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AN INVESTIGATION INTO THE EFFECTIVENESS OF PROCESS ORIENTED GUIDED INQUIRY LEARNING MODEL ON STUDENTS' LEARNING CHEMISTRY CONCEPTS

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Abstract

The main purpose of this study is to investigate the effectiveness of proposed process oriented guided inquiry learning model for chemistry teaching at the high school level in Myanmar. The research design was one of the quasi-experimental designs, the nonequivalent control group design. The participants were selected from Grade Ten students in BEHS Yekyi, BEHS Kwin Thone Zint, BEHS (5) Hinthada, BEHS Neikban, BEHS (2) Danuphyu and BEHS Alamyo in Ayeyawady Region by using simple random sampling method. There were totally (483) participants to conduct the experiment for this research study. From each school, two intact classes were randomly selected as experimental group who received proposed process oriented guided inquiry learning model and control group who received formal instruction. The instruments were pretest, posttest, and questionnaire. The data were analyzed by using one-way analysis of covariance (One-Way ANCOVA). According to ANCOVA results, there were significant differences in the achievement on concept skills between the experimental groups and control groups in all schools. The results of students' responses from questionnaire expressed that all students who participated in experimental groups had positive attitudes towards proposed process oriented guided inquiry leaning. Research findings proved that proposed process oriented guided inquiry learning model had positive contribution for chemistry teaching at the high school level in Myanmar.

Keywords: Guided Inquiry Learning, Process Oriented Guide Inquiry Learning, Teaching Model, Chemistry, Concept

Introduction

Developing students' teamwork spirits, critical thinking, problem solving and communication skills are educational goals of every discipline in 21st century. To develop these skills among the students, teachers should try to cultivate the habits of inquiry. Inquiry is a seeking for truth, and information through questioning. Inquiry encourages students to discover facts and to develop concepts. It not only provides ways of finding out and thinking, but can also increase students' interest in science (Kuhlthau, Maniotes & Caspari, 2007). In order to survive and flourish as a teacher in today's school; teachers have to learn ways of using effectively associated with teaching methods for students. To fulfill the requirements of basic education sector, it is important that process oriented guided inquiry learning can be implemented in basic education high school level.

Objectives of the Research

(1) To develop a process oriented guided inquiry learning model for chemistry teaching at the high school level.

(2) To investigate the effectiveness of proposed process oriented guided inquiry learning model on students' chemistry achievement.

(3) To explore the attitudes of students who participated in this research on the proposed process oriented guided inquiry learning model, and

(4) To give suggestions and recommendations for the improvement of chemistry teaching

Research Questions

(1) Are there any significant differences in the achievement on concept skills of students who received proposed process oriented guided inquiry learning model in teaching chemistry and those who do not receive it?

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(2) Do students who were taught with proposed process oriented guided inquiry learning model in teaching chemistry have positive attitudes towards the proposed process oriented guided inquiry learning model?

Scope of the Research

(1) This study is geographically restricted to Ayeyawady Region.

(2) Participants in this research study are Grade Ten chemistry students from the selected schools in the academic year (2019-2020).

(3) The content area is limited to six chapters from Grade Ten chemistry textbook prescribed by the Basic Education Curriculum, Syllabus and Textbook Committee of Ministry of Education, 2018.

Definitions of Key Terms

For this research study, definitions of key terms are presented as follows.

Guided Inquiry Learning: Guided inquiry is defined as interacting with concrete materials to gain knowledge about some scientific concepts by the guidance of the teacher in order to be able to solve a problem (Hassard, 2005).

Process Oriented Guided Inquiry Learning: Process oriented guided inquiry learning (POGIL) is a research-based, student-centered philosophy and science pedagogy in which students work in small groups to engage in guided inquiry using carefully designed materials that direct and guide students to build and rebuild their chemistry knowledge (Moog, Creegan, Hanson, Spencer & Straumanis, 2006).

Teaching Model: A teaching model is a plan or pattern that can be used to shape curriculum, to design instructional materials, and to guide instruction in the classroom and other settings (Joyce & Weil, 1980).

Chemistry: Chemistry is the study of the composition of matter and the changes that matter undergoes. Chemistry affects all aspects of life and most natural events because all living and nonliving things are made of matter (Wilbraham, Staley, Matta & Waterman, 2012).

Concept: A concept is a set of specific objects, symbols, or events which are grouped together on the basis of shared characteristics and which can be referenced by a particular name or symbol (Merill & Tennyson, 1977).

Statement of the Problem

Chemistry, the central science, is a systematic inquiry about natural phenomena. Although chemistry is central in the drive of global sustainable economic development, students have many misconceptions about chemistry. Chemistry curricula commonly incorporate many abstract concepts which are central to further learning in both chemistry and other science. Chemistry learning involves conceptual relationships among macroscopic, microscopic, and symbolic representations (Dori & Hamairi, 2003, cited in Bilgin, 2006).

