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Development of learning management model for enhancing scientific citizenship of upper secondary school students

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Abstract

The research objectives were: (1) to develop a learning management model for enhancing scientific citizenship; and (2) to study the results of scientific citizenship after the learning management model implementation. The sample consisted of 53 tenth-grade students who were selected by using purposive sampling. The learning management model was conducted by quantitative research methodology. Two phases were used in the research methodology: The first phase was the development and examination for the quality of the learning management model. The second phase was the implementation of the developed learning management model. The research instrument included: a learning management model, learning management plans, a scientific citizenship test, and a scientific citizenship test scoring rubric. Data results were then statistically analyzed based on the mean, standard deviation, and *t*-test. The research results indicated that: (1) the developed learning management model consisted of five components: principle, objective, learning instruction, evaluation, and limitation. There were five steps comprising the first phase. Step 1: confronting socioscientific issues, step 2: analyzing stakeholders, step 3: exploring the alternatives of scientific citizenship from various perspectives, step 4: realizing and considering different perspectives, and step 5: expressing participation in society. The results of the assessment for suitability by experts were at the most appropriate level, with a mean of 4.60 and a standard deviation of 0.54.; (2) Students who learned using the learning management model had higher post-test scores than pre-test scores of scientific citizenship and higher than the cut-off score at a significance level of .05.

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Introduction

Citizenship is defined as the attribute of individuals to lead a country through a crisis and establish peace (Samudavanich, 1999). The world is paying attention to how people in a country evolve into citizens, particularly in scientific education, which focuses on encouraging citizenship through science courses. Sadler et al. (2007) said that science education plays an important role in the development of citizenship. This is consistent with the statement by Deboer (2000), who proposed that people with scientific knowledge are better at understanding the changes that occur in society.

Citizens with knowledge of science and important living skills will be able to independently evaluate options critically and decide to accept or avoid government proposals for the benefit of both health and livelihood, which is called scientific citizenship (Sternsdorff-Cisterna, 2015). This is consistent with the description of scientific citizenship given by Arsingsamanan et al. (2021) as a person who has knowledge, skill, and understanding of the nature of science and can apply scientific knowledge as a foundation for living and expressing their standpoint in society rationally. This scientific citizenship gives importance in terms of personal, social interaction, and social awareness in various dimensions. A scientific citizen should have knowledge of contemporary science as it corresponds to daily life and sets contemporary norms, for example, DNA technology. Thus, it is important to citizens of the future as DNA technology started to play an increasingly important role in the health and well-being of the people (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015; Wellington, 2003).

The condition of learning management for promoting citizenship previously in Thailand did not met its goals. Although the curriculum at each level of education was designed to promote citizenship, it is still not applicable in students' real life as it should be. In addition, learning management focused on basic knowledge and did not give importance to the promoting of scientific citizenship (Office of the Education Council Secretariat, 2016).

Therefore, the provision of science education in Thailand to promote scientific citizenship should allow learners to practice in learning activities. This creates knowledge and connects old experiences with new experiences rationally according to the theory of constructivism (Rangubtuk, 1999). Also, promoting citizenship through science requires learning activities for learners to gain experiences through social building, social participating, and gaining first-hand experience. This is consistent with the social constructivist theory (Osborne, 2000; Ratcliffe & Grace, 2003). The socioscientific issues (SSI) used in the classroom should be social issues related to science, and currently being debated in society issues that can develop scientific citizenship, including scientific argumentation, decision-making, and social awareness (Sadler & Zeidler, 2005). In addition, such should be consistent with the context and related to the learner's community by Context-Based Learning, which will give students decision-making experience the context in the social and cultural environment, as well as to transfer knowledge to other situations and practice to raise awareness of society from close context (Overton, 2007). It is important to manage to learn that students can challenge their own point-of-view with the learning experience, resulting in a change in perspective cognition, behavior, and understanding of the changes that occur around them according to the theory of transformative learning (Mezirow, 2003; Panich, 2015).

In Thailand, there is still limited development of the learning management model related to scientific citizenship. The researcher was therefore interested in developing a model of learning management to promote scientific citizenship for high school students with an aim to help ameliorate citizenship for Thai youths to become equal to those of other countries. The research took into consideration two objectives as follows: (1) development of a learning management model for enhancing the students' scientific citizenship; and (2) studying the results of students' scientific citizenship after learning management model implementation.

