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The Effectiveness of Using Thelen's Model on Acquiring Physical Concepts and Developing Scientific Thinking for Tenth-Grade Students in Jordan

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Abstract

The current research aims to know the effect of teaching using Thelen's Model on acquiring physical concepts and developing scientific thinking among tenth-grade students in Jordan. The researcher used the quasi-experimental method. The sample consisted of 55 female students in the tenth grade for the academic year 2021-2022 from Mutah Secondary School for Girls. The researcher prepared a test for physical concepts and built a test for developing scientific thinking. Their validity and reliability were verified. SPSS software was used to analyze the data statistically. The results showed that the students of the experimental group who studied according to Thelen's Model outperformed the control group who studied in the usual way in the test of acquiring physical concepts, and in the test of developing scientific thinking with a statistically significant difference. In light of the results, the researcher recommended the necessity of using Thelen's Model in teaching physics because of its effective impact in acquiring concepts related to this subject and in developing scientific thinking.

Key words: Thelen's model; Physical concepts; Scientific thinking; Tenth-grade; Jordan

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1. INTRODUCTION

The present age in which we live is characterized by an increasing reliance on the information in one form or another. Some call it the "information age", which allows the different societies of the world to exchange knowledge and experiences, leading to the acceleration of scientific discoveries and technological innovations derived from science that lead to the progress and prosperity of the world and contribute to the realization of its aspirations and aspirations in life. In order to keep pace with these rapid developments, attention must be paid to the development of creative minds capable of solving the problems that exist. Accordingly, the development of students' mental capacities has become the main objective of the educational process in all the countries of the world (Al-Khataybeh, 2022).

Therefore, education is considered to be the wide field in which nations compete for the advancement and development of their societies. As a general field, education has been affected by the technological and knowledge revolutions that characterized the last decades of the previous century and the early years of the current century, which made it possible to develop the educational process in educational institutions at all levels, stages, patterns and levels (Davidson & Worsham, 1992).

Education is part of education and one of its important means in achieving its goals, as it plays an important role in achieving learning. The need to regulate the educational process is one of the necessary imperatives imposed by the progress of humanity. The renaissance that has afflicted the developed world has come only through attention to education and school curricula (Mayesky, 1998).

Psychological and educational studies and research have been interested in learning about the strategies, methods, models, and teaching methods that facilitate learning, which is one of the main components of the curriculum that affects and is affected by its components and contributes effectively to the success of the educational process and the achievement of educational goals. Among these methods that are used in teaching

in order to encourage students to learn, increase their creativity, develop their skills and experience, and acquire knowledge is the collaborative learning method (David, 2000). This helps to teach students to work together based on collaboration, based on respect for the talents and individual differences among members of the heterogeneous group. Creating a material-rich learning environment, adopting appropriate teaching methods focused on learning by working in groups and solving problems, creating appropriate teaching materials through textbooks and special programs, and taking into account the needs and inclinations of learners is an important stimulus to the process of developing student thinking (Duckworth, 1987).

Thelen's Model (collective inquiry) model is an important learning model in collaborative learning that helps to develop student's scientific thinking. It focuses on interactions within small groups to bring about changes and positive academic and social outcomes (Konzek, 2002).

The importance of this model in teaching is highlighted as giving students a sense of the dimensions and contents of the lesson and allowing them to express their views in a democratic and scientific spirit (Hargreaves, 2009; Lind, 1999).

Based on the above, this model gives great importance to concepts in science education and helps to shift the impact of education, thus helping to create relationships between the different elements at any educational time and enabling it to recognize the similarities between what was learned and the new attitudes.

The acquisition of concepts at the educational level is one of the most important challenges facing teachers in the field of education. This requires a change in the aims of education, from merely communicating information, facts, and knowledge to helping them to develop mental habits that will enable them to live in a changing society, given the enormous change in all aspects of life. Facts and information can be learned by simply recounting and remembering what has been learned. However, this mental process is not an end in itself, but the aim behind this is to learn to acquire and apply concepts in new situations that the learner has never known about (Joyce& Weil,2009).

