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Learning Outcomes on Nuclear Chemistry and 21st Century Skills of the First-Year Undergraduates Students through Cooperative Learning and Self-Directed Learning

ผลการเรียนรู้เรื่องเคมีนิวเคลียร์และทักษะแห่งศตวรรษที่ 21 ของนิสิตปริญญาตรีชั้นปีที่ 1 ที่ได้รับการจัดการเรียนรู้แบบร่วมมือร่วมกับการเรียนรู้ด้วยตนเอง

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บทคัดย่อ

วัตถุประสงค์ของการวิจัยนี้ คือ 1) เพื่อเปรียบเทียบผลการเรียนรู้เรื่องเคมีนิวเคลียร์ของผู้เรียนระหว่างก่อนเรียนและหลังเรียนที่ได้รับการจัดการเรียนรู้แบบร่วมมือร่วมกับการเรียนรู้ด้วยตนเอง 2) เพื่อศึกษาทักษะแห่งศตวรรษที่ 21 (ทักษะการเรียนรู้และนวัตกรรม) ของผู้เรียนหลังเรียนโดยใช้การเรียนรู้แบบร่วมมือร่วมกับการเรียนรู้ด้วยตนเอง และ 3) เพื่อศึกษาความพึงพอใจของผู้เรียนที่มีต่อการจัดการเรียนรู้ฯ รูปแบบของงานวิจัยเป็นแบบกึ่งทดลอง (Quasi-experimental research) ใช้กลุ่มทดลองหนึ่งกลุ่มซึ่งมีการทดสอบก่อนเรียนและหลังเรียน (One group pretest posttest design) กลุ่มตัวอย่างคือนิสิตคณะวิทยาศาสตร์ชั้นปีที่ 1 จำนวน 1 ห้องเรียน (35 คน) ผลการวิจัยพบว่า ผลการเรียนรู้เรื่องเคมีนิวเคลียร์ของผู้เรียนมีค่าเฉลี่ยของคะแนนหลังเรียนสูงกว่าก่อนเรียนอย่างมีนัยสำคัญทางสถิติที่ระดับ .05 ผลการประเมินตนเองของผู้เรียนด้านทักษะการเรียนรู้และนวัตกรรมมีค่าเฉลี่ยอยู่ในระดับดี ($\bar{X}$= 3.98 จากคะแนนเต็ม 5) และผู้เรียนมีความพึงพอใจต่อการจัดการเรียนรู้อยู่ในรับดีมาก การวิจัยนี้สรุปได้ว่า การจัดการเรียนรู้แบบร่วมมือร่วมกับการเรียนรู้ด้วยตนเองสามารถพัฒนาผลการเรียนรู้เรื่องเคมีนิวเคลียร์และทักษะแห่งศตวรรษที่ 21 ของผู้เรียนได้ และผู้เรียนมีความพึงพอใจที่ดีมากต่อการจัดการเรียนรู้

คำสำคัญ: *การเรียนรู้แบบร่วมมือ การเรียนรู้ด้วยตนเอง ผลการเรียนรู้ เคมีนิวเคลียร์*

Abstract

The purposes of this research were: 1) to compare the students' learning outcomes between before and after learning by using cooperative learning and self-directed learning, 2) to study the students' the 21st century skills (focusing on learning and innovation skills) of the students using self-

assessment form, and 3) to study the students' satisfaction towards the instruction on nuclear chemistry using cooperative learning and self-directed learning. A quasi-experimental research of one group pre-test post-test design was used in this study. The sample group was one classroom (35 students) of the first-year science undergraduate students. The results showed that the mean scores of the learning outcomes of posttest were higher than those of pretest at the statistically significant level of .05. The mean score of students' self-assessment of 21st century skills (learning and innovation skills) was at good level or high level of performance ($\bar{x}$= 3.98 from total score = 5), and the students' satisfaction towards the instruction was at very good level. The main conclusion showed that cooperative learning and self-directed learning can enhance the students' learning outcomes and 21st century skills and the participants showed positive opinions towards the instruction.

