The Curriculum Development of Science Camp for Primary Students in Udon Thani Municipality Schools Based on Constructivist Paradigm and Learners' Skills in 21st Century

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Abstract
The Science Camp for Municipality Students Project was collaborative science camp conducted by the Faculty of Education, Udon Thani Rajabhat University, and Udon Thani Municipality in which an educational experience was designed to provide students with opportunities to apply basic concepts in science and thereby develop their 21st century skills. Three study objectives were 1) to construct and develop a science camp curriculum through an area-based context for primary students by collaboration between school teachers, expert referees, camp mentors and researchers, 2) to compare students' understanding of science concepts before and after using science learning stations, and, 3) to study students' 21st century skills throughout science camp activities. The individuals attending this science camp were comprised of 80 Mukkamontri 4 and 5 students from the Municipality 2 School. Seven science learning stations were designed for each group. Each station consisted of a scientific scenario, question, and a Predict-Observe-Explain task. Data collection was employed with two-tier multiple choice questions, written student work and interviews. Data triangulation was used to interpret and confirm students' understanding of scientific concepts before and after working at each station. The results of the study revealed the following: 1) seven science stations were completely constructed through collaborative workshop, 2) the proportion of students with correct science concepts after working in these seven stations was 74100%, and, 3) the students' 21st century skills after finishing the camp process were at a high level, between 3.6 and 4.1 on a 5 point Lickert scale.

Keywords: curriculum, science camp, constructivist, learners' skills in 21st century

Introduction

Since 2002, formal teaching and learning activities in Thailand have become focused on student-centred approach both in schools and at universities. After the announcement of the National Education Act B.E. 2542 (1999) and Amendments (Second National Education Act B.E. 2545 (2002), a constructivist paradigm has been progressively implemented for planning learning activities inside and out of classrooms. This paradigm was recognized as one supporting student-centred approach applying students' prior knowledge and understanding. Additionally, the new educational policy features a complete change in approach to basic education in Thailand. Beginning in 2012, all schools in Thailand adopted a new approach to planning school curricula. Each school developed its own curriculum based upon the Basic Education Core Curriculum B.E. 2551 (A.D. 2008) (Bureau of Academic Affairs and Educational Standards, 2008). Now student-centred and constructivist approaches are widely employed in promoting five key competencies and eight desirable learner characteristics within the basic educational system. The five key competencies and Learners' skills in 21st century have several facets, such as communication, creativity and problem solving skills (Buaraphan, 2012). The current study investigated the science camp curriculum, its coherence, and current conceptual scientific understanding of primary students in the local area. This was done by presenting challenging alternative (incorrect) concepts during the science camp process. Each was based upon a student-centred, constructivist approach addressing skills that learners' will need in the 21st century.

Constructivism includes both psychological and epistemological principles. It advances the notion that knowledge is not merely received passively, but is progressively built up by the cognising subject. It holds that the function of cognition is adaptive, enabling the learner to construct viable explanations of experiences (Driver, 1989). Such constructivist ideas embrace many facets of Piaget's genetic epistemology and often serve as a reference position for discussions of constructivism in education (Treagust, Duit, & Fraser, 1996). Constructivist teaching approach also considered students' beliefs and concepts with respect to a student-centred pedagogy in science instruction by including a focus on the interests, learning skills and needs of students in actively constructing their knowledge (Duit, 1994).

In educational constructivism, teaching approaches also consist of two principles such as individual constructivists' and social constructivists' views on learning. Individual constructivist educators believe that knowledge is not merely received passively, but is progressively built up by the cognising subject. It holds that the function of cognition is adaptive, enabling the learner to construct viable explanations of experiences. This idea follows Piaget's genetic epistemology. Additionally, social constructivist educators believe that knowledge not only is personally constructed but also is socially mediated (Driver, 1989; Treagust, Duit, & Fraser 1996) following Vikosky's epistemology.

Learners' individual and group skills in the 21st century need to include learning and innovation skills, life and career skills, as well as information, media and technology skills. Learning and innovation skills, the 4Cs, include critical thinking and problem solving, communication, collaboration, and creativity and innovation. Mentors in each station tried to encourage students to individually complete their own worksheets based on the 3Rs, i.e., reading, writing and arithmetic (Buaraphan, 2012).