In Myanmar, chemistry is taught at the high school level in English language. However, students taught the science subjects in Myanmar language from primary to middle school level. Besides, Myanmar is undergoing critical lack of resources and skills and little practical application in the classroom. It emphasizes upon rote learning and memorization of factual information. Therefore, students can have misconceptions in chemistry lessons due to language barriers, lack of resources and skills and little practical application.

Process oriented guided inquiry learning can solve many struggles faced by teachers and students in teaching of chemistry. It is hoped that it can be useful, to some extent, for the improvement of chemistry teaching at the high school level in Myanmar. Therefore, this study is to explore both students' chemistry concept skills and the attitudes of chemistry students towards proposed process oriented guided inquiry learning model.

Review of Related Literature

Philosophical Foundations of Process Oriented Guided Inquiry Learning

Progressivism, pragmatism, cognitivism and constructivism are deeply taken into philosophical foundations for developing proposed process oriented guided inquiry learning model.

Progressives place more emphasis on the process of learning than on the end product. In process oriented guided inquiry learning, the emphasis is on the process rather than on the product. Process oriented guided inquiry learning derives students to be good problem solvers and good thinkers.

Pragmatism puts emphasis on free flow of ideas, spirit of inquiry of investigation and discussion. Students investigate learning activities, solve chemistry problems and then explore experiments to get necessary concept. In process oriented guided inquiry learning model, the implementing phase focuses on learning activities to think about and solve the investigated problem.

Cognitivism involves how people think and gain knowledge (Brandi, 2011). In process oriented guided inquiry learning model, students explore, determine and apply concepts. Constructivism emphasizes hands-on activity, activity-based teaching and learning (Ozmon & Craver, 1986). Students construct their own understanding and knowledge through experiences. In process oriented guided inquiry learning model, the implementing phase emphasizes students to construct knowledge by connecting with their previous ideas and experiences.

Psychological Foundations of Process Oriented Guided Inquiry Learning

Piaget's cognitive learning theory, Vygotsky's sociocultural theory and Gagne's information processing theory are deeply taken into psychological foundations for developing proposed process oriented guided inquiry learning model. In Piaget's cognitive learning theory, cognitive development is achieved through observation and experimentation. In Vygotsky's sociocultural theory, interactions with persons in the environment stimulate developmental processes and foster cognitive growth (Schunk, 2012). Gagne's information processing model describes how people input information into their central processor (brain), and how they process that information within various memory systems until appropriate output or responses can be generated (Fetsco & McClure, 2005).

Background Teaching Models of Process Oriented Guided Inquiry Learning

Gerlach and Ely model, Talyzina's cognitivo-cybernetic model, Bybee's 5E instructional model and Professor Dr. Khin Zaw's multimodal model are background teaching models that support the proposed process oriented guided inquiry learning model.

Gerlach and Ely model consists of ten elements: identification of content, specification of objectives, assessment of entering behaviors, determination of strategy, organization of groups, allocation of time, allocation of space, selection of resources, evaluation of performance, and analysis of feedback. The orientation phase of proposed process oriented guided inquiry learning model is based on the first and second phase of Gerlach and Ely model, organizing small groups step in the organization phase of proposed process oriented guided inquiry learning model is based on the fifth phase of Gerlach and Ely model, the summative evaluation phase of proposed process oriented guided inquiry learning model is based on the ninth phase of Gerlach and Ely model, and the feedback phase of proposed process oriented guided inquiry learning model is based on the last phase of Gerlach and Ely model.

Talyzina's cognitivo-cybernetic model is composed of eight elements: instructional objectives, input level or entering behavior, selection and/or structuring of knowledge, technological devices or multimedia presentation of materials, acquisitional steps or step-by-step psychological theory, teaching algorithms, feedback phase, and regulation or corrective action stage. Defining instructional objective in the orientation phase of proposed process oriented guided inquiry learning model is based on the first phase of Talyzina's cognitivo-cybernetic model, connecting to prior conception step in the implementation phase of proposed process oriented guided inquiry learning model is based on the second phase of Talyzina's cognitivo-cybernetic model, and feedback phase of proposed process oriented guided inquiry learning model is based on the seven phase of Talyzina's cognitivo-cybernetic model.

Bybee's 5E instructional model comprises of five components: engagement, exploration, explanation, elaboration and evaluation. The heart of proposed process oriented guided inquiry learning model is implementation phase. Every step in implementation phase of proposed process oriented guided inquiry learning model is based on Bybee's 5E instructional model.

Khin Zaw's multimodal model consists of five main components: channel capacity, brain resilience, redundancy, unitizing/symbolizing modes, and diffusing/re-synthesizing modes. It is important in teaching and learning process because it gives pedagogues, teachers and students the ways how the human brain works, transmits and transforms information and data. Identifying a need to learn and connecting to prior conception in implementation phase of proposed process oriented guided inquiry learning model is based on channel capacity of multimodal model. Moreover, the brain must think and devise ways and means of coping with the overwhelming multitude of stimulus information to be taught that have to be encountered every day of its physical life.

