Key words: Learning environmental education, 7E-learning cycle approach, with metacognitive techniques, teacher's handbook approaches, integrated science process skills, critical thinking

INTRODUCTION

National Educational Act 1999, Section 22, stated that the educational management had to be based on rational that all students had competency in learning and developing themselves. They were the most important persons in educational management both formal and informal system and nonformal education system by giving an importance to integration of knowledge, ethics and learning process based on appropriateness of educational level in part of learning. For Science, it needed to cause Scientific knowledge, skill and attitude as well as maintenance management, utilization from natural resources and environment with balance and long lasting. Besides, Basic Education Curriculum 2001 focused on unity in policy and variety in practices, as the curriculum determining objectives for developing Thai people to be perfect, good, intelligent, happy and Thai style human beings.

Environmental Education was a process recognizing value and explaining thinking for applying in developing necessary competency and attitude as well as leading decision making and collecting behavior regarding to benefit of environment leading to value for knowing major approaches for developing indispensable attitude leading to knowledge and appreciation of relationship between human and culture and physical environment and biological environment surrounding us. It was the process

Corresponding Author: Sutee Sornsakda, Faculty of Environmental and Resource Studies, Mahasarakham University, Mahasarakham 44150, Thailand

focusing on developing world population with understanding toward the occurred environment and problems including expertise, attitude, motivation, acceptance and skill in order to problems solving of oneself and public (UNESCO, 1975). The recent environmental problem was *toxic environment* caused by the rapid increasing number of human population. As a result, they needed to search for habitat and agricultural product as their food. So, human beings interfered natural balance by farming which violated natural ecology by constructing town for their residents, using more technology, as well as building various kinds of industrial factory. Consequently, the wastages from houses and factories caused natural unbalance, for instance, deforestation caused destroyed environment, pollution of sewage and air, as well as toxic environment from noise, chemical substance, radioactive and impact from human's utilization. Every kind of wastage dumped into river and ocean around the world. Consequently, there were increased collections of water source every year. If these problems weren't solved by inhibiting or correcting the human beings' actions, the human couldn't be survived.

The real state of implementation in Environmental Education in schools was based on teachers or administrators' readiness as major things. The instructional management didn't cover every school. Moreover, the activities of Environmental Education were only extra curricular activities without continuity and long lasting. Most of school instructional activities would occur and follow objective of each project, organization, or research unit implementing in school. The existed activities performed in too limited boundary like imitation without understanding as former pattern which didn't cause awareness or change way of life and behavior. Therefore, an environmental problem wasn't transferred to other environmental issues. The activity management of Environmental Education affected the students' better learning achievement only in leading group students and interested people. Furthermore, the activity management of Environmental Education was a learning process very much based on Science process skill. Therefore, the instruction of Environmental Education should emphasize on instructional activity management, which could connect various kinds of experience or surrounding environment of students with their interest, curiosity. The students should have opportunity in practicing most. The teachers should administer different kinds of teaching techniques for variety in managing activities such as inquiry teaching, problem solving instruction, or Scientific technique so that the students could develop their capacity and had thinking process (Abraham *et al*., 1994). The teachers had to develop their students for understanding natural things, attitude, including ethics and morality as well as awareness of environment. So, they had to obtain knowledge and understand nature and environment as well as be role model for their students (Abell and Smith, 1994). Besides, they should develop their students' thinking ability (Renner and Marek, 1990) based on Constructivism. It was believed that the students would use their prior knowledge or conception during studying, while organizing new stimulus in order to create new approaches (Hewson and Hewson, 1988). which was the learning with none perception from new learning origins. But, it occurred from the students were persons who constructed their own body of knowledge by using former approaches and knowledge (Wheatley, 1991).