This study applied area-based research, student-centred and constructivist approaches as well as the necessary 21st century skills in a 1-day science camp for students. The research process involved 1) a review of a theoretical framework about science camps and educational curricula, 2) brainstorming among science teachers in Udon Thani Municipality schools to collect broad ideas and set alternative concepts for students, 3) construction and validation of science stations used in the curriculum of the science camp, 4) design and conduct of relevant science experiments, 5) reflection upon the results of learning activities both with respect to conceptual understanding and science camp processes, and, 6) evaluating science camp activities. The study adopted some common strategies for investigating students' understandings, including two-tier multiple-choice tests (Treagust, 1988), Predict-Observe-Explain (POE) sequences (Gunstone, 1995), interviews (Chen, Lin, & Lin, 2002), and written work tasks based on learners' 21st century skills (Kay, 2010 cited in Buaraphan, 2012). Additionally, learners' 21st century skills were assessed using a survey instrument compiled by the current author, school teachers and science camp mentors (as expert referees). It was used to investigate students' 21st century skills in science camp activities.

The current study's author constructed science problems based upon concepts and experiences of local science teachers in the Udon Thani Municipality. The science curriculum was completed upon reflecting activities from camp members, camp mentors, and expert referees.

The aims of the study were to develop a curriculum for a science camp using an area-based context and to investigate the effectiveness of using science learning stations to improve students' understandings of various scientific concepts, using multiple investigation methods as part of a 1-day science camp. Additionally, students' 21st century skills were investigated using a questionnaire after they finishing learning activities as part of the science camp evaluation process. Learning activities through this science camp curriculum challenged students' present conceptual understandings in primary school by consideration of alternative conceptions presented through participation in group activities within constructivist-oriented science learning stations.

Research applying a student-centred approach, constructivist paradigm and learners' 21st century skills was conducted during a 1-day teacher workshop and a 1-day school science camp named "Science Camp for Municipality Students". The development process of the science camp curriculum involved 1) reviewing theoretical framework, 2) brainstorming to develop broad ideas and students' alternative concepts, 3) constructing and validating science stations, 4) designing and conducting relevant experiments at the science stations, 5) reflecting upon learning activities by camp members, camp mentors and school teachers, and 6) evaluating science camp activities.

The study included of two main parts, workshop and science camp activities. A teacher workshop was done as an area-based approach. It adopted pedagogical content knowledge (PCK) to focus broadly upon scientific contents and alternative concepts for students. Science camp activities adopted some common strategies for investigating students' understandings, including two-tier multiple-choice tests (Treagust, 1988) which included situation, question, answers and suitable reasons (Pathommapas, 2012), Predict-Observe-Explain (POE) sequences (Gunstone, 1995) through experiments, interviews (Chen, Lin, & Lin, 2002), and written tasks. Additionally, students' 21st century skills were evaluated using a survey questionnaire compiled during the teacher workshop.

2. METHODOLOGY AND RESEARCH DESIGN

2.1 Methodology

The research methodology used workshop activities as an area-based strategy to prepare science stations and pretest-experiment-posttest techniques for measuring changes in students' conceptual understandings. Furthermore, pedagogical content knowledge (PCK) and learners' 21st century skills were used for developing ideas and evaluating science camp activities, respectively.

The teacher workshop used an area-based strategy based upon student-centred approaches and a PCK sequence. Science content was developed as strand, standard and grade-level indicators of the Basic Education Core Curriculum B.E. 2551 (A.D. 2008). Pedagogical knowledge used group activities in science stations through a science camp process. So, PCK was the main strategy for designing each science station.

Assessment techniques for group and individual activities in this study were based upon established assessment strategies, including the two-tier test, interviews, written work and open investigation. Furthermore, learners' 21st century skills were assessed and evaluated using a Science Camp Evaluation questionnaire.