Proposed Process Oriented Guided Inquiry Learning Model

Proposed process oriented guided inquiry learning model for effective instructional process is developed for Myanmar high school chemistry teaching. Proposed process oriented guided inquiry learning model is organized into four main phases.

(1) Orientation;
(2) Organization;
(3) Implementation; and
(4) Summative Evaluation.

These four phases are sequential and interrelated. The teacher first orientates, organizes, then implements those plans and finally evaluates the achievement of students' chemistry activities and knowledge.

(1) Orientation

The orientation phase prepares for students' learning. This stage is composed of two tasks including preparation of content, and defining instructional objectives.

(2) Organization

The organization phase is essential as the beginning of the learning process. This stage is also consisted of two tasks including organizing small groups, and assigning and defining roles.

(3) Implementation

The implementation phase is a key to succeed the whole teaching and learning process for teachers. This stage is composed of nine tasks including identifying a need to learn, connecting to prior conception, providing instructional materials, exploring experiment for concept, determining concept, applying concept in context, reporting findings, generalizing solution of problem and formative evaluation.

(4) Summative Evaluation

After implementation phase, summative evaluation is performed. To evaluate how well the students have achieved the instructional objectives, summative evaluation is made. If they can perform well in an inquiry process, they can proceed to the next content. If they cannot, they have to go back again to the step of feedback according to the proposed process oriented guided inquiry learning model.

The proposed process oriented guided inquiry learning model is described in the following Figure 1.

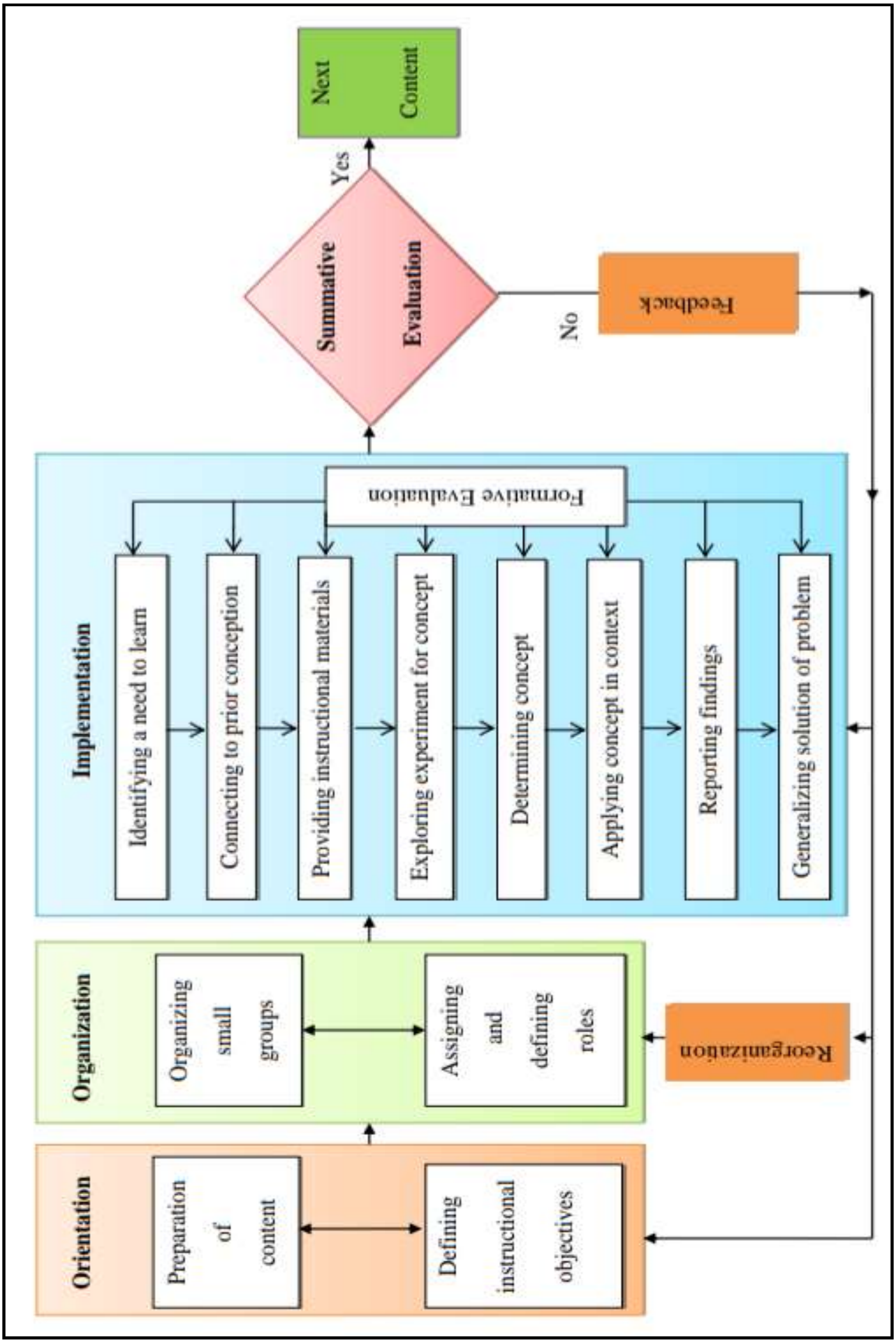

Figure 1: Proposed Process Oriented Guided Inquiry Learning Model

Method

Population and Sample: Table 1 shows population and sample size of this research study.