The most appropriate educational stage for training in scientific thinking is the secondary stage. Students accumulate sufficient basic knowledge that enables them to understand and practice scientific thinking with maturity and responsibility. This indicates a positive relationship between the level of school achievement of students in scientific subjects and their level of understanding of scientific ways of thinking. This means that their level of achievement increases with the increasing understanding, use, and application of the scientific method of studying science (Raffini, 1993).

Education is no longer a small category in society. Today, it faces many difficulties that it has not been accustomed to, due to the rapid changes taking place in the world today. The task of education has thus become difficult, which has led to the low level of achievement of learners in various subjects in general and physics in particular (Al-Khataybeh, 2006; Zeece, 1999).

Teaching is still far from ambition and a large part of teachers in basic and secondary schools teaching in Jordan generally follow traditional teaching methods. Thus, it is clear that the traditional teaching of physics has always focused on preserving the subject imposed on students, rather than solving the problems they face in their scientific activity and daily lives (American Association for the Advancement of Science, 1993).

In addition, there is the cognitive impetus from scientific concepts in a single material and the obligation of the learner to master it as an end in itself without paying attention to its use and use in their daily life situations (AL-Khataybeh& AL-Awasa, 2016).

Accordingly, the problem of current research is highlighted in the answer to the following question: What is the effectiveness of using Thelen's Model on acquiring physical concepts and developing scientific thinking for tenth-grade students Jordan?

1.1 Objectives of the Research

The current search is aimed at identifying an effect:-

- The use of Thelen's Model in the acquisition of physical concepts in intermediate tenth-grade physics students.

- The use of Thelen's Model for the development of scientific thinking in tenth-grade physics students.

1.2 Research Hypotheses

To achieve the goals, the following hypotheses were put forward:

- There is no statistically significant difference at the significance level (0.05) between the mean scores of the pilot group students who studied the physics subject on the Thelen's Model and the average scores of the control group students who studied on the standard method of acquiring physical concepts.

- There is no statistically significant difference at the level of 0.05 between the mean scores of the pilot group students who studied the physics subject on the Thelen's Model and the average scores of the control group students who studied on the standard method of the distance test for the development of scientific thinking.

1.3 Procedural Definitions of Terms

- Thelen's Model: - is the model that seeks to develop the ideal society through democratization but in a collective manner and with scientific inquiry considering that the classroom is a small community similar to the big one. Procedurally, the researcher Thelen's Model defined as a group interaction process for female students in tenth- grade through confronting female students in their groups in the physics class with a bewildering attitude,

and exploring the group's reactions to the situation by identifying the problem and formulating it in an important, treatable and researchable way, then the individual self-study and the collective study of the problem, monitoring the progress made by female students in the second middle grade, and urging student groups to cooperate to exchange ideas between groups in order to reach a solution in a democratic atmosphere prevailing in the classroom."

- Acquisition: - is the formation of new synaptic associations which, if entries are commonplace, will strengthen the connections being aroused. The formation of associations will depend largely on prior experience. The researcher defines acquisition as the ability of female students in tenth- grade to acquire and store knowledge and to use physical concepts, their definition, distinction, and application. During the trial period, they were measured by the degrees obtained by female students in the physical concepts acquisition test prepared by the researcher.

- Concept: - An idea or representation of a common element that can distinguish groups or workbooks or that is a general and abstract mental conception of a topic or situation. Procedurally, concept is defined as a word in the form of reason, or a word indicating the characteristic set of natural physical phenomena which a student, by employing for her mental processes, devotes to the physical concepts taught to tenth-graders in intermediate terms, the acquisition of which is measured by the degree to which the female student obtains in the conceptual test designed for this purpose.

