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Effect of 5P model on academic achievement, creative thinking, and research characteristics

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ABSTRACT

This study examined significant changes on the academic achievement, creative thinking, and research characteristics of Grade 9 students after the intervention of the 5P model and 5E model with an experimental group and control group, respectively. The 5P model is an integrated, research-based, learning instructional design model. In total, 76 out of 324 Grade 9 students were purposively selected from a high school located in Mahasarakham province, Thailand. The experimental group and the control group each comprised 38 samples. Researchers employed a 2 × 2 experimental research design. The findings revealed that the overall academic achievement, creative thinking, and research characteristics were significantly improved after the intervention of the 5P model as well as for the 5E model. However, the effect of the 5P model was found to be greater compared to the 5E model. As a result, the 5P model has been proved to be an innovative, instructional model to enhance students' learning outcomes in terms of academic achievement, creative thinking, and research characteristics.

Introduction

Instruction is a systematic process in which a plan of teaching and learning activities that assist students' memory is organized (Isman, 2011). An instructional design model helps educators or teachers to visualize the problem. As a result, the concept of the developing learner becomes a vital principle for the development instructional model (Chinnery, 2014). Research-based learning (RBL) is regarded as an important learning and instructional innovation (Dochy, Berghmans, Kyndt, & Baeten, 2011) and can enhance learners' research competencies, critical thinking, research skill, reflectivity, and creative thinking (Walkington et al., 2011; Wannapiroon, 2014) thus supporting the learner as a researcher (Willison & O'Regan, 2007).

The 5P instructional model is integrated RBL and was developed by researchers to cover five main phases, namely persuasion, planning, performance, production, and presentation. The 5E instructional model as used by the control group is supported by the Institute for the Promotion of Teaching Science and Technology (2012) for use in a standard classroom in Thailand. The 5E model is comprised of five phases namely engage, explore, explain, elaborate, and evaluate.

The 5P model is highly structured and controlled by the teacher to provide opportunities for learners to learn science using the research process. It incorporates cooperation, idea freedom, creativity, and ethics in the supporting learning environment. Exchange and sharing

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ideas are mostly encouraged in the instructional process and students have opportunities to do real research. In the persuasion stage, teachers investigate learners' prior knowledge. Learners study the principles of the research process. They study research ethics, analyze, train, and share research questions with regard to the case study. In the planning phase, learners are trained to develop their research plan and share with their friends. In the performance stage, learners collect and analyze data under supervision. In the production phase, learners are trained to conclude their results of the data analysis. In the presentation phase, learners are requested to write their research reports and present their research process.

On the other hand, the 5E model is a conventional model. In the engage phase, learners have to make connections between the past and present learning experiences. The explore phase provides learners with a common base of experiences. In the explain phase, teachers help learners to explain the concepts they have explored in the previous phase. This is followed by the elaborate phase. Learners are encouraged to extend their conceptual understanding and practice their skills and behavior. The final phase is the evaluate phase, where learners are encouraged to assess their understanding and abilities while the teachers evaluate the learners' understanding of key concepts and skills development.

Statement of Problem

In the 21st century, classroom learning has to be planned to enhance the creative thinking of learners for the needs of society in the long term (Office of Education Council, 2014). Creative thinking is an essential soft skill for future Thai citizens and impacts on the development of innovation (Miller & Dumford, 2015). Since RBL is the key approach of the 5P model, it is essential to explore it. Hence the appropriateness of the integration of RBL in each education level is strongly emphasized and supported by the Thailand National Education Act (1999) as amended by Act (No.2) (2002) and further amended by Act (No.3) (Thailand Ministry of Education, 2010). Generally, Thailand Ministry of Education (2010) aimed to encourage teachers to provide a positive learning environment with the assistance of instructional media as well as proper facilitation.

In the present review, research priorities ranged from studying better instructional practices for literacy and the use of new technology, and cross-sectional research collaborations. The broad imperative to improve learning and literacy continues to be one of the great challenges of the 21st century (Wagner, 2014). Designing and responding to an appropriate set of research priorities will be one of the most important ways to address the future of learning, literacy, and education. Various surveys of employers of college graduates have revealed three major complaints—poor writing and verbal skills, inability to problem-solve, and difficulties working collaboratively with other professionals (Li, 2015). These weaknesses can be partly attributed to the traditional teacher-centered instruction that students typically receive throughout their learning process. As a result, an effective instructional model is sorely needed to motivate learners to grasp the content knowledge and connect it to the real world.