Literature Review

In today's society, Citizen is a must to have knowledge and understanding of scientific content related to social issues (Osborne, 2000), in order to become an alert citizen who is ready to cope with the crises and changes that will occur in the age of globalization (Davies, 2004). Scientific citizenship is a person with scientific knowledge skills and understanding the impact of the advancement of science and technology knowledge towards individuals, society, and the world (Berkowitz & Simmons, 2003), who can apply scientific knowledge as a foundation for living. It consists of 3 aspects and 7 indicators, namely, the aspect of a person: basic scientific knowledge, scientific inquiry, and scientific mind; the aspect of social interaction: scientific argumentation, and decision-

making; and the aspect of social awareness: self-awareness, and public awareness according to social duties (Arsingsamanan et al., 2021).

In foreign countries, policies and educational programs have been adjusted according to the promotion of citizenship through science courses (Ministerial Council on Education, Employment, Training and Youth Affairs [MCEETYA], 2008; Next Generation Science Standards [NGSS], 2013; Oxfam, 2006). In Thailand, the Office of Education Council Secretariat (2016) made a policy proposal for educational development to promote citizenship, stating that learning activities should allow learners to practice for the development of knowledge, understanding, skills, attitudes, and behavioral changes. When learners are confronted with problems that contradict prior knowledge, they will experience an intellectual conflict and seek solutions by creating new experiences (Bednar et al., 1995; Gagnon & Collay, 2001), in which the knowledge arises through social interactions with other people (Vygotsky, 1978; McLellan, 1996). When they face situations that differ from their original point of view, the learner will change considerably in terms of content, process, paradigm, and rational exchange of ideas (Mezirow, 2003; Panich, 2015). This leads to the conceptual framework as shown in Figure 1.

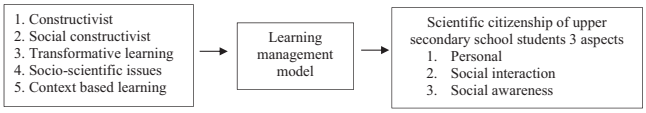

Figure 1 Conceptual framework

Methodology

The quantitative research methodology was applied in this study in the form of experimental research with a pre-experimental design as one group and a pretest-posttest design as the other. The research method was divided into two phases.

Phase 1: The development and examination of the quality of the learning management model to promote scientific citizenship were as follows:

1. Studying information about concepts, theories, and research related to the development of learning management models and scientific citizenship for drafting the learning management model and the learning management plans to promote scientific citizenship.

2. Conducting a learning management model and the learning management plans designed and created by synthesizing the elements of the learning management model, including principles, objectives, learning instruction, evaluation, and limitations.

3. Checking the quality of the learning management model and the learning management plans by 5 experts using a 5-level estimation scale.

4. Applying and testing the learning management model and the learning management plans in a pilot trial with 36 grade 10 students studying a science-mathematics curriculum.

Phase 2: Implementing the developed learning management model was as follows:

1. Applying the developed learning management model to a sample group of 53 students using one group pretest-posttest design with the 13 items open-ended of the scientific citizenship test by spending a total of 12 hours.

2. Determining the criteria using Berk's cut-off score method (Berk, 1976) by comparing the sample group's pretest scores with the pilot trial group's posttest scores and analyzing the data.

Participants

The sample included 53 selected grade-10 students studying in the science-mathematics curriculum in one of the big schools in Phitsanulok Province during the second semester of 2020, based on purposive sampling.

Research Instruments

The research instruments included: a learning management model, learning management plans, a scientific citizenship test, and a scientific citizenship test scoring rubric. After developing all research instruments, the suitability of learning management plans (4.54) check was done by 5 experts and through pilot trial respectively. A scientific citizenship test was checked for the difficulty (0.39–0.65), the discrimination power (0.20–0.50), the validity (0.60–1.00), and the reliability of the Cronbach (0.65).

Data Analysis

Finding mean and standard deviation to analyze the quality of the learning management model reviewed by 5 experts. The students' scientific citizenship was analyzed by scoring individual student responses and comparing the mean scores between the pre-test and post-test scores by using the *t*-test for the dependent sample and comparing post-test scores with the cut-off score by *t*-test for one sample at a significance level of .05.

Results and Discussion

The Results of the Development and Quality Inspection of the Learning Management Model to Promote Science Citizenship.