- Development:- It is a process that seeks social harmony among members of society and includes the satisfaction of organic, psychological and social needs. Procedural definition of development: developing and improving the scientific thinking abilities of tenth-grade students, after the researcher used the Thelen's Model in physics education, with the aim of developing these abilities, which are measured by the degree that female tenth-grade students receive in the Scientific Thinking Development Test prepared for this purpose.

- Scientific thinking: - Organized, evidence-based, evidence-based mental activity used by humans to address problem-seeking situations with a sound methodology organized within the context of mental and factual assumptions. Procedurally defined as a set of mental processes and sequential steps by female students of tenth-grade which lead to new knowledge, ranging from problem identification, imposition and testing of the validity of the task to generalization, measured in the total degree to which a female student receives a response to the items of the Experiment for the Development of Scientific Thinking prepared for the current research.

- Tenth-Grade: It is the last grade for the basic stage, which is between the basic and secondary stages. The function of this grade is to prepare students for a higher stage, which is the secondary stage.

2. THEORETICAL BACKGROUND

2.1 Constructivism Theory

Science education and learning entered the third millennium to face a set of challenges and variables, and it is, therefore, necessary for science teachers to deal unconventional with these challenges. Education is the only way to meet the challenges of the twenty-first century. We must recognize that the changes that have taken place in the educational establishment in the last century are unavoidable. This transformation has been accompanied by the constructivism theory, which represents a paradigm change in science education (Garrison, 2000; National Research Council, 1996). Swiss scholar Jean Piaget is the first to lay the foundations of the construction theory, despite its origins in Giambaste Vico. He says that knowledge lies in the building and reconstruction of knowledge (Colapinto, 1988; Scandura, 1976).

Many studies, based on the principles of cognitive science, have had a major impact on educational applications, particularly educational applications:

- Cognitive Apprenticeship (Brown, Collins, & Duguid, 1989); It is a concept that emphasizes that what students learn should be applied simultaneously through learning attitudes (situated learning) and cognitive attitudes, in which students learn through collaborative learning and collective inquiry.

- Vanderbilt's Cognition & Technology Group Anchored Instruction developed by a group of researchers at Vanderbilt's Learning and Technology Center based on the concept of learning, called Indigenous Task-based Learning, a type of education in which learners engage in problem-rich environments that allow for continuous learning by teachers and students through collaborative learning (Carpenter & Taylor, 2003).

According to structural philosophy, a student is a discoverer of what he is learning, practices scientific thought, is a forager of meaning, is a builder of his knowledge, and is involved in the management and evaluation of learning.

2.2 Collaborative Learning Strategy

Educators in the 21st century were interested in how teachers could achieve better learning than in how teachers could provide better information, allowing a shift from teacher-led lecture and discussion) learning models to learner-centered learning activities and learning models such as collaborative learning that divide learners into small groups working on a task (Aronson, 2000).

It is also possible to learn from the results of research conducted in the field of collaborative learning that it is better than individual learning, increases students' self-esteem, develops affection between members of one group and other groups, develops students' positive attitudes towards themselves and their schoolmates, increases

students' scientific thinking, creativity, and participation, reduces their anxiety and leads to the development of leadership skills and teamwork (Al-Khataybeh, 2018; Johnson et al, 2013).

There are several methods, techniques, models, and patterns of collaborative learning with different names, titles, and techniques in the literature of research. Among them, the researcher mentions the following: - First: Jigsaw (1) method; Second: Modified Jigsaw2 Method; Third: STAD method; Fourth: Think-pair-share Model; Fifth: Group Investigation Model (Bertucci et al, 2000).

2.3 Thelen's Model (Group Investigation Model)

In 1960, Thelen relied on John Dewey's ideas, which stemmed from his theory contained in his book "Democracy and Education." He recommended that the organization of the school and its interaction be based on the idea that it is a small democratic society. Democracy requires the creation of a democratic culture with the following appropriate standards and procedures:

- Education must be in a democratic society.
- Culture provides a democratic school.
- Teachers are the first educators of democratic life.