Keywords*: Cooperative learning, Self-directed learning, Learning outcomes, Nuclear chemistry*

Introduction

Cooperative learning and self-directed learning are an essential factor for higher education. The learning process involves a change in the instructor's role from lecturer to facilitator to organize groups and to encourage working together (Weimer, 2012).The expected educational changes, the skills requested for the 21stcentury: putting the focus on life-long learning, collaborative and self-directed learning (Damian & Georgescu, 2014). The P21 Framework for 21st Century Learning indicates that collaboration is one of the four Cs, along with creativity, critical thinking, and communication (Marassa, 2017; P 21 Partnership, 2017). Research suggests that a focus on developing collaboration knowledge and skill is important for several reasons: people who know more about collaborating go on to enjoy higher performance in team settings, training students to work together makes collaborative or cooperative learning approaches to teaching more successful in terms of student learning, strengthening students' collaboration skills can also enhance their prospects for employment and job advancement once they leave school. Learning and innovation skills are being recognized as the skills that separate students who are prepared for increasingly complex life and work environments in the 21st century. A focus on creativity, critical thinking, communication and collaboration is essential to prepare students for the future.

There is strong agreement among researchers that cooperative learning and self-directed learning methods have positive effects on student achievement. In addition, cooperative learning is a very useful method for checking on understanding and helping to teach a variety of learning strategies. Cooperative learning and self-directed learning are effective ways to stimulate students to become more interested in the subject, thereby acquiring a better comprehension of what they had studied. Instruction for higher education must develop self-directed learning skills to students and promote

students with 21st century skills. Self-directed learning is a competence that must be developed for the learning process for undergraduate students. From the experience that the researcher taught the undergraduate students on the course of chemistry for science teachers I, it is found that the students still have quite a few learning and innovation skills. For these reasons, techniques of cooperative learning and self-directed learning were used for instructional methods to improve the learning outcomes on Chemistry and 21st century skills of the first-year science undergraduates (focusing on learning and innovation skills).

Many studies support that CPL can enhance academic performance and learning achievement of students (Johnson , Johnson & Stanne, 2017). CPL is an effective teaching method or instructional methods to promote critical thinking skills, helps to develop higher level thinking skills of students. Furthermore Cooperative learning activities can encourage student responsibility for learning, increases student retention and builds self-esteem (Foldnes, 2016; Herrmann, 2013; Roseth, Jhonson & Johnson, 2008). The review of the literature strongly suggests that cooperative learning has been used as instructional strategy with positive effect on academic achievement (Gull & Shehzad, 2015).

Self-directed learning (SDL) has been studied over the years and it was determinate that it is mainly found in the adult education. Furthermore, SDL is one of instructional methods that promote learner self-direction of personality characteristics in learning. SDL is a learning process through which individual take responsibility and initiative to determine their learning needs, formulate learning goals, identify resources for learning, select and implement learning strategies and evaluate learning outcomes within a given framework. Many studies support that SDL is beneficial to planning and designing instruction (Geri, 2007). Using self-directed learning activity can improve science learning achievement and learning skills (Okoye & Okecha, 2008). In addition, the research result of Kanan and Osman (2015) shows that students that are highly self-directed can depend on themselves in learning science and would have greater academic achievement in science. SDL skills are much needed to prepare student to enter university. Therefore, self-directed learning readiness was suggested to be one of the contributing factors towards higher academic achievement in science (Kavalenco & Smirnova, 2015).

For these reasons, instructional techniques of cooperative learning and self-directed learning were used in the course SC211 Chemistry for Science Teachers I, which the researcher is the instructor of this course. The topic of Nuclear Chemistry, which was a part of the content of this course was used to design the learning activities. This study aims to improve the students' learning outcomes and 21st century skills, which focusing on learning and innovation skills. Cooperative learning technique was used in organizing learning activities in the class and self-directed learning technique was used both in the class and outside the class.

Objectives of the Study

The aims of this research were:

1) to compare the students' learning outcomes between before and after learning by using cooperative learning and self-directed learning,

2) to study the 21st century skills (focusing on learning and innovation skills) of the students using self-assessment form, and

3) to study the students' satisfaction towards the instruction on nuclear chemistry using cooperative leaning and self-directed learning.

Methods

Research design: A quasi-experimental research of one group pretest posttest design was used in this study.

Participants

The sample group was one classroom of the first-year undergraduate science students, in the program of Bachelor of Education (General Science) in the Department of General Science, Faculty of Science, at Srinakharinwirot University in Bangkok, Thailand. The participants were selected by using purposive sampling from the students who enrolled in the course of SC211 Chemistry for Science Teachers I in the second semester of the 2017 academic year. There were 35 students (12 males and 23 females) in the class. These students were taught by the researcher as the instructor of this course.