Literature Review

According to Guinness (2012), the challenge of bringing RBL to undergraduate development studies and anthropology students led to convening a field school in Indonesia. The field school has been vital in introducing students to fieldwork methodology and in developing a deeper understanding of the relation of research data to development theory. In addition, students who participate in the field school discover a whole new aspect to learning where an emotional and intellectual response to the field situation is required and they are challenged to consider the ethical issues that are raised in the course of their research.

Smith and Rust (2011) studied the potential of RBL for the creation of truly inclusive academic communities of practice. The academic community in higher education is becoming increasingly fragmented with arguably the greatest fault line between research and teaching. Their study argued that through the reinvention of the undergraduate curriculum to focus on student engagement in research and research-type activities, a truly inclusive community of academic practice can be created with consequent benefits to academics, to students, and to support staff. Practical guidelines had been developed by Smith and Rust for the organization and management of students and staff and for the design and layout of academic accommodation.

Tongsakul and Jitgarun (2006) investigated factors empowering electrical students' learning achievement through project-based learning as perceived by the opinions of instructors and students. The results of the study by Tongsakul and Jitgarun showed that both instructors and students agreed on interesting/attention ($\bar{x}$ = .799 and .885, respectively) while other factors such as planning ($\bar{x}$ = .722), sharing ideas ($\bar{x}$ = .582), thinking ($\bar{x}$ = .576), facilitating ($\bar{x}$ = .547), construction ($\bar{x}$ = .540), scientific process ($\bar{x}$ = .525), multiple intelligence ($\bar{x}$ = .479), and goal setting ($\bar{x}$ = .453) were perceived by instructors, while students were more interested in advising/guiding ($\bar{x}$ = .863), thinking ($\bar{x}$ = .661), goal setting ($\bar{x}$ = .634), multiple intelligence ($\bar{x}$ = .553), scientific process ($\bar{x}$ = .528), assisting ($\bar{x}$ = .524), and sharing ideas ($\bar{x}$ = .492).

Research Objectives

The main aims of this research were to study the effect of using the 5P model on academic achievement, creative thinking, and research characteristics. This paper reports a subsequent study after researchers had conducted a pilot study to develop the 5P model using the RBL approach on understanding of the learning phenomenon. Specifically, this study aimed to achieve the following objectives:

(1) To identify the academic achievement, creative thinking, and research characteristics of Grade 9 students before and after utilizing the 5P model

(experimental group) and the 5E model (control group), respectively.

(2) To study the differences in the academic achievement, creative thinking, and research characteristics between the experimental group and control group.

Methodology

Researchers utilized a 2 (instructional model: 5P vs 5E) $\times$ 2 (time of measure: pretest versus posttest) experimental research design. The randomly selected sample consisted of 76 from 324 Grade 9 students in nine classes in a high school located in Mahasarakham province, Thailand during the second semester of the 2014 academic year. The 76 samples were divided into two groups consisting of 38 students in the experimental group (neurocognitive-based model, 5P: $n = 38$; males = 9; mean age = 14.73, SD = .45) and 38 students in the control group (conventional model, 5E: $n = 38$; males = 8; mean age = 14.68, SD = .47).

Learning outcomes including academic achievement, creative thinking, and research characteristics in two groups were examined in two science classrooms. Each class was presented and taught an identical unit (eco-system science content), one class using the 5P model and the other using the 5E model for 3 h per week, for a total of six weeks. Both classes were pretested and posttested at the beginning and the end of the six weeks. This experimental design aimed to describe the variation of information under the conditions of different instructional models which was hypothesized to reflect the variation or change in outcomes. The approach is generally associated with true experiments in which the design introduces conditions that directly affect the variation.

The research instruments were mainly used as tests to measure learning outcomes. There were seven types of tests used: science content knowledge (40 items), science process skills (45 items), science attitude (25 items), science creative thinking test (5 items), research skill test (35 items), research skill inventory (35 items), and research ethics checklist (21 items). All seven types of tests were evaluated for validity using Bunterm et al. (2014) as well as for construct validity using Srikoon and Bunterm (2015).

In this study, the researchers tested whether the mean score of the two groups was the same across nine constructs simultaneously. Wilks's lambda (in the multivariate setting with a combination of dependent variables) performs the same role as the F-test performs in one-way analysis of variance. Wilks' lambda is a direct measure of the proportion of variance in the combination of dependent variables that is unaccounted for by the group variable (Everitt & Dunn, 1991).