Many of the basic features of this method were designed by Thelen and refined by Sharan and his group, and this method is perhaps the most complex and difficult to apply to group learning (Davidson& Major, 2014; Joyce & Weil, 2009). Thelen was concerned with the democratic foundations of social relations and human interaction among members of society and it was assumed that this model could be achieved by building education within the democratic process. Based on what he once mentioned, students in Thelen's Model in the classroom are not only onlookers but active learners, because they are responsible for their own education. Teachers can take on the role of facilitator, and they can have the freedom and direct help to reach conclusions. All this helps make the learning process exciting and new (Sharan & Sharan, 1992).

2.4 Planning & Implementation of Teaching under Thelen's Model

The teaching shall be planned and implemented in the framework of the collective inquiry model in six stages. Each element represents a step in the general structure of the model. The steps of this model can be illustrated in the following stages:-

Phase 1: Select survey subject:

At this stage, the subject of the survey is determined by three steps:

a. The teacher presents the student's subject or problem in the form of a superior question.

b. The main question or theme is divided into sub questions.

c. Students shall be divided into cooperative groups of 2-6 members each. Subtopics or sub-questions shall be divided among these groups.

Phase 2: Group survey planning:

At this stage, the members of each group formulate the topic or problem in the form of one or more research questions and together plan the search method required to answer the question or questions.

Phase 3: Execute Search

At this stage, the survey or research is carried out. Each group implements the plan that has been previously agreed upon. Each group member collects the necessary information from various sources and uses these results to solve the problem in question.

Phase 4: Preparation of the final report

This step represents the cumulative effect of each group's work, which may be in the form of a written report, a demonstration, a form, an audio tape, or a video. In this step, group members include a committee to coordinate the display of the final report or product after it is presented to their colleagues in the group.

Phase 5: View the final report

Each group prepares its final report and presents it to all class students. Students or teachers establish a set of criteria to judge the quality of the report and its presentation.

Phase 6: Assessment

This phase is being carried out in several ways, including:

a. The instructor assesses the research students undertook in each group, namely, the plan, the resources used by the group, and the conclusions reached.

b. The group can submit two or three questions, and these questions represent the basis upon which a final test can be made for all students. In this case, each group would base the answers of the students of the other groups on the questions they had formulated.

c. Each group should monitor and manage their own effectiveness and provide a brief overview of what they have learned and how students interact with this process.

d. Systematic reporting by students on the adoption of the Teamwork Problem Solving Model (Joyce & Weil, 2009; Ian& Samuel, 2005).

Thelen's Model provides a positive educational environment for students by helping them accomplish their tasks, such as solutions and suggestions for solving new problems.

2.5 Concepts

Concepts are among the most complex levels in the field of cognitive psychology. They are the meanings and the comprehension that an individual has. They are expressed in terms of specific words, phrases, or processes that lead to the development and growth of his ability to think and build ideas, and enough to understand his or her experiences about the world of things around him. The meaning of a certain concept depends on a set of links between other concepts, which have formed verbal and related statements over time, and some of which are personal (Barcelona, 2014). The researcher believes that

the learning and acquiring of concepts is represented by the ability of students to distinguish between the influences or characteristics associated with the concept and to group these influences or characteristics under a class or rule.

2.6 Scientific Thinking

God created man and distinguished him from other living beings by many grace, including the grace of thought that has received the attention of researchers, educators, and philosophers throughout history. All schools of philosophy thought, education and psychology have been concerned with developing the thinking of the learner so that it becomes more capable of facing the difficulties that face him, whether in academic fields or in different aspects of life, from social, economic, educational or ethical aspects (Dunbar& Fugelsang, 2005). Educators emphasize that one of the aims of science teaching is to teach students (how do they think?)To achieve this, teaching must focus on helping students acquire the scientific method of thinking or the scientific method of research. Thinking is an acquired skill, not an innate talent. This skill in how to learn can be improved and developed (Donovan& Hoover, 2013; Kuhn & Pearsall, 2000)

The researcher believes that the interest of educators is clearly increasing without activities and activities that make learners the center of the educational process. One of the most prominent of these activities is adopting the method of cooperative groups working to achieve goals by assigning work or important tasks to learners. She believes that Thelen's Model is one of the collaborative methods that play a role in acquiring concepts and developing scientific thinking among learners.