Therefore, learning was the changing of or constructing new knowledge. The instructional management had to focus on constructing knowledge, improving and revising one's prior knowledge while the students had to use their thinking, adjusting their thought and constructing new approaches. They had to search for knowledge by themselves by using process in searching for knowledge. As a result, they would be knowledgeable (Bybee *et al*., 1991). Learning cycle was a strategy of instructional management focusing on the student centered. The students were able to construct knowledge by themselves. They had shared learning and self assessment themselves. For Science instruction, the Scientific process skill would be emphasized since those skills were Intellectual Skills (Finley, 1983) using as a foundation for Scientific Inquiry, Learning by Doing, Meaningful Learning (Ausubel, 1968). Constructivism, which were indispensable for learning various concepts and rationales, which would be useful for inductive consensus with validity and reliability. Besides, the Scientific process skills as Intellectual skills were related to Piaget's thinking ability. The Basic Scientific Thinking was related to concrete operational Thinking (Padilla *et al*., 1983), which partly affect development of the students' scientific process skill and growth of Intellectual development as well as objectivity and reasoning (Haney, 1969). Those characteristics were indispensable to inculcate for every one as well. So, the Learning Cycle was a learning process emphasizing on the students' capacity in using Scientific Inquiry Approach based on Scientific process in finding knowledge or learning experience meaningfully with the basis from Constructivism Leaning Cycle, the students of Biological Science Curriculum Study. Moreover, in 2003 (Eisenkraft, 2003) Learning Cycle was expanded from 5-7 phases including the following learning phases as follows:

- Elicitation phase
- Engagement phase
- Exploration phase
- Explanation phases
- Expansion/Elaboration phase
- Elaboration phase
- Extension phase

Transfer of learning would be emphasized. The students' investigation of prior knowledge would be given an importance in which the teachers shouldn't neglect or leave it since the investigation of students' former knowledge would help the teachers to find what the students should be priority before learning the content. The students would construct knowledge from former knowledge they already had. Consequently, they would have meaningful learning. The neglect or ignorance during this phase would cause difficulty in developing the students' ideas, which wouldn't be as the objective set by teachers (Bransford *et al*., 2000). Metacognition was Higher-ordered Thinking, which was important for meaningful learning could well develop the students' intelligence. If it could be integrated in Inquiry Learning. Blank (2000) integrated Metacognition with Blank's 4 phases which were adequately adapted and renamed as Metacognitive Learning Cycle: MLC. The students would be asked to reveal and reflect their status or condition of their own Science Ideas (Blank, 2000). Scientific Technique using Meta Cognitive Techniques regarding to Intelligibility, Wide-applicability and Plausibility.

To study and compare learning achievement,

- Integrated science process skills and critical Thinking before and after learning from 7-E Learning Cycle with metacognitive techniques, by using the students' in overall and classification by learning achievement
- Integrated Science process skills and critical thinking before and after learning based on teachers' handbook in overall and as classified by learning achievement
- Achievement, integrated level of Scientific process skill and critical thinking of students with different learning achievement and learning styles

MATERIALS AND METHODS

For research methodology and experimental design, the boundary was determined as follows:

Population included 500 Mathayomsuksa 5 Students from 11 classrooms, Chumphae-suksa School, Chumphae District, under The Office of Khon Kaen Educational Service Area 5, during the first semester of 2008 school year.

Samples included 93 Matayomsuksa 5 Students from 2 classrooms of Chumphae-suksa 5 School, Chumphae District, under jurisdiction of The Office of Khon Kaen Educational Service Area 5, during the first semester of 2008 school year by using Cluster Random Sampling by lottery technique.

This research was an Experimental research. The research design 2×2 Factorial Experimental Design as Pretest-Posttest Equivalent Groups Design (Best, 2003). in Completely Randomized Design as Fixed Effect Model including 2 factors: learning achievement and learning style.

The instrument using in the experiment including two types of knowledge management plans including: knowledge management based on 7-E Learning Cycle With Metacognitive Techniques, for 5 plans, 2 h each plan, using with the experimental group and knowledge management plan based on teachers' handbook Approaches for 5 plans, 2 h each plan, using with the control group. Furthermore, 4 sets of test including The End Cycle sub-test, Learning Achievement Test, Integrated Science Process Skills Test and Critical Thinking Skill Test.

Experimental technique and data gathering, the researcher conducted experiment and collected data by himself with the following details:

Preparation phase: The researcher brought the letter from graduate school, Mahasarakam University, asking for collaboration from director of Chumphae-suksa School, Chumphae District, Khon Kaen Province, to ask permission in conducting experiment and collecting data.

The researcher sampled the students, Matayomsuksa 5/6 Students studying 7-E Learning Cycle With Metacognitive Techniques, as the experimental group and Matayomsuksa 5/4 as the control group.