Variable

The independent variable was the instruction on nuclear chemistry using cooperative learning and self-directed learning.

The dependent variable were:

(1) the students' learning outcomes on nuclear chemistry,

(2) the 21st century skills (learning and innovation skills) of the students, and

(3) the students' satisfaction towards the instruction on nuclear chemistry using cooperative leaning and self-directed learning.

The research tools consisted of: (1) the lesson plans, (2) the program lesson or the textbook on nuclear chemistry, (3) the chapter tests, (4) the learning achievement test on nuclear chemistry, (5) the assessment form and rubrics for group working, (6) the self-assessment form of the students' the 21st century skills (learning and innovation skills), and (7) the students' satisfaction questionnaire towards the instruction.

Data Collection

Research procedure

Phase 1: Studying basic data for designing the learning activities emphasizing on cooperative learning and self-directed learning. The program lesson on nuclear chemistry is the research tool for promoting self-directed learning, which it was developed by the researcher. The collected data was analyzed to design the instruction.

Phase 2: Designing the learning activities on nuclear chemistry using cooperative learning and self-directed learning.

Phase 3: Developing research tools:

(1) Developing the program lesson on nuclear chemistry. The program lesson was developed as the textbook consisted of contents of 4 chapters were: 1) Nucleus of atom, 2) Radioactivity, 3). Nuclear reactions, and 4) Nuclear Technology. Each chapter has the learning objectives, questions, exercises and worksheets. In addition, there are answer keys of each question in appendix. This program lesson was used for students in self-directed learning both individually and in group working.

(2) Developing the lesson plans to manage the learning activities.

(3) Developing the learning activity worksheets for group working of cooperative learning, and preparing the learning resources such as using VDO clip from online learning resources, and using CD-ROM about nuclear chemistry, which developed by Office of Atoms for Peace in Thailand.

(4) Developing the chapter tests (3 tests for chapter 1-3), the tests composed of both multiple choice questions and open ended questions.

(5) Developing the assessment form and the rubric score assessment for group working in chapter 4: Technology nuclear. Students were assigned a learning project of various types of technology nuclear. Assessment of group working consisted of writing group reports, and group presentation, which rubrics contained the effectiveness of writing academic reports, presenting the tasks, and learning skills.

(6) Developing the learning achievement test for pretest and posttest (same tests), consisted of 2 parts; part 1 is a 50-item multiple-choice test, each question has four alternatives and one correct answer (50 points) and part 2 is an essay test consisting of 20 open-ended questions (50 points), which total score are 100 points.

(7) Developing the self-assessment form of the students' the 21st century skills, which this study focus on learning and innovation skills composting of creativity, critical thinking, communication and collaboration. The assessment tool comprised of 15-items. Each item has a 5-point Likert scale with the description "1 = very high", "2 = high", "3 = moderate", "4 = low", "5 = very low".

(8) Developing the students' satisfaction questionnaire towards the instruction. Designing and creating the questionnaire consisted of 2 parts; part 1 is the five-point scale Likert questionnaire with 25 statements of evaluation consisting of 5 parts; part 1: contents (6 items), part 2: learning activities (5

items), part 3: learning materials (4 items), part 4: assessment (4 items), and part 5: value and advantages of learning (6 items). And part 2 of questionnaire contained three open-ended questions to assess the students' opinions toward the instruction.

Phase 4: Implementing the learning activities and collecting data: as follows,

(1) Pretest with the learning achievement test,

(2) Implementing the learning activities with the sample group (6 weeks, 3 hours per week) and collecting data,

(3) Posttest with the learning achievement test, and

(4) Students did the self-assessment form and the satisfaction questionnaire.

The methods of cooperative learning used in this study are Learning Together (LT), and Group Investigation (GI) in which students work together in small groups on the assignments. Students were taught to set group goals, share roles, divide task, and communicate face to face. Students worked together and exchanged ideas. During lesson, desks or table were arranged to facilitate face to face interaction. Students are arranged in small, mixed-ability groups to work together and help each other learn the assigned learning materials. Classes are divided into small groups with 4 members to work together on the assignments with several group activities such as collaborative problem solving tasks in worksheets, group investigation, group reports, and group presentations.