Table 1 Population and Sample Size

Selected District	Selected Township	Selected School	No. of Population	No. of Subject		
				Experimental	Control	Total
Pathein	Yekyi	BEHS Yekyi	125	45	34	79
		BEHS Kwin Thone Zint	64	32	32	64
Hinthada	Hinthada	BEHS (5) Hinthada	123	46	40	86
		BEHS Neikban	101	49	52	101
Maubin	Danuphyu	BEHS (2) Danuphyu	85	46	39	85
		BEHS Alamyo	68	34	34	68
Total			**566**	**252**	**231**	**483**

Research Design: The research design was nonequivalent control group design.

Research Instruments: Pretest, posttest and questionnaire were used as instruments.

Data Analysis: The Statistical Package for the Social Sciences (SPSS) version (22) was used to analyze the data. The data were analyzed by using one-way analysis of covariance.

Findings

Findings for Posttest

The first research question of this study is: "Are there any significant differences in the achievement on concept skills of students who received proposed process oriented guided inquiry learning model in teaching chemistry and those who do not receive it?" To answer this research question, one-way ANCOVA was used to analyze the data from posttest.

From each school, the two intact groups were selected as the experimental group who received proposed process oriented guided inquiry learning model and the control group who received formal instruction. As pointed out by Pallant (2013), ANCOVA is used when the study has been unable to randomly assign the participants to the different groups, but instead has had to use existing groups.

Table 2 shows the results of pretest scores in the six selected schools.

Table 2 Results of Pretest Scores in Six Selected Schools

School	Group	N	M	SD	MD	*F*	*p*
S1	Experimental	45	39.27	4.19	0.53	.31	.582 (ns)
	Control	34	38.74	4.27			
S2	Experimental	32	31.25	3.34	1.88	2.31	.134 (ns)
	Control	32	29.37	6.13			
S3	Experimental	46	32.22	4.26	- 0.50	.32	.571 (ns)
	Control	40	32.72	3.97			
S4	Experimental	49	34.47	3.52	1.16	1.97	.163 (ns)
	Control	52	33.31	4.68			

School	Group	N	M	SD	MD	*F*	*p*
S5	Experimental	46	35.04	5.79	0.04	.00	.966 (ns)
	Control	39	35.00	2.75			
S6	Experimental	34	39.35	5.44	0.38	.10	.753 (ns)
	Control	34	38.97	4.50			

Note. S1 = BEHS Yekyi; S2 = BEHS Kwin Thone Zint; S3 = BEHS (5) Hinthada; S4 = BEHS Neikban; S5 = BEHS (2) Danuphyu; S6 = BEHS Alamyo, ns = not significant

Findings of Concept Skills on Posttest in S1

Table 3 shows the analysis of covariance results for concept skills of posttest in S1.

Table 3 Analysis of Covariance Results for Concept Skills of Posttest in S1

Level	Group	N	M	SD	MD	*F*	*p*
Knowledge	Experimental	45	7.91	1.54	0.17	.31	.577 (ns)
	Control	34	7.74	.97			
Comprehension	Experimental	45	8.58	1.50	3.20	67.24	.000***
	Control	34	5.38	1.59			
Application	Experimental	45	5.69	1.29	3.54	172.79	.000***
	Control	34	2.15	1.08			
Analysis	Experimental	45	7.31	1.16	1.52	12.11	.001**
	Control	34	5.79	2.09			
Synthesis	Experimental	45	6.87	2.13	3.34	35.15	.000***
	Control	34	3.53	2.85			
Evaluation	Experimental	45	7.84	.367	4.02	48.47	.000***
	Control	34	3.82	3.69			
Overall	Experimental	45	44.20	3.51	15.85	178.31	.000***
	Control	34	28.35	7.36			

Note. ***$p < .001$, **$p < .01$, ns = not significant

Concerning knowledge level questions, there was no significant difference in the posttest mean scores between the experimental group and the control group. Therefore, it can be interpreted that the formal instruction had a significant effect on remembering facts and terms like proposed process oriented guided inquiry learning model in S1. For comprehension, application, analysis, synthesis and evaluation level questions, there were significant differences between the experimental group and the control group for the posttest mean scores. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had the ability to understand, apply, analyze, synthesize and evaluate concept skills of students in S1.

Findings of Concept Skills on Posttest in S2

Table 4 shows the analysis of covariance results for concept skills of posttest in S2.