2.2 Research Design

The research design used a series of case studies (Merriam, 1998) which in the design of the seven learning stations, using both quantitative and qualitative methods (Cohen, Manion, & Morrison, 2000) for data collected from primary (levels 4 & 5) students at Municipality 2 Mukkamontri School, Udon Thani Province, Thailand. The students attended a science camp organised by Udon Thani Rajabhat University. The results of these form the substance of this report. The participant sample, numbering 80 students, was divided into groups of approximately 12 which again divided into 2 subgroups. Two subgroups, A and B, were assigned to one science station. As the research was conducted within a science camp format using a constructivist paradigm, the research protocols are therefore presented here in three parts. Part One caught broad scientific ideas and set science station during a teacher workshop (Phases 1, 2 and 3). Part Two explored challenges to students' conceptual understanding scientific concepts (Phase 4) Part Three examinee the quality of the science camp activities (Phases 5 and 6). The research process is outlined in Figure 1.

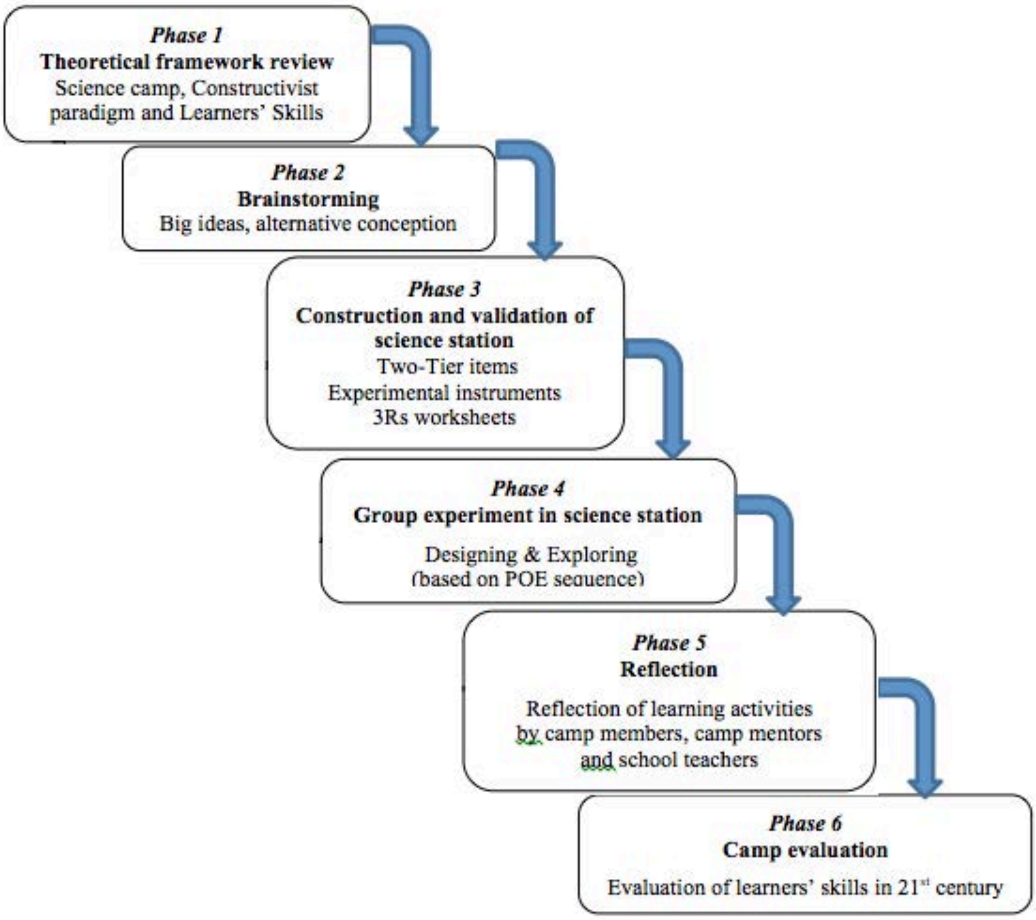


Figure 1: Flow diagram showing group activities within science stations used to modify students' alternative conceptions

Part One: *Workshop for catching broad scientific ideas and setting science station*

The first part of the study was done in a workshop to determine which concepts would be presented at science stations. The details are as below.