Self-directed leaning activity was organized in such a way that students learned and worked using the program lesson on nuclear chemistry. Students prepared themselves for class by studying the program lesson. Between instruction sessions, students were asked to work in group on assigned questions and exercises in worksheets, solved the problems and presented group working in front of the class. At the end of unit or chapter (chapter 1-3), the chapter tests were given each students as individual test, the students were assessed by their individual learning outcomes. The students were assigned a learning project of chapter 4: Nuclear Technology (10 groups: 10 topics). The learning outcomes of chapter 4 were evaluated from group reports and group presentation by using the rubric score and the assessment form for group report and the assessment form for group presentation.

The assessment in this study used both formative assessment and summative assessment. Measurements of performance, testing and tasks. The pre-test and post-test were administered at the beginning and at the end of the instruction period. At the end of unit or chapter (chapter 1-3), the chapter tests were given each students as individual test, the students were assessed by their individual learning outcomes, but there was no test in chapter 4. The participants were assigned a learning project of chapter 4: Nuclear Technology (10 groups: 10 topics). The learning outcomes of chapter 4 were evaluated from group reports and group presentation by using the rubric score and the assessment form for group report and the assessment form for group presentation. The conceptual learning activities shown in Figure 1.

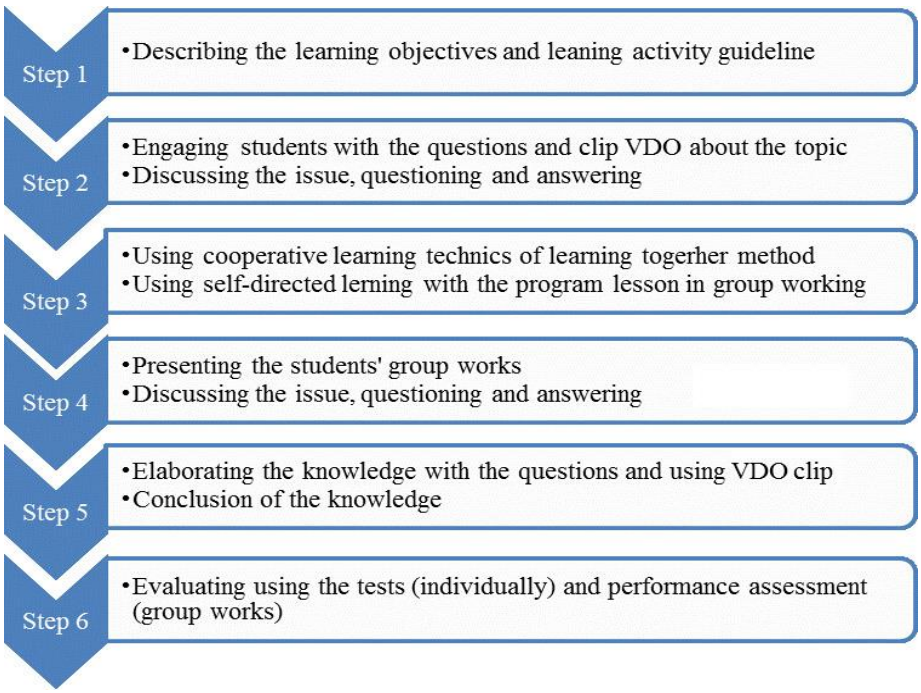

Figure 1 The conceptualization of learning.

The experimental procedure of this research shown in Figure 2.