Table 4 Analysis of Covariance Results for Concept Skills of Posttest in S2

Level	Group	N	M	SD	MD	*F*	*p*
Knowledge	Experimental	32	7.41	1.52	0.41	1.21	.276 (ns)
	Control	32	7.00	1.34			
Comprehension	Experimental	32	8.03	1.53	1.34	8.06	.006**
	Control	32	6.69	2.18			

Level	Group	N	M	SD	MD	*F*	*p*
Application	Experimental	32	5.84	1.11	3.50	78.06	.000***
	Control	32	2.34	1.85			
Analysis	Experimental	32	6.47	1.83	1.47	7.19	.009**
	Control	32	5.00	2.50			
Synthesis	Experimental	32	6.91	1.25	3.35	51.45	.000***
	Control	32	3.56	2.42			
Evaluation	Experimental	32	6.88	1.36	3.50	32.26	.000***
	Control	32	3.38	3.05			
Overall	Experimental	32	41.44	3.00	13.38	89.71	.000***
	Control	32	28.06	7.55			

Note. ***$p < .001$, **$p < .01$, ns = not significant

Concerning knowledge level questions, there was no significant difference in the posttest mean scores between the experimental group and the control group. Therefore, it can be interpreted that the formal instruction had a significant effect on remembering facts and terms like proposed process oriented guided inquiry learning model in S2. For comprehension, application, analysis, synthesis and evaluation level questions, there were significant differences between the experimental group and the control group for the posttest mean scores. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had the ability to understand, apply, analyze, synthesize and evaluate concept skills of students in S2.

Findings of Concept Skills on Posttest in S3

Table 5 shows the analysis of covariance results for concept skills of posttest in S3.

Table 5 Analysis of Covariance Results for Concept Skills of Posttest in S3

Level	Group	N	M	SD	MD	*F*	*p*
Knowledge	Experimental	46	8.20	.78	0.20	1.45	.232 (ns)
	Control	40	8.00	.72			
Comprehension	Experimental	46	9.46	1.05	1.16	15.24	.000***
	Control	40	8.30	1.47			
Application	Experimental	46	6.24	.79	1.76	54.30	.000***
	Control	40	4.48	1.47			
Analysis	Experimental	46	6.65	1.25	1.70	34.21	.000***
	Control	40	4.95	1.43			
Synthesis	Experimental	46	7.35	1.46	5.40	97.64	.000***
	Control	40	1.95	3.15			
Evaluation	Experimental	46	5.76	3.02	4.48	43.25	.000***
	Control	40	1.28	2.57			
Overall	Experimental	46	43.74	4.47	14.79	267.39	.000***
	Control	40	28.95	3.84			

Note. ***$p < .001$, ns = not significant

Concerning knowledge level questions, there was no significant difference in the posttest mean scores between the experimental group and the control group. Therefore, it can be interpreted that the formal instruction had a significant effect on remembering facts and terms like proposed process oriented guided inquiry learning model in S3. For comprehension, application, analysis, synthesis and evaluation level questions, there were significant differences between the experimental group and the control group for the posttest mean scores. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had the ability to understand, apply, analyze, synthesize and evaluate concept skills of students in S3.

Findings of Concept Skills on Posttest in S4

Table 6 shows the analysis of covariance results for concept skills of posttest in S4.

Table 6 Analysis of Covariance Results for Concept Skills of Posttest in S4

Level	Group	N	M	SD	MD	*F*	*p*
Knowledge	Experimental	49	7.80	1.22	- 0.01	.68	.410 (ns)
	Control	52	7.81	1.07			
Comprehension	Experimental	49	9.43	.76	2.58	66.56	.000***
	Control	52	6.85	1.64			
Application	Experimental	49	4.53	1.02	2.95	123.87	.000***
	Control	52	1.58	1.54			
Analysis	Experimental	49	7.18	.81	3.03	76.62	.000***
	Control	52	4.15	2.25			
Synthesis	Experimental	49	6.98	.99	4.94	262.14	.000***
	Control	52	2.04	1.80			
Evaluation	Experimental	49	7.57	.71	3.20	43.21	.000***
	Control	52	4.37	3.16			
Overall	Experimental	49	43.55	2.22	16.70	240.12	.000***
	Control	52	26.85	6.64			

Note. ***p < .001, ns = not significant

Concerning knowledge level questions, there was no significant difference in the posttest mean scores between the experimental group and the control group. Therefore, it can be interpreted that the formal instruction had a significant effect on remembering facts and terms like proposed process oriented guided inquiry learning model in S4. For comprehension, application, analysis, synthesis and evaluation level questions, there were significant differences between the experimental group and the control group for the posttest mean scores. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had the ability to understand, apply, analyze, synthesize and evaluate concept skills of students in S4.

Findings of Concept Skills on Posttest in S5

Table 7 describes the analysis of covariance results for concept skills of posttest in S5.