Results

The results are presented in accordance with the research objectives in two parts—descriptive and inferential findings.

Results of Academic Achievement, Creative Thinking, and Research Characteristics

The descriptive statistics of pretest versus posttest academic achievement, creative thinking, and research characteristics for both the 5P and 5E model groups are presented in Tables 1–3, respectively. Academic achievement was measured based on three categories—content knowledge, science process skills, and science attitude. Creative thinking was measured based on three categories—fluent thinking, original thinking, and flexible thinking. Research characteristics were measured based on three categories—research skill, research behavior, and research ethic. All the posttest results showed an increase

Table 1
Descriptive statistics of academic achievement

Group	n	Mean (Standard Deviation)					
		Content knowledge		Science process skills		Science attitude	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
5P model	38	23.921 (4.487)	28.237 (4.050)	23.474 (5.039)	38.711 (2.680)	81.263 (10.492)	105.421 (4.654)
5E model	38	22.447 (4.183)	24.184 (4.986)	21.711 (10.606)	24.474 (6.725)	81.237 (6.528)	84.237 (8.284)

Table 2
Descriptive statistics of creative thinking

Group	n	Mean (Standard Deviation)					
		Fluent thinking		Original thinking		Flexible thinking	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
5P model	38	32.289 (11.729)	42.211 (9.092)	17.421 (3.477)	23.789 (2.988)	45.816 (13.831)	59.816 (14.630)
5E model	38	30.000 (12.370)	31.237 (12.341)	15.974 (4.246)	18.684 (4.192)	44.132 (25.901)	44.658 (16.816)

Table 3
Descriptive statistics of research characteristics

Group	n	Mean (Standard Deviation)					
		Research skill		Research behavior		Research ethic	
		Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
5P model	38	20.605 (4.487)	27.053 (2.313)	124.842 (18.587)	151.921 (7.855)	17.868 (2.384)	20.000 (1.452)
5E model	38	19.237 (3.044)	20.895 (3.630)	123.632 (13.808)	130.789 (13.814)	17.816 (2.252)	18.053 (2.143)

Table 4
Multivariate tests for academic achievement

Effect	Wilks'Lamda	F	df_1	df_2	p	η_p^2
Between groups						
Model	.447	29.658	3.000	72.000	.000	.553
Within groups						
Time	.133	156.511	3.000	72.000	.000	.867
Model × Time	.219	85.804	3.000	72.000	.000	.781

compared to the pretest results using either the 5P model or the 5E model. A comparison of the total score of both groups showed that the experimental group performed better than the control group for all three learning outcomes.

Multivariate Test of Academic Achievement, Creative Thinking, and Research Characteristics

All the multivariate tests (Wilk's lambdas) for the three variables (academic achievement, creative thinking, and research characteristics) were significant suggesting that the instruction models significantly influenced academic achievement ($F[3,72] = 29.658$, $p = .000$), creative thinking ($F[3,72] = 5.982$, $p = .001$), and research characteristics ($F[3,72] = 16.067$, $p = .000$) and explained 55.3 percent of the variance of academic achievement ($\eta_p^2 = .553$), 20.0 percent of the variance of creative thinking ($\eta_p^2 = .200$), and 40.1 percent of the variance of research characteristics ($\eta_p^2 = .401$).

Time had a significant influence on academic achievement ($F[3,72] = 156.511$, $p = .000$), creative thinking ($F[3,72] = 60.084$, $p = .000$), and research characteristics ($F[3,72] = 59.005$, $p = .000$) and explained 86.7 percent of the variance of academic achievement ($\eta_p^2 = .867$), 71.5 percent of the variance of creative thinking ($\eta_p^2 = .715$), and 71.1 percent of the variance of research characteristics ($\eta_p^2 = .711$). Moreover, instruction models had a significant interaction with time ($F[3,72] = 85.804$, $p = .000$), ($F[3,72] = 21.444$, $p = .000$), ($F[3,72] = 21.366$, $p = .000$) and explained 78.1 percent of the variance of academic achievement ($\eta_p^2 = .781$), 47.2 percent of the variance of creative thinking ($\eta_p^2 = .472$), and 47.1 percent of the variance of research characteristics ($\eta_p^2 = .471$). These results are presented in Tables 4–6, respectively.