3. METHOD

The researcher discusses the actions undertaken by her to achieve the two objectives of the research: identification of the scientific material; preparation of an experiment (acquisition of physical concepts and development of scientific thinking); preparation of lesson plans, behavioral objectives, and experimental design, and research groups.

3.1 Pilot Design

Each pilot research has its own design, which is a blueprint and a work program for how to implement the experiment and plan the circumstances and factors surrounding the studied phenomenon, and then note what is happening. The researcher undertook an experimental, partially tuned design appropriate for the circumstances of the current search.

Table 1
Experimental Design of the Research

Dependent Variable	Independent Variable	Group
Physical Concept Acquisition Test	Thelen's Model	Experimental
Scientific Thinking Development Test	The Usual Way	Control

3.2 Research Community and Sample

a. Research community: The research community identified female tenth-grade students in Jordan during the scholastic year (2021-2022).

b. Sample research: The researcher selected Mutah secondary school for Girls for her research. After the researcher visited the school and found that it had three divisions, and through random way, the (A) division was chosen to represent the experimental group whose female students would be taught on Thelen's Model, while the (B) division represented the control group whose female students would study in the traditional way. The total of the two divisions was 55 students.

Table 2
Distribution of the research sample students to the experimental and control groups

Group	Number
Experimental	28
Control	27
Total	55

3.3 The Equivalence Procedure for Research Groups

The researcher worked on the statistical equality of the two groups of the current research in some variables that may affect the variables related to the research, although random selection ensures the equality of the two groups. The researcher used the intelligence test (Raven) for the two research groups. Using statistical analysis, it was found that the two research groups are equivalent, as shown in the following table.

Table 3
Mean, variance, and T-value (calculated and tabulated) in the intelligence test of the students of the two research groups

Sig.	T-Value		df	Variance	Mean	No.	Group
	Tabulated	Calculated					
Not significant at (0.05)	2،021	0.931	53	34.91	34.39	28	Experimental
				35.61	34.18	27	Control

3.4 Determining the Scientific Material

The selected chapters were determined from the physics book for the tenth grade to be taught by the Jordanian Ministry of Education (2022-2021).

3.5 Setting Behavioral Goals

The researcher formulated the behavioral goals based on the analysis of the content of the educational material that was included in the experiment and reached (117)

behavioral goals distributed over the content of the selected chapters of the physics textbook for the tenth grade. The researcher presented these behavioral goals to a group of experts and specialists in the field of education, psychology, and teaching methods Science, measurement, and evaluation to express their opinions and observations about them and their suitability to the level of the objective they are measuring and their coverage of the subject.

3.6 Preparing Teaching Plans

The researcher prepared to teach plans for physics topics for the tenth grade that will be studied in the experiment in the light of the book's content and the formulated behavioral objectives and according to Thelen's Model for the students of the experimental group and the traditional method used for the students of the control group. The researcher presented a model of these plans to a group of experts and specialists in Methods of teaching science and psychology to seek their opinions, observations, and suggestions to improve the formulation of those plans and make them sound to ensure the success of the experiment.

3.7 Preparing Tests of Current Research

Preparing a test used to measure the acquisition of physical concepts for the current research sample. The researcher prepared the test according to the content of the study material and curriculum vocabulary for the physics textbook for the tenth grade, and a test for the development of scientific thinking in order to measure the level of students in adopting the scientific method of thinking.

A- Preparing the Physical Concepts Acquisition Test:
The researcher prepared a post-conceptual test through which to verify the effectiveness of the teaching method used in acquiring physical concepts. The post-test included (48) test items with four optional alternatives, one of which represents the correct answer, while the rest of the alternatives represent the wrong answer about the concept you measure. The items, numbering (16), is a concept, and the researcher took into consideration in preparing the items that each concept should have three test items that measure the mental processes of acquiring the concept, which is (definition, distinction, application).