Table 7 Analysis of Covariance Results for Concept Skills of Posttest in S5

Level	Group	N	M	SD	MD	*F*	*p*
Knowledge	Experimental	46	8.41	.69	0.59	8.19	.005**
	Control	39	7.82	1.19			
Comprehension	Experimental	46	9.72	.50	0.57	7.47	.008**
	Control	39	9.15	1.23			
Application	Experimental	46	5.87	.40	0.95	13.01	.001**
	Control	39	4.92	1.59			

Level	Group	N	M	SD	MD	*F*	*p*
Analysis	Experimental	46	5.72	1.15	1.85	40.08	.000***
	Control	39	3.87	1.45			
Synthesis	Experimental	46	4.37	1.06	1.99	47.38	.000***
	Control	39	2.38	1.57			
Evaluation	Experimental	46	7.48	.72	1.79	16.51	.000***
	Control	39	5.69	2.28			
Overall	Experimental	46	41.57	1.81	7.72	81.78	.000***
	Control	39	33.85	5.49			

Note. ***p < .001, **p < .01

Concerning knowledge, comprehension, application, analysis, synthesis and evaluation level questions, there were significant differences between the experimental group and the control group for the posttest mean scores. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had the ability to remember, understand, apply, analyze, synthesize and evaluate concept skills of students in S5.

Findings of Concept Skills on Posttest in S6

Table 8 shows the analysis of covariance results for concept skills of posttest in S6.

Table 8 Analysis of Covariance Results for Concept Skills of Posttest in S6

Level	Group	N	M	SD	MD	*F*	*p*
Knowledge	Experimental	34	7.59	.74	0.24	.79	.375 (ns)
	Control	34	7.35	1.35			
Comprehension	Experimental	34	9.12	.84	1.47	17.20	.000***
	Control	34	7.65	1.76			
Application	Experimental	34	6.59	.86	3.33	51.97	.000***
	Control	34	3.26	2.50			
Analysis	Experimental	34	5.53	1.29	1.00	7.54	.008**
	Control	34	4.53	1.75			
Synthesis	Experimental	34	6.50	1.73	5.06	126.72	.000***
	Control	34	1.44	1.96			
Evaluation	Experimental	34	7.44	.50	3.91	53.87	.000***
	Control	34	3.53	3.06			
Overall	Experimental	34	42.76	2.92	14.94	224.87	.000***
	Control	34	27.82	5.14			

Note. ***p < .001, **p < .01, ns = not significant

Concerning knowledge level questions, there was no significant difference in the posttest mean scores between the experimental group and the control group. Therefore, it can be interpreted that the formal instruction had a significant effect on remembering facts and terms like proposed process oriented guided inquiry learning model in S6. For comprehension, application, analysis, synthesis and evaluation level questions, there were significant differences between the experimental group and the control group for the posttest mean scores. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had the ability to understand, apply, analyze, synthesize and evaluate concept skills of students in S6.

Figure 2 shows graphic illustrations of the comparison of concept skills on overall posttest mean scores for the six selected schools.