Phase 1: **Theoretical framework review**

Review of the theoretical framework was done in the first teacher workshop of the research study. This phase was conducted with expert referees and researchers to guide development of the science camp using a constructivist paradigm using a 21st century learners' skills.

Phase 2: **Brainstorming for broad ideas and alternative concepts**

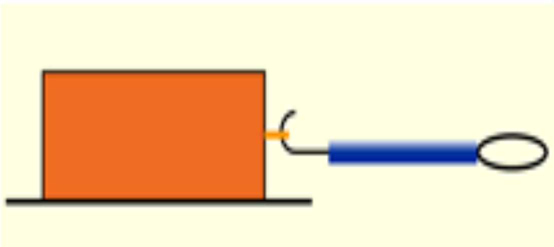
The last phase of the teacher workshop was brainstorming to determine broad ideas, and gather students' alternative concepts. The teacher workshop used an area-based strategy. Using their experience, each teacher tried to provide his or her students with alternative concepts. Then, priorities were set and science stations designed.

Phase 3: **Construction and validation of science station**

The science station designs were carefully checked for both content and format by three expert referees. The referees all held Doctorates in Science Education. Finally, ten science stations were set up to include experimental instruments, a poster exhibition, a mentor's manual and a student worksheet. Two-tier multiple choice questions, a science station poster and a student worksheet are shown in Figures 2, 3 and 4, respectively.

Strand 4: **Forces and Motion**
Standard: **SC4.2**
Grade-level Indicator: **SC4.2**

Scenario: Pull a piece of brick which is on the rigid surface, such as table, with spring balance as figure. Determine static friction by reading balance scale in Newton unit while immediately start moving.



<table>
<tr><td colspan="3">Question 1: If two pieces of tiny sticks are fixed with oil clay between the brick and floor in parallel direction of movement. What does the static friction change?</td></tr>
<tr><td>Assertion
1) no change
2) increase
3) *decrease
4) there is no rule of friction</td><td>because</td><td>Reason
a) The weight of brick which pressed to the table is the same quantity;
b) The use of sticks have no effect to the friction change;
c) *The area which pressed to the table is smaller;
d) The surface of brick is rougher.</td></tr>
</table>

* *Correct answer*

Figure 2: Two-tier item question for static friction (translated from Thai version)