The synthesis of the learning management model to promote scientific citizenship for students applies the basic theories and concepts including constructivist theory, social constructivist theory, theory of transformative learning, the concept of socioscientific issues, and context-based learning concepts. From an experts evaluation, the overall learning management model was suitable at the highest level with a mean of 4.60 and a standard deviation of 0.54, with details of the learning management model consisting of 5 steps as shown in Figure 2.

The developed learning management model can be used in a real-life context since the researcher used the theories and basic concepts of education to create the learning management model. It was consistent with the development guidelines for the learning management model according to the concept by Joyce and Weil (2000), which states that the development of a learning management model must start by analyzing the theories and basic concepts of education.

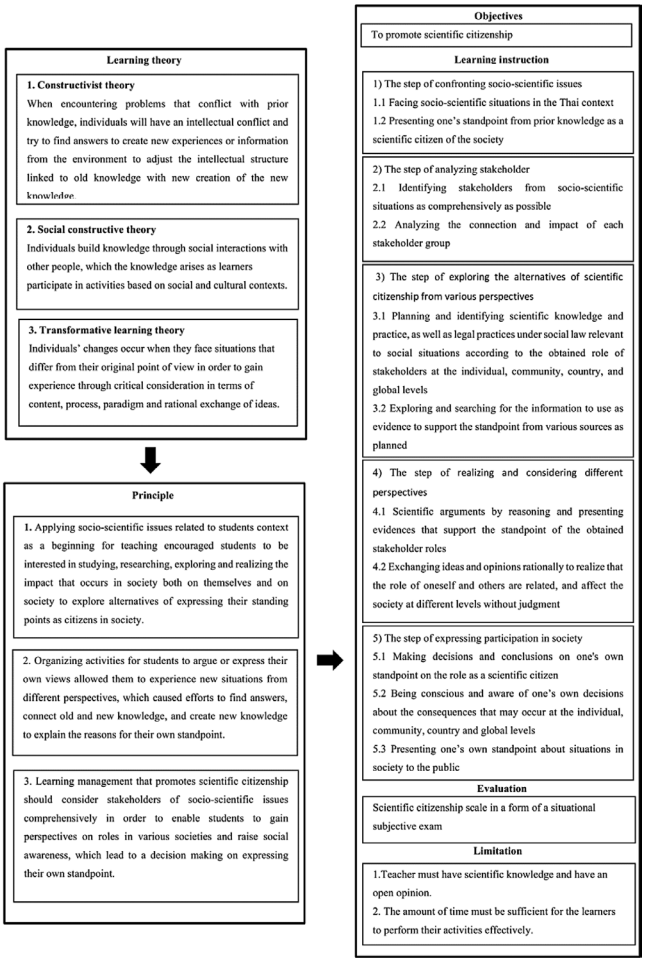

Figure 2 A model of learning management to promote scientific citizenship

The researcher developed five steps for the learning management model that promotes scientific citizenship. Each step of learning management can be discussed as follows:

1. Confronting science-related social issues. Socioscientific issues were selected since they are issues seen from different perspectives among several groups of people in society. This is in harmony with Zeidler et al. (2005), who mentioned that science-related social issues are not only the issues that occur in society, but also the issues caused by conflicts in scientific knowledge, as well as relationships with morality, ethics, society, politics, culture, and economics. The contexts must be related to the content to be taught so as to help students understand the content or scientific concepts more clearly (Bennett & Lubben, 2006; De Jong, 2008; Overton, 2007).

2. Examining stakeholders. This is consistent with real-life society that comprises groups of people with different careers and thoughts. Each person is affected by different problems. Sternsdorff-Cisterna (2015) mentioned that there are always groups of people in every society who gain advantages over the disadvantaged based on government decision-making. Disadvantaged people must be able to examine or criticize government responses to questions and problems in society for people's safety.

3. Exploring and seeking choices of scientific citizenship in different views. For every group of people in society, decision-making to solve problems should be based on knowledge and proper practices. This is consistent with DePace (2020), who said that becoming a scientific citizen means, a person should have scientific knowledge and understand the practical application of scientific knowledge, including laws in society.

4. Realizing and considering things from different perspectives. Students shall practice and participate in noteworthy discussions about issues. They shall make choices after listening to various perspectives from other people in society. This is consistent with Aihwa (1999), who mentioned that scientific citizens need to make appropriate choices for solving arising crises by themselves.