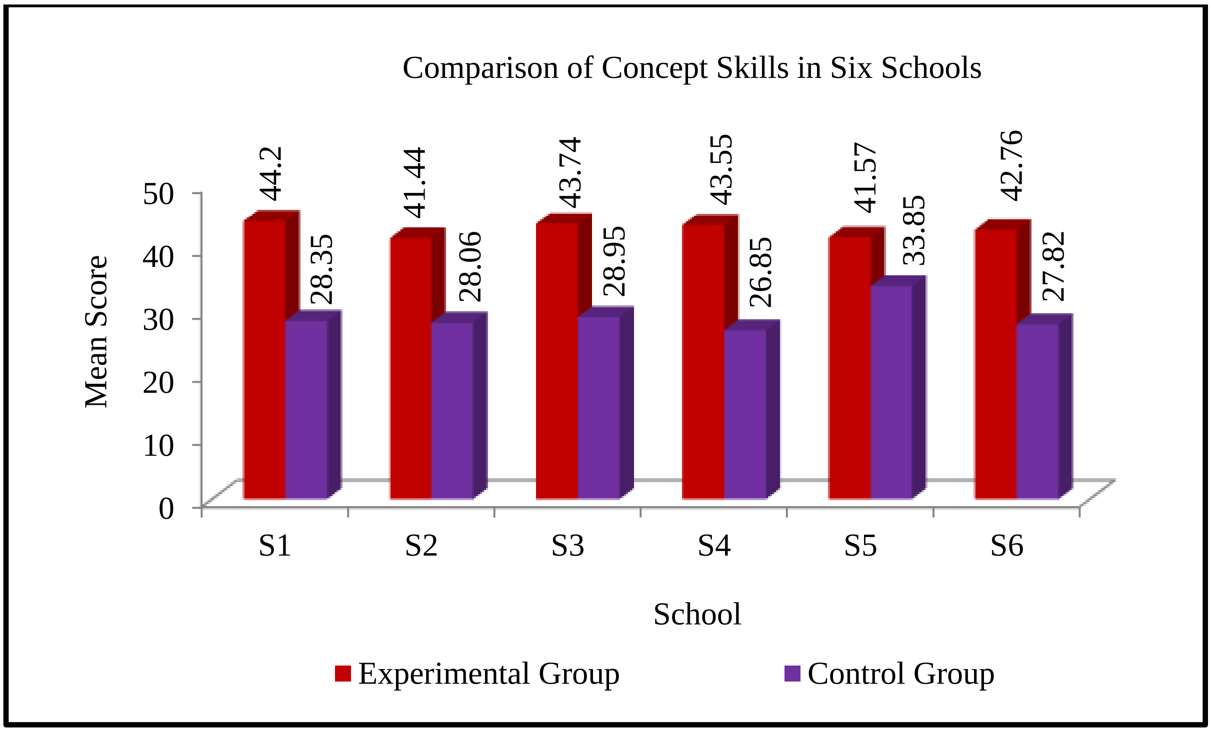

Figure 2 Graphic Illustration of the Comparison of Concept Skills on Overall Posttest Mean Scores for the Six Selected Schools

Findings for Students' Responses from Questionnaire

The second research question of this study is: "Do students who were taught with proposed process oriented guided inquiry learning model in teaching chemistry have positive attitudes towards the proposed process oriented guided inquiry learning model? To answer this research question, percentages of agreement and disagreement were calculated for all items in the questionnaire.

The attitudes of students who participated in experimental groups towards proposed process oriented guided inquiry learning are presented in terms of four areas such as developing good habits through small group discussions (item number 1, 2, 3 and 4), developing good habits through inquiring (item number 5, 6, 7 and 8), developing good habits through practical activities (item number 9, 10, 11 and 12), and developing POGIL process skills (item number 13, 14, 15, 16, 17, 18 and 19).

The students' attitude questionnaire consists of (19) statements linked to a five-point Likert scale, ranging from strongly disagree to strongly agree. The scores were given 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, and 5 = strongly agree. All these questions are structured items that were answered by ticking the provided response options.

Table 9 shows the results of students' attitudes towards proposed process oriented guided inquiry learning model.

Table 9 Students' Attitudes toward Proposed Process Oriented Guided Inquiry Learning Model

Item No.	Statement	N	Percentage (%)				
			Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1.	Through this proposed process oriented guided inquiry learning model, I develop cognitive and social skills.	252	1	2	6	73	28
2.	Through this proposed process oriented guided inquiry learning model, I develop the skills of finding new information through familiar content, debating and working hard to get the correct solution.	252	2	2	4	55	37
3.	Through this proposed process oriented guided inquiry learning model, I can learn to work in groups and develop the habit of collaboration to solve problems.	252	1	1	1	35	62
4.	Through this proposed process oriented guided inquiry learning model, I develop the habit of responsibility in different roles (manager, spokesperson, recorder and strategy analyst).	252	0.3	2.7	9.5	45	42.5
5.	Through this proposed process oriented guided inquiry learning model, I develop the habit of inquiring various concerns about a problem.	252	0.3	1.2	6	43.3	49.2
6.	Through this proposed process oriented guided inquiry learning model, I develop the habit of inquiring the possible ways to solve a problem.	252	0.3	2.7	8	55	34
7.	Through this proposed process oriented guided inquiry learning model, I develop the habits of inquiring not only chemistry subject but also other subjects.	252	1	0	6	38	55
8.	Through this proposed process oriented guided inquiry learning model, I develop the habits of inquiring in order to gain new knowledge and experiences.	252	1	0.8	5	45.6	47.6
9.	Through this proposed process oriented guided inquiry learning model, I am satisfied myself as it is important for academic achievement.	252	0.3	2.7	7	40	50

Item No.	Statement	N	Percentage (%)				
			Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
10.	Through this proposed process oriented guided inquiry learning model, I want to ask questions and discuss with each other until I get the correct answers.	252	3	2	6	41	48
11.	Through this proposed process oriented guided inquiry learning model, I want to do hands-on activities myself.	252	2	2	11	47	38
12.	Through this proposed process oriented guided inquiry learning model, I want to implement this teaching model not only in chemistry but also in other subjects.	252	1	4	6	41	48
13.	This teaching model enables me to improve knowledge and information.	252	3	6	17	56	18
14.	This teaching model enables me to develop critical thinking skill.	252	1	3	7.5	58	30.5
15.	This teaching model enables me to develop problem solving skill.	252	1	12	18	46.8	22.2
16.	This teaching model enables me to develop the skill of management in their learning activities.	252	1	3	13.9	43.6	38.5
17.	This teaching model enables me to develop communication skill.	252	1	4	6	50	39
18.	This teaching model enables me to develop teamwork spirit.	252	1	1	3	46	49
19.	This teaching model enables me to develop self-assessment and assessment of other's responses.	252	2	2	11	43.3	41.7

Note. N = Number of students who participated in the experimental groups

Based on the results of Table (9), most of the students who participated in experimental groups had positive attitudes in four areas of proposed process oriented guided inquiry learning model: developing good habits through small group discussions, developing good habits through inquiring, developing good habits through practical activities, and developing POGIL process skills. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had a significant effect on students' learning to get chemistry concepts.