The researcher divided students into high achievement students and low achievement students by using Mathayomsuksa 4 Students' grade point average from Biology Subject by transforming into T-Score, The high grade students had their T-Score 50 points and higher. The low achievement students had 50 points and lower. There were 50 high achievement students and 43 low achievement students. The comparison of statistical differences found that there were significant differences in their average grades between both groups of students.

Teaching implementation: The pretest was administered to the students learning from 7-E Learning Cycle With Metacognitive Techniques and studying from teachers' handbook by using The Learning Achievement Test, Integrated Science Process Skills Measure and Critical Thinking Skill Test.

The instruction was performed for both groups with the same content for 5 weeks, 2 h each week, total of 10 h, during June-July 2008.

The posttest phase, posttest was dministered by Learning Plans using 7-E Learning Cycle With Metacognitive Techniques, constructed for 5 plans, total of 10 h, with Matayomsuksa 5/6 as the experimental group and The Knowledge Management Plans based on teachers' handbook were administered with the control group.

Implementation after learning phase, the posttest was administered with the experimental group and control group when they studied all of 5 plans by using The Learning Achievement Test, Integrated Science Process Skills and Critical Thinking Test.

For data collection, there were following phases: the answer sheet from Learning Achievement Test regarding to Life and Environment: titled Ecology System: Changing and Replacement: Energy Transfer: Relationship in Ecology System: Equilibrium Maintenance of Ecology System, measuring Integrated Science Process Skills both pretest and posttest, for scoring the answers.

The scores from The Learning Achievement Test, Integrated Science Process Skills Test, were calculated for the Mean, Percentage and Standard Deviation.

The scores from The learning Achievement Test, Integrated Science Process Skills and Critical Thinking Skill, were tested based on assumption of Two-way MANCOVA technique by testing Normality, Homogeneity of Variance and Homogeneity of Variance-Covariance Matrices, found that the data was congruent with the assumption.

The differences between average scores of the pretest and posttest from The Learning Achievement, Science Process Skills and Critical Thinking, by using statistical testing as Paired t-test.

The scores from Learning Achievement, Integrated Science Process Skills and Critical Thinking from posttest of the experimental group and control group with different learning achievement by using F-test (Two-Way MANCOVA).

RESULTS AND DISCUSSION

The overall student, high Achievement student group and low achievement students group had their learning achievement, Integrated Science Process Skills, in overall and each aspect of 3-5 aspects and Critical Thinking, there was an increase in every aspect of posttest from pretest at 0.05 significant level (Table 1).

The above findings might be because of: 7-E Learning Cycle With Metacognitive Techniques, as an inquiry, which was the Intellectual Procedures (Welch, 1981) focusing on Piaget's Intellectual Developmental Theory regarding to Assimilation and Accommodation and Organization which would be applied in Phase 3 as Exploration Phase (Marek *et al*., 1990). Phase 4 as Explanation Phase, Phase 5 as Explanation Phase and in Phase 1 as Elicitation, would create the students' intrinsic motivation in searching for knowledge and striving for success. For Phase 7 as Extension, the students would apply rationales and approaches in constructing new knowledge and keeping it. When they were stimulated by external stimulus, they would use their prior knowledge by organizing new knowledge with the former one. As a result, broader scope of knowledge and more meaningful one would occur (Ausubel, 1968) affecting the appropriate development of Learning Achievement, Integrated Level of Scientific Process Skill and Critical Thinking.

Table 1: Comparison of overall learning achievement, integrated science process skill and critical thinking, of students with different learning achievement and learning by different learning approaches (Two-way MANCOVA)

Source	No. of variable	Hypo thesis	Error df	F	p
Learning achievement	3	23.515	3	87	0.000*
Learning approaches	-	9.648	3	87	0.000*
Achievement* approaches	-	11.288	3	87	0.000*

*Significance at 0.05 level

7-E Learning Cycle With Meta cognitive Techniques, the activities were organized for students to Practice Scientific Process Skill as Intellectual Skills (Bransford *et al*., 2000) in every phase. There were many repetitions in each phase, the students could regular practice their ability in every aspect of process skill (Ebrahim, 2004) based on Law of exercise (Thorndike, 2008). Consequently, they could be able to develop Scientific Process Skill as well as enhance Critical Thinking as Higher ordered Thinking and Learning Achievement.