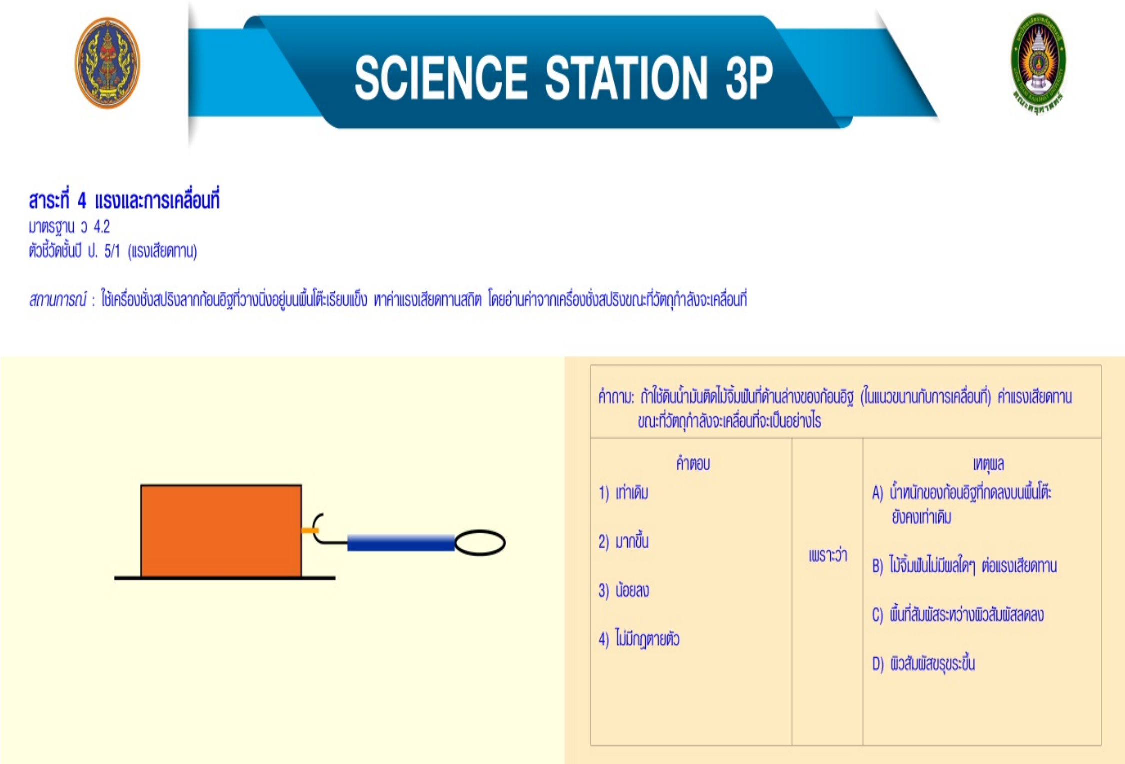


Figure 3: Poster of Science Station 3P using for learning activities in Science Camp (Thai Version)

Student work Sheet

Reading

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Writing

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Arithmetic

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Figure 4: Format of student's work sheet based on 3R's

***Part Two**: Exploration for challenging students' science conceptual understandings*

Part Two was a constructivist exploration via group work activities at science stations. There was one phase in this part. The learning activities were done via a science camp process. The details of this part are given in Phase 4.

Phase 4: **Designing & exploring the constructivist-informed laboratory**

The sequence activities in Phase 4 were pretest, group exploration and posttest. Group exploration in this phase involved a group design to construct laboratories focused on experimental objectives and exploration of results based on the Predict-Observe-Explain (POE) task model. The students designed, tested and confirmed the results by themselves. Successful completion of the POE tasks required that students' independently recognise and modify their individual conceptual understandings. This process involved the following three steps:

Step 1: Groups of students developed the experimental objectives, designed POE scenarios (more than one) and set up the laboratory procedures by themselves.
Step 2: Groups of students tested POE tasks (more than one) and confirmed the appropriateness of the concepts involved, based upon the POE task results.
Step 3: Each student completed an individual worksheet, 3R's, in accordance with the concepts he or she learned in their experiments.

***Part Three**: Examination the quality of the science camp activities*

Phase 5: **Reflection**

Reflective activities were done in the last section of the science camp before its formal closure. The presenters were group members and science station mentors using the Plus-Minus-Interesting (PMI technique). There were three steps in this process:
Step 1: Groups discussed positive experiences (Plus), limited experiences (Minus) and the most interesting experience (Interesting) of learning activities in science camp.
Step 2: Oral presentation from group representative members and station mentors by random selection.
Step 3: Gathering and summarizing data and drawing conclusions.

Phase 6: **Science Camp evaluation**

This phase was the final part of science camp. Its purpose was to determine students' 21st century skills as a part of science camp evaluation. The Science Camp Evaluation questionnaire was used to assess these skills and was followed by assessment before formal closure of the science camp project. This 14-item questionnaire consisted of 8 items for Learning and Innovation Skills, 3 items for Life and Career Skills, and 3 items for Information, Media, and Technology Skills. It was compiled by the study author and science teachers as workshop activities. The content validity (Creswell, 2008) of this instrument and succeeding question scores were verified by experts comprised of University colleagues. Students individually completed questionnaires and returned them to camp mentors for interpretation and evaluation.

3. RESULTS

Results and data analysis pertaining to the five-step research design are as follows:

***Part One**: Workshop for gathering broad ideas about science and setting science stations*

Phases 1, 2 and 3

After completion of teacher workshops in Phases 1 and 2, and expert validation in Phase 3, ten science stations based on the same number of science concepts were completed. Media for these stations were printed including poster presentations, mentor manuals and student worksheets. The ten station concepts were:

Station 1: Light refraction
Station 2: Floating force
Station 3: Static friction
Station 4: Free fall
Station 5: Sound frequency
Station 6: Food web
Station 7: Air pressure
Station 8: Solubility
Station 9: Electric circuit
Station 10: Animal taxonomy

***Part Two**: Exploration challenging students' science conceptual understandings*

Phase 4

The results from students' answers to the two-tier diagnostic pre-test questionnaire at seven stations, 1-7, were triangulated with data from their written work and personal interviews. The numbers and percentages of pre-instruction students with correct, alternative or unclear science concepts are shown in Table 1.