Discussion and Suggestions

Concerning knowledge level on posttest scores, there were no significant differences between experimental groups and control groups at knowledge level questions in S1, S2, S3, S4 and S6. Generally, formal instruction could improve the lowest level of cognitive domain.

Therefore, it can be interpreted that the formal instruction could improve and remember facts, terms and basic concepts on knowledge level questions like proposed process oriented guided inquiry learning model. However, there was a significant difference between experimental group and control group at knowledge level questions in S5. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had a significant effect on the development of concept skills of students in S5.

Concerning comprehension, application, analysis, synthesis and evaluation level questions on posttest scores, there were significant differences between experimental groups and control groups at comprehension, application, analysis, synthesis and evaluation level questions in all schools. This is due to the fact that students from the experimental groups understand chemistry facts, ideas and concepts by organizing, comparing, interpreting, giving descriptions and stating the main ideas more than those of control groups. This result is similar with the findings of Şen, Yilmaz and Geban (2016) from a public school in Turkey that process oriented guided inquiry learning resulted in a better acquisition of scientific conceptions and in changing misconceptions in electrochemistry concepts.

Concerning attitude questionnaire of students towards proposed process oriented guided inquiry learning model, it consists of four main areas such as developing the good habits through small group discussions, developing the good habits through inquiring, developing the good habits through practical activities, and developing POGIL process skills. According to the results, all students who participated in experimental groups had positive attitudes towards proposed process oriented guided inquiry learning model. Therefore, it can be concluded that proposed process oriented guided inquiry learning model has the positive effects on the development of concept skills of students at the high school level in Myanmar.

From the results of research findings, the following suggestions are described to improve teaching and learning of chemistry. Concerning suggestions for students' learning, the experimental groups who received proposed process oriented guided inquiry learning model were significantly higher than control groups who did not receive it for concept skills on posttest from the six selected schools. Relating the students' attitudes towards proposed process oriented guided inquiry learning model, it consists of four areas: developing the good habits through small group discussions, developing the good habits through inquiring, developing the good habits through practical activities and developing POGIL process skills. According to these results, it was found that all students who participated in experimental groups had positive attitudes towards proposed process oriented guided inquiry learning model. This is due to the fact that most of the students agree that they were very interested in proposed process oriented guided inquiry learning model because they worked in small group discussion, learned practical activities, and explored chemistry concepts through additional reference books and key questions. Therefore, it is suggested that chemistry students should be given the opportunities such as small group discussion, practical activities, exploring chemistry concepts through additional reference books and key questions.

Concerning suggestions for the improvement of chemistry subject, chemistry is based on both practice and interpretation. According to Basic Education Curriculum, Syllabus and Textbook Committee (2017-2018), there are (15) chapters in Grade Ten chemistry textbook. It is organized five main areas such as matter, laboratory preparation, laws and questions and problems, mathematical problems and practical activities. However, it is not possible to use proposed process oriented guided inquiry learning model for all activities and chemistry concepts in Grade Ten chemistry textbook. But, it should be used based on the time and circumstance of a lesson. Therefore, it is suggested that chemistry teachers should use this learning model in accordance with the nature of the content area.

The results of this research study contributed to the improvement of teaching and learning chemistry at the high school level. However, there is no perfection for all circumstances of a situation. Therefore, it is necessary to conduct for future research study. Since all data were collected from Ayeyawady Region, further research study should be carried out in the rest of the States and Regions to become generalization. Actually, this research study was carried out in chemistry subject of Grade Ten. So, further research should be carried out Grade Eleven and other subjects. In this study, the content areas were limited to six chapters: symbols, formulae and equations, formula writing and the naming system, the mole concept, oxygen and its compounds, oxides and hydroxides and hydrogen from Grade Ten chemistry textbook. Further research should be carried out more topics to become generalization.

According to these results, experimental groups improved concept skills more than those of control groups in all schools. The results also showed that proposed process oriented guided inquiry learning model made improvement not only in urban schools but also in rural schools. Therefore, it can be interpreted that proposed process oriented guided inquiry learning model had a significant effect on the development of concept skills of students in all schools.

Conclusion

The main objective of this study is to investigate the effectiveness of proposed process oriented guided inquiry learning model for chemistry teaching at the high school level. Process oriented guided inquiry learning is a very effective teaching method not only in rural schools but also in urban schools for the improvement of academic achievement of students. According to the results of research findings, it can be concluded that students who were taught by proposed process oriented guided inquiry learning model positively contributed to the improvement of students' academic achievement at the high school level. Therefore, it is hoped that the proposed process oriented guided inquiry learning model will make substantial contributions to the chemistry teaching optimum in Myanmar high schools.

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