The multivariate test informs the significance of at least one mean pairing; thus, the individual comparisons of the

Table 5
Multivariate tests for creative thinking

Effect	Wilks'Lamda	F	df_1	df_2	p	η_p^2
Between groups						
Model	.800	5.982	3.000	72.000	.001	.200
Within groups						
Time	.285	60.084	3.000	72.000	.000	.715
Model × Time	.528	21.444	3.000	72.000	.000	.472

Table 6
Multivariate tests for research characteristics

Effect	Wilks'Lamda	F	df_1	df_2	p	η_p^2
Between groups						
Model	.599	16.067	3.000	72.000	.000	.401
Within groups						
Time	.289	59.005	3.000	72.000	.000	.711
Model × Time	.529	21.366	3.000	72.000	.000	.471

Table 7
Significant *F*-tests for univariate ANOVA follow up tests for academic achievement

Effect	SS	MS	df	F	*p*	η_p^2
Science content knowledge						
Between groups						
Model	290.132	290.132	1	9.654	.003	.115
Error	2223.947	30.053	74			
Within groups						
Time	348.026	348.026	1	37.067	.000	.334
Model × Time	63.184	63.184	1	6.730	.011	.083
Error	694.789	9.389	74			
Science process skills						
Between groups						
Model	2432.000	2432.000	1	30.645	.000	.293
Error	5872.711	79.361	74			
Within groups						
Time	3078.000	3078.000	1	195.032	.000	.725
Model × Time	1478.132	1478.132	1	93.659	.000	.559
Error	1167.868	15.782	74			
Science attitude						
Between groups						
Model	4273.921	4273.921	1	48.435	.000	.396
Error	6529.842	88.241	74			
Within groups						
Time	7006.737	7006.737	1	210.727	.000	.740
Model × Time	4252.737	4252.737	1	127.900	.000	.633
Error	2460.526	33.250	74			

observed mean difference are conducted using univariate ANOVA. From Tables 7–9, the instruction model and time had a significant influence on the three dependent variables. Moreover, interaction between the instruction model and time also had a significant influence on the three dependent variables.

However, the multivariate ANOVA follow-up does not provide a specific mean difference, but rather the overall group effects for any time point for any one of the effects of interest. In order to investigate the specific mean differences, individual t-tests of the mean difference need to be conducted. In addition, simultaneous 95 percent confidence intervals were computed in order to provide further insight into the variability of plausible mean differences between the observed groups. These are presented in Tables 10–12, which show that the pretesting for academic achievement, creative thinking, and research characteristics did not differ significantly. Furthermore, all posttesting did differ significantly for all three dependent variables. The researchers concluded that both the 5P and

Table 8
Significant *F*-tests for univariate ANOVA follow up tests for creative thinking

Effect	SS	MS	df	F	*p*	η_p^2
Fluent thinking						
Between groups						
Model	1671.158	1671.158	1	6.723	.011	.083
Error	18394.184	248.570	74			
Within groups						
Time	1182.737	1182.737	1	83.290	.000	.530
Model × Time	716.447	716.447	1	50.453	.000	.405
Error	1050.816	14.200	74			
Original thinking						
Between groups						
Model	407.901	407.901	1	18.333	.000	.199
Error	1646.434	22.249	74			
Within groups						
Time	783.059	783.059	1	129.250	.000	.636
Model × Time	127.112	127.112	1	20.981	.000	.221
Error	448.329	6.058	74			
Flexible thinking						
Between groups						
Model	2694.737	2694.737	1	5.018	.028	.064
Error	39741.579	537.048	74			
Within groups						
Time	2004.632	2004.632	1	14.073	.000	.160
Model × Time	1724.632	1724.632	1	12.108	.001	.141
Error	10540.737	142.442	74			

Table 9
Significant *F*-tests for univariate ANOVA follow up tests for research characteristics

Effect	SS	MS	df	F	*p*	η_p^2
Research skill						
Between groups						
Model	538.132	538.132	1	30.692	.000	.293
Error	1297.447	17.533	74			
Within groups						
Time	624.105	624.105	1	97.030	.000	.567
Model × Time	217.921	217.921	1	33.880	.000	.314
Error	475.974	6.432	74			
Research behavior						
Between groups						
Model	4742.112	4742.112	1	16.103	.000	.179
Error	21792.066	294.487	74			
Within groups						
Time	11135.533	11135.533	1	111.522	.000	.601
Model × Time	3770.059	3770.059	1	37.757	.000	.338
Error	7388.908	99.850	74			
Research ethic						
Between groups						
Model	38.000	38.000	1	6.244	.015	.078
Error	450.342	6.086	74			
Within groups						
Time	53.289	53.289	1	20.160	.000	.214
Model × Time	34.105	34.105	1	12.902	.001	.148
Error	195.605	2.643	74			

5E models can enhance academic achievement, creative thinking, and research characteristics but the 5P model produced a greater enhancement than the 5E model.