Table 1. Results of students' pre-constructed conceptions, focusing upon level of understanding

Level of Understanding	Science station 1		Science station 2		Science station 3		Science station 4		Science station 5		Science station 6		Science station 7	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Correct conception	7	22.0	7	12	14	24.0	14	23.0	6	15.0	46	97.9	8	36.0
Unclear conception	10	31.0	10	10	7	12.0	0	0	16	40.0	0	0	7	32.0
Alternative conception	15	47.0	17	64	38	64.0	46	77.0	18	45.0	1	2.1	7	32.0
Total	32	100.0	34	86	59	100.0	60	100.0	40	100.0	47	100.0	22	100.0

N= number of students, % = percentage

Station 1: Light refraction, Station 2: Floating force, Station 3: Static friction, Station 4: Free fall, Station 5: Sound frequency, Station 6: Food web, and Station 7: Air pressure

Students' answers to the two-tier diagnostic post-test questionnaires, obtained after completing the science station activities, were triangulated with data from their written work and personal interviews. The post-test questionnaire results show that the number of students having correct conceptual understandings was higher than that of the pre-test results. The numbers and percentages of post-instruction students with correct, alternative or unclear science conceptions are shown in Table 2.

Students' answers to the two-tier diagnostic post-test questionnaires, obtained after completing the science station activities, were triangulated with data from their written work and personal interviews. The post-test questionnaire results show that the number of students having correct conceptual understanding was higher than that of the pre-test results. The numbers and percentages of post-instruction, students with correct, alternative or unclear science conceptions are shown in Table 2.

Table 2. Results of students' post-constructed conceptions, focusing upon level of Understanding

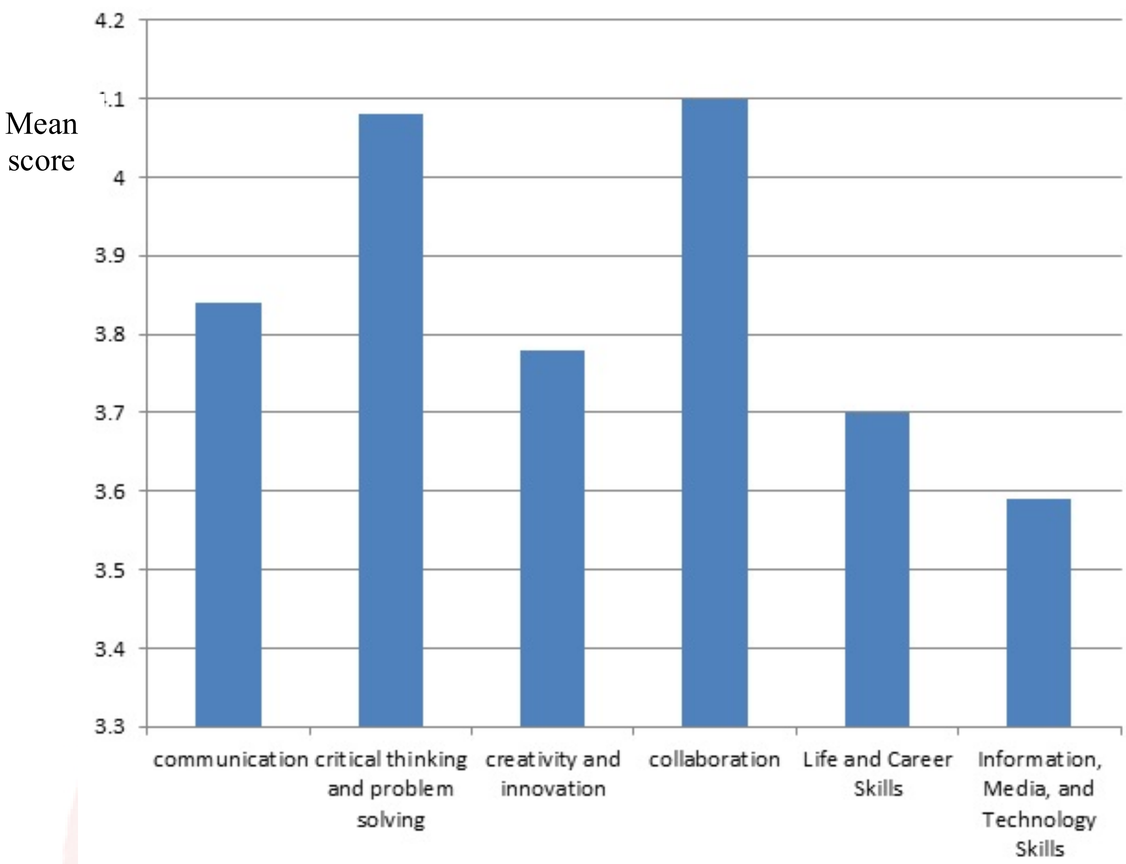
Level of Understanding	Science station 1		Science station 2		Science station 3		Science station 4		Science station 5		Science station 6		Science station 7	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Correct conception	26	74.0	43	100.0	53	89.8	60	97.4	40	100.0	47	100.0	19	86.0
Unclear conception	7	20.0	0	0	1	1.7	1	1.6	0	0	0	0	3	14.0
Alternative conception	2	6.0	0	0	5	8.5	0	0	0	0	0	0	0	32.0
Total	35	100.0	43	100.0	59	100.0	61	100.0	40	100.0	47	100.0	22	100.0