For instructional management in each Phase by using Metacognitive Techniques for all 3 patterns as Intelligibility, Plausibility and Wide-Applicability, it caused the students to practice their own thinking ideas and their friends' (Thinking about Thinking) (Georghiades, 2000) from Cooperative Learning and practice in small group so that the students could have chance to negotiate and critique their friends' ideas until it could be concluded according to learning principle of Social Constructivism (Phillips, 1976). Those learning processes had supported students for playing their roles in constructing Intellectual Ability and other kinds of Higher Ordered Thinking, for example, Critical Thinking and Problem Solving until being able to develop one's learning achievement, Integrated Science Process Skills and Critical Thinking appropriately in higher level than before learning.

The experimental group students had Overall and each aspect in learning achievement, Integrated Science Process Skills and overall Critical Thinking and Interpretation, in higher level than those who studied from teachers' handbook at 0.05 significant level (Table 2).

The findings were as follows might be because of: for 7-E Learning Cycle With Metacognitive Techniques, each phases of process skills was clearly specified. The students could use their process skill in every phase for many times and continuously like the cycle. So, they were able to regularly practice competency in every aspect of process skill (Fish, 1994).

For Learning Cycle as inquiry, which was Intellectual Procedures. In such process learning, not only Integrated Science Process Skills would be practiced, but the students also were trained their Metacognition throughout the time by asking questions what they had already known or their own thought for developing Intelligibility, Plausibility and Wide-Applicability (Beeth, 1998). As a result, the students were able to better develop 4 aspects of Integrated Science Process Skills than learning by the teachers' handbook.

The high grade students had the overall and each aspect of 4 aspects of Integrated Science Process Skills (except induction aspect) higher than the low grade students at 0.05 significant level (Table 3).

For differences in overall and each aspect of 4-5 aspects learning achievement between the high achievement students and low achievement students, it might be because of the high achievement students had better Mental structure (Renner and Phillips, 1980). Knowledge Structure (Blank, 2000). than low achievement students. So, they could better study abstract objects (Rabideau, 2005). Besides, the high achievement students were interested in and enthusiastic in learning, self confident (Heins, 1980) able to better themselves (Fish, 1994).

For achieving desired goal, as well as more intrinsic motivation than those who were low achievement students (Rabideua, 2005). Consequently, they obtained higher learning achievement in all 3 aspects than low achievement students.

There was an interaction between learning achievement and model on learning achievement, overall and each aspect of 4 aspects of Integrated Science Process Skills (except in operational definition aspect) and overall and each aspect for 3 aspects (except deduction and argumentation assessment) at 0.05 significant level (Table 1).

The interaction between learning achievement and model showed that the instructional management by using learning model, Science teachers had to consider the appropriate selection with their students' learning ability level. In addition, it also helped both high and low grade students to be able to learn with full potentiality and efficiency considering topic or learning substance.

Table 2: Comparison of differences in integrated science process skills for each aspect of students with different learning performances and learning approaches (Two-way MANCOVA)

Source	No. of variable	Hypo thesis	Hypo df	F	p
Learning achievement	5	5.00	85	15.053	0.000*
Learning approaches	-	5.00	85	3.018	0.000*
Achievement* approaches	-	5.00	85	3.333	0.000*

Table 3: Comparison of each aspect of Critical Thinking of students with different learning achievements and learning approaches (Two-way MANCOVA)

Source	No. of variable	Hypo thesis	Error df	F	p
Learning achievement	5	5.00	85	12.741	0.000*
Learning approaches	-	5.00	85	4.604	0.001*
Achievement* approaches	-	5.00	85	4.480	0.001*

* Significant at 0.05 level

CONCLUSION

The overall students: the overall of experimental student group studying by 7-E Learning Cycle With Metacognitive Techniques, had average learning achievement scores, overall and each aspect from 5 aspects of Integrated Science Process Skills and overall and each aspect from 5 aspects of critical thinking scores, higher than pretest at 0.05 significant level.

The overall control group students taught by teachers' handbook, had their learning achievement scores, overall and every aspect of Integrated Science Process Skills and overall and every aspect of Critical Thinking Scores, higher than pretest at 0.05 significant level.

The experimental group students had their learning achievement in overall and every aspect for Integrated Science Process Skills and overall Critical Thinking and interpretation aspect, higher than the control group at 0.01 significant level.