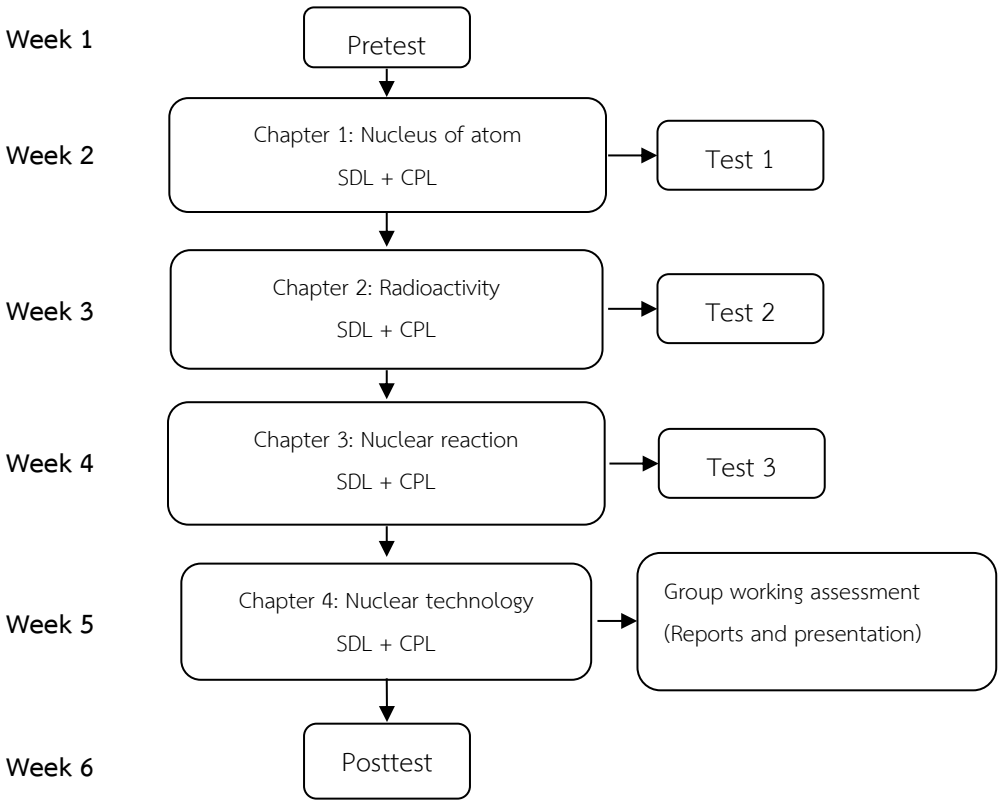

Figure 2 The conceptualization of research procedure.

Framework of the contents and learning activities in this study shown in Table 1.

Table 1. The contents and learning activities.

Chapter	Contents	Learning Activities
Chapter1 Nucleus of Atom	1.1 Introduction of nuclear chemistry 1.2 Composition of nucleus 1.3 Nuclear symbol 1.4 Isotope isotone and isobar 1.5 Binding energy 1.6 Stability of nucleus	Out of class : Self-directed learning using the program lesson, In class: Cooperative learning Learning together
Chapter2 Radioactivity	2.1 Discovery of Radioactivity 2.2 Radioactive decay (alpha rays, beta rays, and gamma rays) 2.3 Penetrating power of alpha, beta, and gamma radiation) 2.4 Radioactive decay rate 2.5 Half-life 2.6 Radioactive series 2.7 Radiation protection and safety of radiation sources	Out of class: Self-directed learning using the program lesson. In class: Cooperative learning Learning together, Small group discussion Problem solving, Writing concept map Student's presentation (Using VDO clip to elaborate the knowledge) Questioning and answering
Chapter3 Nuclear Reactions	3.1 Nuclear reactions 3.2 Writing nuclear equations 3.3 Nuclear fission and nuclear fusion 3.4 Nuclear reaction VS Chemistry reaction 3.5 Nuclear energy	Self-directed learning using the program lesson, Cooperative learning Learning together
Chapter4 Nuclear Technology	4.1 Nuclear technology 4.2 The many uses of nuclear Technology 4.3 Nuclear safety	Out of class: Self-directed learning using the program lesson In class: Cooperative learning - Group investigation - Writing group report - Group presentation (Oral presentation using Power Point and VDO clips)

Data Analysis

The quantitative data were analyzed by using mean, standard deviation, percentage. Learning outcomes of the students were collected the data from testing and tasks between learning, and the percentage mean score of learning outcomes after learning, which analyzed from the posttest scores.

The statistics of t-test for dependent sample was used to compare the mean scores of students' learning outcomes of posttest and pretest at the statistically significant .05 level. The qualitative data from the questionnaire were analyzed by using content analysis.

Results

1. The Learning outcome between learning and after learning.

The learning outcomes of 35 first-year undergraduate science students are presented in Table 2.

Table 2 Scores of students' learning outcomes.