N= number of students, % = percentage

***Part Three**: Examination the quality of the science camp activities*

Phases 5 and 6

The mean scores of the five point scale of the Science Camp Evaluation questionnaire reflect personal satisfaction with respect to perceived changes in learners' 21st century skills after completing the science camp. These data appear in Figure 5 and Table 3.



Note: *1-strongly disagree, 2- disagree, 3-Neutral, 4- agree 5- strongly agree*

Figure 5: Comparison of mean scores for learners' skills in 21st century (n=72)

Table 3: Mean scores, standard deviations and personal ratings of students' skills in 21st century (n=72)

Students' skills	Mean	Std. Deviation	Rating
Communication	3.84	0.88	agree
Critical thinking and problem solving	4.08	0.97	agree
Creativity and innovation	3.78	0.88	agree
Collaboration	4.10	0.88	agree
Life and career skills	3.70	0.89	agree
Information media and technology skills	3.59	1.30	agree

The results showed that learners' 21st century skills received high scores for all of six skills. Scores for learning and innovation skills, i.e., communication, critical thinking and problem solving, creativity and innovation, and collaboration were 3.84, 4.08, 3.78 and 4.10, respectively. The scores in life and career skills, and information media and technology skills were 3.70 and 3.59, respectively. These responses suggest that a science camp curriculum based upon a constructivist learning paradigm is suitable and useful for developing students' 21st century skills with respect to the relevant competencies.

4. FINDINGS AND CONCLUSIONS

The research findings indicate that essential concepts pertaining to seven scientific concepts changed following participation in science camp learning activities. The science camp curriculum served to enhance students' understanding of concepts in various areas and may serve as a promising means for investigating both the *process* of conceptual change and the *influence of conditions* generally supportive of such changes.

A science camp curriculum is suitable to explore constructivist-oriented activities within science learning stations, using a series of Predict-Observe-Explain (POE) tasks and constructivist experiments. Science camp processes appear to be useful facilitators for the achievement of conceptual changes. Group activities conducted during the science camp environment resulted in a significant degree of success in rectifying inaccurate conceptual understandings of science students. After completion of the learning activities, the majority of student understanding was found to be correct. Students' 21st century skills , gauged from their responses to a five-point Lickert on the project questionnaire suggested that a high degree of students' satisfaction was derived from attending the science camp using POE tasks and constructivist experiments.

The findings of this study have broad implications for the use of science stations employing a science camp curriculum, constructivist approach and relevant science camp processes in formal Thai education. This will provide students with improved opportunities for developing their understanding of essential concepts in the various ideas of science at the primary school level.

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