The students as classified by learning achievement: the high achievement experimental group students taught by 7-E Learning Cycle With Metacognitive Techniques, had higher learning achievement, overall and every aspect for Integrated Science Process Skills and overall and every aspect of Critical Thinking than pretest at 0.05 significant level. For the high achievement control group students taught by teachers' handbook, had higher learningachievement in overall and each aspect from 5 aspects on Integrated Science Process Skills and overall and each aspect for 3 aspects on Critical Thinking Scores, than pretest at 0.05 significant level.

The low achievement experimental group students taught by 7-E Learning Cycle With Metacognitive Techniques, had higher learning achievement, overall and each aspect for 3 aspects of Scientific Process Skill and overall and every aspect of Critical Thinking than the pretest at 0.05 significant level. For the low achievement control group students taught by teachers' handbook, had higher learning achievement, overall and every aspect of Integrated Science Process Skills than the pretest at 0.05 significant level.

The high achievement students had overall and each aspect for 4 aspects of learning achievement in Integrated Science Process Skills (except in operational definition aspect) and overall and each aspect for 3 aspects of Critical Thinking (except in deduction and argumentation assessment aspects) at 0.05 significant level.

The interaction between learning performance and model on learning achievement, overall and each aspect for 4 aspects of Integrated Science Process Skills (except in operational definition aspect) and overall and each aspect for 3 aspects (except deduction and argumentation assessment aspect) at 0.05 significant level.

RECOMMENDATIONS

The learning achievement as 7-E Learning Cycle With Metacognitive Techniques, regarding to the content of environmental Education between different class levels, should be studied and compared.

The learning achievement as 7-E Learning Cycle With Metacognitive Techniques and other kinds of inquiry teaching affecting other variables, such as analytical thinking, synthetic thinking, reasoning thinking and logical thinking etc, should be studied and compared.

The duration of teaching time for each plan should be adjusted as 3 h.

The 7-E Learning Cycle With Metacognitive Techniques, Instruction should be studied and compared with other kinds of instructional model between different class levels by spending more time such as for one semester.

ACKNOWLEDGEMENTS

This thesis was successful by mercy and support by Associate Professor Dr. Paitool Suksri-ngam as major advisor, Dr. Adisak Singseewo as co-advisor, Associate Professor Dr. Chaiyod Reaungsu-suwan as the chairman of oral examination and Dr. Netchanok Jansawang as an expert for kindly providing advices, suggestions and investigations the mistakes since the beginning until finishing. The researcher would like to show highly gratitude in this occasion.

REFERENCES

Abell, S.K. and D.C. Smith, 1994. What is science?: Preservice elementary teachers'conceptions of the nature of science. Int. J. Sci. Edu., 16 (4): 475-487. http://www.informaworld.com/10.1080/0950069940160407.

Abraham, M.R., V.M. Williamson and S.L. Westbrook, 1994. A cross-age study of the understanding of five chemistry concepts. J. Res. Sci. Teach., 31 (2): 147-165. http://dx.doi.org/10.1002/tea.3660310206.

Ausubel, D.P., 1968. Meaning and Meaningful learning in Educational Psychology: A Cognitive View. Holt, Rinehart and Winston. New York, pp: 38-48. ISBN : 0-03-089951-6.

Beeth, M.E., 1998. Teaching for conceptual change: Using status as a metacognitive tool. Sci. Edu., 82 (3): 343-356. http://dx.doi.org/10.1002/(SICI)1098-237X(199806)82:3<343::AID-SCE3>3.0.CO;2-C.

Best, J.W., 2003. Experimental and Quasi-Experimental Research. 3rd Edn. Research in Education. Englewood Cliff, N.J. Prentice-Hall, pp: 159-209.

Blank, L.M., 2000. A metacognitive learning cycle: A better warranty for student understanding? Sci. Edu., 84 (4): 486-506. http://dx.doi.org/10.1002/1098-237X(200007)84:4<486::AID-SCE4>3.0.CO;2-U.

Bransford, J.D., A.L. Brown and R.R. Cocking, 2000. Learning and transfer. How People Learn: Brain, Mind, Experience and School. Washington, D.C.: National Academy Press, pp: 51-78. ISBN: 10-0-309-07036-8.