Assessment	n	Total score	Mean score	S.D.	Percentage
1. Chapter test 1	35	40	38.44	1.73	96.10
2. Chapter test 2	35	50	47.64	3.07	95.28
3. Chapter test 3	35	30	26.59	1.36	88.63
4. Group reports and group presentation	35	40	34.43	2.34	86.08
Total scores (During Learning)	35	160	148.10	4.92	92.56
Post-test					
Part 1: Multiple choice test	35	50	42.37	2.82	84.74
Part 2: Open-ended questions test	35	50	46.29	2.70	92.57
Total scores (Post Learning)	35	100	88.66	4.87	88.66

Table 2 shows that the mean scores of assessment between learning equal 148.10 from overall score of 160 (92.56%). Mean score of chapter 1: Nucleus of Atom is 38.44 (96.10%), mean score of chapter 2: Radioactivity is 47.64 (95.28%), mean score of chapter 3: Nuclear Reaction is 26.59 (88.63%), and the mean score of chapter 4: Nuclear Technology is 34.43 (86.08%) respectively. The percentage means score of the posttest scores were 88.66.

2. Comparisons between students' learning achievements of their pretest and posttest assessment.

The results of students' learning outcomes between pre-test and post-test assessments are presented in Table 3.

Table 3 T-test results of pretest and posttest scores of learning outcomes (*n*=35)

Test	Total score	Pretest		Posttest		Percentage of progress (%)	t-test	
		$\overline{x}$	S.D.	$\overline{x}$	S.D.		t	*Sig.*
Learning outcomes	100	42.97	8.25	88.66	4.87	45.69	38.15*	.000

* Statistically significant .05 level

Table 3 shows that the mean scores of posttest (88.66%) were higher than those of pretest (42.97%) at the statistically significant .05 level, and the percentage of progress was 45.69.

3. The students' self-assessment of 21st century skills.

The students' 21st century skills were assessed by using the five-point scale Likert questionnaire with 15 statements of evaluation, which focus on learning and innovation skills. This questionnaire was used for the students' self-assessment. The results are presented in Table 4.

Table 4 The students' self-assessment of 21st century skills (learning and innovation skills).

items	$\overline{x}$	S.D.	level
1. I have developed analytical thinking skills and critical thinking skills.	3.97	0.57	good
2. I developed problem solving skills.	3.86	0.69	good
3. I developed the ability in reasoning.	3.71	0.71	good
4. I have developed systematic thinking.	3.69	0.68	good
5. I have developed skills in using information communication technology.	4.03	0.82	good
6. I can choose the right technology.	3.86	0.69	good
7. I have improved the information searching skills.	4.06	0.76	good
8. I have developed my communication skills.	4.06	0.68	good
9. I have developed my ability to receive messages that others convey effectively.	3.89	0.63	good

items	$\overline{x}$	S.D.	level
10. I have developed my ability to use spoken language to communicate knowledge appropriately.	3.86	0.65	good
11. I have developed my ability to use written language appropriately.	3.69	0.68	good
12. I have developed the ability to speak and interact with others.	3.91	0.56	good
13. I have developed skills to work with others.	4.37	0.73	Very good
14. I have trained to accept the opinions of others.	4.37	0.55	Very good
15. I have trained responsibilities both myself and others.	4.40	0.65	Very good
total	3.98	0.70	good

Table 4 shows that the mean score of the questionnaire was at high level of performance or at good level ($\overline{x}$= = 3.98, S.D. = 0.70).

4. The students' satisfactions towards the instruction on nuclear chemistry using cooperative leaning and self-directed learning.

The students' satisfactions toward the instruction on nuclear chemistry using cooperative leaning and self-directed learning were assessed by using the five-point scale Likert questionnaire with 25 statements of evaluation, which divided into 5 parts; part 1: content, part 2: learning activity, part 3: learning media, part 4: assessment, and part 5: value and advantages of learning. The results are presented in Table 5.

Table 5 The students' satisfactions towards the instruction on nuclear chemistry using cooperative leaning and self-directed learning.