5. Expressing social involvement. Students have a chance to make their decision again after getting through scientific argumentation skills and critical thinking skills. They perceived different perspectives from people with different careers in society who are both privileged and disadvantaged. They need to evaluate and carefully

consider the information for decision-making, consistent with Aihwa (1999), who mentioned that scientific citizens are required to have scientific knowledge, be able to evaluate and manage government crisis and be able to make choices for solving an ongoing crisis appropriately by themselves.

The Results of a Study on the Use of the Learning Management Model to Promote Scientific Citizenship

For the comparison of mean scores of science citizenship before and after class with the learning management model to promote scientific citizenship among upper secondary school students by t-test for dependent sample, the results are shown in Table 1.

The researchers measured and evaluated students' scientific citizenship by comparing post-test scores with a set criterion using cut-off scores (Berk, 1976). It was found that the the cut-off score was 12, calculated by selecting a score with the highest possibility of making a correct decision, the lowest possibility of making a mistake, and the highest accuracy coefficient of the criterion as a cut-off score.

According to the comparison of the mean posttest scientific citizenship scores with the cut-off score by a one-sample t-test, the results are shown in Table 2.

After arranging the learning to promote scientific citizenship, the students in the experimental group wrote a reflection of their thoughts after participating in the learning management in a posttest note form. Most of the students commented positively on the learning management model. They said the learning management model was fun and a very new experience for studying in the classroom.

Regarding the post-test mean score for each component of scientific citizenship, it was found that every component was higher than the pre-test mean score since the developed learning model could develop students to achieve all the components of scientific citizenship. This is consistent with DePace (2020), who stated that scientific knowledge should be developed in order to develop scientific citizens. Significant skills should be practiced, and the person should have a positive attitude. In each step, students shall gain experience by themselves; practicing enables students to become complete scientific citizens. This is consistent with Varis et al. (2018), who described that direct learning experiences aided students by allowing them to learn by themselves, thus promoting students to become enthusiastic citizens. Moreover, the results were also consistent with Sternsdorff-Cisterna (2015), who conducted research with scientific citizenship defined as a desire to work around the state in order to protect current and future generations' health and lives.

The developed learning management model helps encourage students to be more curious about science-related social issues. It allows students an opportunity to study further or seek more information by using an inquiry process for scientific knowledge until learning takes place within students; previous experience and new experiences are thus connected. The findings were consistent with the constructivism theory. Moreover, students shall conduct scientific arguments by giving logical reasons, evidence, and effect on society to support the standpoint of the stakeholder and have an effect on society at different levels. This is consistent with Vygotsky (1978), who stated that individuals should create knowledge through social interaction with others. The model can create experiences for students, making them have changes in knowledge, understanding, points of view towards society, and social expression. This is consistent with Mezirow (2000), who mentioned that individuals would change when they confront situations different from their past perspectives and thoroughly and critically consider them in terms of content, process, and paradigm, and exchange their thoughts rationally. Furthermore, it is in line with Panich (2015), who found that changes should take effect when considering worldview, knowledge, understanding, and behavior change.

Table 2 The comparison of the mean posttest scientific citizenship scores with the cut-off score

N	Mean score	Standard deviation	Cut-off score	*t*	*p*
53	17.32	4.56	12	17.97*	.00

Note: * $p < .05$.

Table 1 The comparison of mean scores separated by components of scientific citizenship before and after instructional the learning management model

Components	Full score	Pretest		Posttest		Percentage change	*t*	*p*
		$\bar{x}$	*SD*	$\bar{x}$	SD			
Individual aspect	8	3.55	1.29	6.17	1.37	73.80	11.70*	.00
Social interaction	12	4.62	2.10	8.49	1.71	83.77	15.05*	.00
Social awareness	3	1.47	0.99	2.66	0.52	80.95	8.48*	.00
Scientific Citizenship	23	9.64	8.47	17.32	4.65	79.67	23.45*	.00

Note: * $p < .05$.

Conclusion

The learning management model was appropriate for enhancing students' scientific citizenship. Teachers would be able to implement each step of the learning management model and adapt the instruction in accordance with the context of the students. This study also concluded that learning activities can encourage students to become more scientific citizens in all three aspects through personal, social interaction, and social awareness.

Recommendation

A study on factors and learning management guidelines that focus on enhancing scientific citizenship in the 1st component (individual aspect) should be additionally conducted since it was found that the post-test mean score from the learning management model for enhancing scientific citizenship based on this component seems to increase at the lowest level.

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