Bybee, R.W., J.C. Powell, J.D. Ellis, J.R. Giese, L. Parisi and L. Singleton, 1991. Integrating the history and nature of science and technology in science and social studies curriculum. Sci. Edu., 75 (1): 143-155. http://dx.doi.org/10.1002/sce.3730750113.

Ebrahim, A., 2004. The Effects of Traditional Learning and a Learning Cycle Inquiry Learning Strategy on Student's Science Achievement and Attitudes Toward Elementary Science. Ph.D. Ohio University. http://proquest.umi.com/pqdweb?did=765928401&sid=2&Fmt=2&clientId=47904&RQT=309&VName=PQD.

Eisenkraft, A., 2003. Expanding the 5E Model. The Sci. Teacher, 47 (4): 56-59. www.nsta.org/pdfs/2009NewOrleansProgram3.pdf.

Finley, F.N., 1983. Science processes. J. Res. Sci. Teach., 20(1): 47-54. http://dx.doi.org/10.1002/tea.3660200105.

Fish, T.C., 1994. Relationship between Managing Teamwork with Teacher and Building Self-confidence for Science Learning Among Children. Ph.D. University of Southampton. http://proquest.umi.com/pqdweb?did=740728091&sid=5&Fmt=2&clientId=47904&RQT=309&VName=PQD.

Georghiades, P., 2000. Beyond conceptual change learning in science education: Focusing on transfer, durability and metacognition. Edu. Res., 42 (2): 119-139. http://www.informaworld.com/10.1080/001318800363773.

Haney, R.E., 1969. The Development of Scientific Attitude. In: Hans O. Anderson (Ed.). Readings in Science Education for the Secondary School. New York, Macmillan, pp: 198-204.

Heins, E.D., 1980. Training Learning Disabled Children's Self-Control: Cued and Non-Cued Self-Recording in The Classroom. Ph.D. University of Verginia. http://proquest.umi.com/pqdweb?Did=749701551&sid=4&Fmt=2&clientId=47904&RQT=309&VName=PQD.

Hewson, P.W. and M.G.A'B. Hewson, 1988. An appropriate conception of teaching science: A view from studies of science learning. Sci. Edu., 72 (5): 597-614. http://dx.doi.org/10.1002/sce.3730720506.

Marek, E.A., C. Eubanks and T.H. Gallaher, 1990. Teachers' understanding and the use of the learning cycle. J. Res. Sci. Teach., 27 (9): 821-834. http://dx.doi.org/10.1002/tea.3660270903.

Padilla, M.J., F.G. Dillashaw and J.R. Okey, 1983. The relationship between science process skill and formal thinking abilities. J. Res. Sci. Teach., 20 (3): 239-246. http://dx.doi.org/10.1002/tea.3660200308.

Phillips, D.G., 1976. Piagetian perspective on science teaching. Sci. Teacher, 43 (2): 30-31. EJ: 133485.

Rabideau, S.T., 2005. Effects of Achievement Motivation on Behavior. http://www.Personalityresearch.org/paper/rabideau.html.

Renner, J.W. and D.G., Phillips, 1980. Piaget's Developmental Model: A Basic for Research in Science Education. School Sci. Mathe., 80 (3): 193-199. EJ: 220070.

Renner, J.W. and E.A. Marek, 1990. An educational theory base for science teaching. J. Res. Sci. Teach., 27 (3): 241-246. http://dx.doi.org/ 10.1002/tea.3660270307.

Thorndike, E.L., 2008. Thorndike's Experiments. New World Encyclopedia. http://www.newworldencyclopedia.org/entry/Edwaed.

UNESCO (United Nations Educational, Scientific and Cultural Organization), 1975. The Belgrade Charter. In The International Environmental Workshop in Belgrade, Yugoslavia. http://www.gdrc.org/uem/ee/belgrade.html.

Welch, W.W., 1981. Inquiry in School Science. In: Norris, C.H. and R.E. Yager (Eds.). What Research Says to the Science Teachers. Washington, D.C., National Science Teachers Association, pp: 53-64. ISBN: 978-087-3 55-018-5.

Wheatley, G.H., 1991. Constructivist perspectives on science and mathematics learning. Sci. Edu., 75(1): 9-21. http://dx.doi.org/10.1002/sce.3730750103.