	items	$\overline{x}$	S.D.	level
part 1: content				
1	Course content is important and valuable for learning.	4.49	0.51	Very good
2	The content is consistent with the learning objectives.	4.49	0.61	Very good
3	The content is detailed enough to enhance understanding of nuclear chemistry.	4.20	0.72	good

	items	$\overline{x}$	S.D.	level
4	The content is modern and up to date with current changes.	4.29	0.62	Very good
5	The content is difficult and suitable for the level of knowledge of the learners.	4.03	0.75	good
6	The content is useful for future professions.	4.34	0.68	Very good
Total average score in content		4.30	0.67	Very good
part 2: learning activity				
7	The activities encourage the students' problem solving	4.20	0.72	good
8	The activities trained the learners to work in groups to learn together.	4.60	0.60	Very good
9	The activities developed the students' ability in learning by themselves	4.49	0.61	Very good
10	The activities developed students' communication skills	4.34	0.59	Very good
11	the activities developed the students' information technology skills	4.06	0.80	good
Total average score in learning activity		4.34	0.69	Very good
part 3: learning media				
12	Learning media used were appropriate.	4.14	0.69	good
13	There is a variety of learning media used.	3.94	0.76	good
14	Learning media can promote knowledge and understanding of subject areas.	4.14	0.60	good
15	Learning media are sufficient for conducting learning activities.	4.14	0.65	good
Total average score in learning media		4.09	0.68	good
part 4: assessment				
16	Evaluation is consistent with the learning objectives.	4.26	0.56	Very good
17	There are various measurement methods.	4.09	0.78	good
18	Measuring tools are suitable for the learning level of students.	4.06	0.59	good
19	Measurement and evaluation are appropriate	4.23	0.55	Very good
Total average score in assessment		4.16	0.63	good
part 5: value and advantages of learning				
20	I have practiced my own learning skills.	4.60	0.55	Very good
21	I have created a habit of working with others.	4.60	0.60	Very good
22	I practice responsibility for myself and others.	4.51	0.70	Very good
23	I have developed my ability to think and solve problems.	4.29	0.57	Very good

items	$\overline{x}$	S.D.	level
24 I have developed communication skills.	4.49	0.61	Very good
25 I have developed information technology skills.	4.03	0.66	good
Total average score in value and advantages of learning	4.42	0.65	Very good
Total average score	4.28	0.67	Very good

Table 5 indicated that the students' satisfactions towards the instruction were at the very high level or at very good level ($\overline{x}$= 4.28, S.D. = 0.67). The results showed that the students' satisfactions towards in each part following; part 1: content was at very good level ($\overline{x}$= 4.30, S.D. = 0.67), part 2: learning activity was at very good level ($\overline{x}$= 4.34, S.D. = 0.69), part 3: learning media was at good level ($\overline{x}$= 4.09, S.D. = 0.68), part 4: assessment was at good level ($\overline{x}$= 4.16, S.D. = 0.63), and part 5: value and advantages of learning was at very good level ($\overline{x}$= 4.42, S.D. = 0.65).

The three open-ended questions were analyzed by using contents analysis. The result showed positive opinions towards the instruction. Some students have some problems in self-directed learning, such as they have no time to study the programmed text book. However, most students' opinions showed that the students have satisfactions towards the instruction using cooperative learning and self-directed learning.

Conclusion

The study was conducted through four steps: 1) document study for gathering related literatures and researches, 2) developing the research tools, 3) conducting and implementing the learning activities with first-year science undergraduates and collecting data, and 4) analyzing the collected data.

1) The mean scores of the learning outcomes of posttest were higher than those of pretest at the statistically significant level of .05 ($\overline{x}_{pretest}$= 42.97%, $\overline{x}_{posttest}$= 88.66%), and the percentage of progress was 42.63.

2) The mean score of self-assessment of 21st century skills (focusing on learning and innovation skills) was at high level or good level of performance ($\overline{x}$= 3.98, S.D. = 0.70).

3) The students' satisfaction towards the instruction on nuclear chemistry using cooperative leaning and self-directed learning was at very good level ($\overline{x}$= 4.28, S.D. = 0.67).

The main conclusion drawn from this study is that using cooperative learning and self-directed learning can enhance the students' learning outcomes and 21st century skills.

Discussion

The results of this study showed that promoting self-directed learning by using the program lesson or program instruction can enhance chemistry leaning achievement. The mean scores of the learning outcomes of posttest were higher than those of pretest at the statistically significant level of .05. These findings indicate that implementing the learning activities using cooperative learning and self-directed learning can improve learning outcomes of science undergraduates. The activities allow students to work together in small, mixed-ability groups. The teacher's role shifts from learning disseminator to learning facilitator. The responsibility for learning shifts from the teacher to the student. In addition, when students work together, they have the opportunity to critique and revise each other's ideas. The researcher's observation found that the instructional method encouraged students' understanding in nuclear chemistry, motivated them practice the 21st century skills, which focus on creativity and innovation, critical thinking and problem solving, communication, collaboration, information management, effective use of technology. For example, the students learned about Nuclear Technology from various learning resources such as articles form journals, news from newspapers, books, websites.