Discussion and Conclusion

The results of this study indicated there are significant differences between the two intervention groups. In order to ensure that the differences in science learning outcomes were due to the instructional models, the researchers undertook the following steps. The experimental and control groups that received different 5P model or 5E model intervention were determined randomly to ensure that the differences were distributed equally between the two groups in order to correct for any systematic errors. The two groups were found to be not significantly different from each other in the pretest. The researchers determined that the instructional models were the prime factors

Table 10
Significant mean difference *t*-tests for academic achievement

Academic achievement	Mean difference	t	*p*	95% Simultaneous confidence interval	
				lower	upper
Pretest content knowledge	−1.474	−1.481	.143	−3.456	.509
Posttest content knowledge	−4.053	−3.889	.000	−6.129	−1.976
Pretest science process skill	−1.763	−.926	.358	−5.559	2.032
Posttest science process skill	−14.237	−12.122	.000	−16.577	−11.897
Pretest science attitude	−.026	−.013	.990	−4.021	3.968
Posttest science attitude	−21.184	−13.744	.000	−24.255	−18.113

Table 11
Significant mean difference *t*-tests for creative thinking

Creative thinking	Mean difference	t	*p*	95% Simultaneous confidence interval	
				lower	upper
Pretest fluent thinking	−2.289	−.828	.410	−7.800	3.221
Posttest fluent thinking	−10.974	−4.413	.000	−15.928	−6.019
Pretest original thinking	−1.447	−1.626	.108	−3.221	.326
Posttest original thinking	−5.105	−6.113	.000	−6.769	−3.441
Pretest flexible thinking	−1.684	−.354	.725	−11.175	7.807
Posttest flexible thinking	−15.158	−4.192	.000	−22.363	−7.953

Table 12
Significant mean difference *t*-tests for research characteristics

Research characteristic	Mean difference	t	*p*	95% Simultaneous confidence interval	
				lower	upper
Pretest research skill	−1.368	−1.556	.124	−3.121	.384
Posttest research skill	−6.158	−8.819	.000	−7.549	−4.767
Pretest research behavior	−1.211	−.322	.748	−8.695	6.274
Posttest research behavior	−21.132	−8.197	.000	−26.268	−15.995
Pretest research ethic	−.053	−.099	.921	−1.113	1.008
Posttest research ethic	−1.947	−4.638	.000	−2.784	−1.111

contributing to learners' science learning outcomes, namely academic achievement, creative thinking, and research characteristics.

Today's teachers are called upon to work with colleagues to design learning environments that promote deeper engagement in learning as a reciprocal process. Since the 5P model was created to enhance students' academic achievement, teachers should be provided with training on the utilization of this model to promote students' engagement in their learning. The findings also indicated that emphasis on the development of research skills was important to enhance students' ability to construct their knowledge. Consequently, teachers should provide sufficient opportunities for students to develop research skills. This finding was in accordance with the results reported by Meerah et al. (2012), Walkington et al. (2011), and Willison and O'Regan (2007).

In addition one of the focus variables in this study was related to creative thinking. The 5P model is able to improve students' creative thinking through the development of creative thinking activities. For example, being able to speedily write down the problem situation (Wolff, 2012), to mind map (Barkley, 2010; Wolff, 2012), and to undertake creative categorization (Levy & Hagan, 2014) show development of students' creative thinking skills following implementation of the 5P model. Although the 5E model also showed improvement in creative thinking development, the improvement was less than that from using the 5P model. In addition, research characteristics are absolutely developed by utilizing the 5P model because this model places strong emphasis on teaching research skill training based on the research ethic. Therefore, the results of this study revealed that the 5P model can better enhance research characteristics, too.

It was concluded that the new instructional design 5P model, based on the theoretical foundation of RBL, is able to enhance the academic achievement, creative thinking, and research characteristics of Grade 9 students. It is a high-impact educational practice as shown by this study, and the benefits of RBL are being recognized as an important instructional design model. Maintaining a productive 5P instructional design model requires not only the dedication of the participating teachers, but also the establishment of a culture across schools that encourages research-based learning and provides a network of support for the teaching community. The proposed 5P model and its results had a positive impact on student learning. Essential further work includes developing this model with more direct and indirect assessment.

Conflict of interest

None.

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