According to Beer, (2018), 21st century skills are about the thinking processes and behaviors students will use as they learn subject area content and work with others to deepen their understanding of the content. In this study, VDO clips were used to encourage the students about the topic of the contents, and had them discuss by using questions. The students did group activities using cooperative learning technique of Learning Together (LT) and Group Investigation (GI). Students worked together in small groups to finish the tasks. The cooperative learning activities of group investigation also gave them the opportunities to present their works to the class and share the ideas with others. Enhancing understanding of the learning by using group projects on Nuclear Technology that require students to use the content knowledge in writing group report and presenting information using PowerPoint and VDO clip to extend their understanding through collaboration with others.

These findings showed that using chapter tests, group reports, and group presentation as assessment tools can enhance the students' learning outcomes. Formative testing is usually conducted throughout the learning program, that is, at the end of a teaching unit. The use of formative assessment tools in the form of essay and multiple choice tests has been predicted to affect students' self-directed learning. SDL is an intentional psychological activity that students direct and control with the aim of acquiring knowledge and understanding about a specific subject. In addition, Gavriel (2013) stated that "the effectiveness of formative assessment depends on the level of student self-directed learning". In addition, self-assessment has been shown to help students develop meta-cognitive skills that can be used in all aspects of higher education, and it has been shown to improve student achievement in a range of different academic areas (Ritchie, 2016). Additionally, the students showed positive opinions

toward the instruction. The students were enthusiastic to work in group because they had the opportunity to discuss, share ideas and exchange knowledge with others. They enjoyed the learning activities, which allowed them to do solving problems, practicing the critical thinking, discussing, and presenting data.

In this study, students gave oral presentation on topic of Nuclear Technology using PowerPoint presentations and VDO Clips on various topics. The teamwork activities made the students help each other in learning and workings. The students were received the suggestion about the roles and behaviors for effective group working. In addition, students can summarize their learning. For the classroom atmosphere, students enjoyed learning and had more fun in doing activities. They participated in doing activities, discussing the result of work, and presenting data with high responsibility. They discussed concepts of what they learned and worked together to finish the assignment. In addition, they helped each other in searching and analyzing data in order to present their works in front of the class. They exchanged knowledge with other members in the group. The students were suggested the rubric of assessment of group reports and group presentation before beginning the learning project. The role of the researcher as the instructor was to offer more ideas, feedback, encouragement, and suggestions to groups to enhance their learning. According to Daniel and Jordan (2017) point out that working in collaborative groups has been shown to have beneficial outcomes. There are many researches showed that using cooperative learning is beneficial to students. Cooperative learning can enhance achievement and attitudes of students. Cooperative learning when using as instructional strategy has positive effect on students' academic achievement (Gull & Shehzad, 2015).

From the result of this study, it can be concluded that the cooperative learning and self-directed learning can improve the students' learning outcomes and 21st century skills. Furthermore, feedback from the students showed positive attitude to instruction.

Recommendation

1. Suggestions on results implementation

For educators who are interested in teaching chemistry using cooperative leaning and self-directed learning, the following must be concerned:

1.1) Instructors should prepare the learning materials and the learning medias such as the program lesson or textbooks for students practice self-directed learning out of class. And the instructor should prepare the VDO clips for supporting the students' learning activities.

1.2) In using cooperative learning in the class, the instructors' role are: build a co-operative learning environment, help to motivate and direct the students' learning experience, facilitate students' initiatives for learning, be available for consultations as appropriate during learning process. The instructor should encourage and improve the students' group process.

2. Suggestions for further research

2.1) There should be research and development of instructional techniques to enhance the leaning and innovation skills and information, media, and technology skills in context of chemistry.

2.2) There should be chemistry learning activities and learning medias to improve the self-directed learning skills of science undergraduate students, and to support students in searching and preparing background of knowledge for learning.

2.3) There should be a comparative study between the control and experimental groups studied with cooperative learning and self-directed learning.

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Figure 4 The students' learning activities, the programmed text book, and VDO-CD on Nuclear Chemistry

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