B- Preparing a test for developing scientific thinking:
The researcher built a test for the development of scientific thinking for the students of the two research groups (experimental and control) in proportion to the characteristics of the academic stage and the scientific subject. It measures the student's ability to gather information (the second domain), (six) items measure the student's ability to test the hypotheses (the third domain), and (five) items measure the student's ability to test the validity of the hypotheses (the fourth domain) and the researcher has placed (four) items that measure The student's ability to interpret the data (the fifth field) and (five) items that measure the student's ability to generalize or use the results (the sixth field) in new situations.

3.8 The Final Application of the Experiment

After completing the period of applying the experiment to the students of the two research groups this lasted for two months. The researcher applied the physical concepts acquisition test to the two research groups (experimental and control), after completing the teaching of the specific subject in the selected chapters of the physics book for the tenth grade. The development of a scientific thinking test was applied to the two groups (experimental and control), and the researcher herself corrected the answers of the students of the two research groups.

4. RESULTS & DISCUSSION

4.1 The Results

a- The results related to the first hypothesis which states: There is no statistically significant difference at the significance level (0.05) between the mean scores of the experimental group students who study according to Thelen's Model and the average scores of the control group students who study according to the traditional method in the test.

After correcting the answers of the students of the two search groups for the items of the physical concepts acquisition test, the results showed that the mean of the total scores obtained by the members of the experimental group was (35.03) with variation (27.36), and the mean of the total scores obtained by the students of the control group was (23.33) and with variation (19.17). To find out the significance of the statistical difference, the researcher used the t-test for two independent samples.

Table 4
Means, variance and the calculated T-value of the two groups in the physical concepts acquisition test

Sig.	T-Value		df	Variance	Mean	No.	Group
	Tabulated	Calculated					
Significant at (0.05)	2،021	9.21	52	27.36	35.03	28	Experimental
				19.17	23.33	27	Control

Table 4 shows that the calculated T-value of (9.21) is greater than the tabulated value of (2,021) at the significance level (0.05) and the degree of freedom (52), which indicates the existence of a statistically significant difference between the average scores of the students of the two groups The research and in favor of the experimental group, and accordingly, rejects the null hypothesis and accepts the alternative hypothesis which

states that there is a statistically significant difference at the significance level (0.05) between the mean scores of the experimental group students who study according to Thelen's Model and the average scores of the students of the control group who study according to" For the usual method of testing the acquisition of physical concepts.

b- The results related to the second hypothesis which states: There is no statistically significant difference at the level of significance (0.05) between the mean scores of the experimental group students who studied according to Thelen's Model and the average scores of the control group students who studied according to the usual method in the development of scientific thinking test.

After correcting the answers for the test items, the results showed that the means of the total scores obtained by the experimental group students (17.464), with a discrepancy of (9.59), and the arithmetic means of the total scores obtained by the students of the control group (15.037) with a discrepancy of (5.88), and to find out the significance of the differences between For these averages, the researcher used the t-test for two independent samples.

Table 5
Means, variance, and the calculated T-value of the two groups in the post-test for the development of scientific thinking.

Sig.	T-Value		df	Variance	Mean	No.	Group
	Tabulated	Calculated					
Significant at (0.05)	2.021	2.95	53	9.59 5.88	17.464 15.037	28 27	Experimental Control

Table 5 shows that the calculated T-value (2.95) is greater than the tabulated value of (2.021) at the level of significance (0.05) and with a degree of freedom (53), this indicates the superiority of the students of the experimental group who studied using Thelen's Model over the students of the control group which was studied in the usual way in the post-scientific thinking test.

The researcher calculated the scores of the students of the two research groups in the post and pre-tests of scientific thinking. The researcher extracted the arithmetic mean, the average differences between the scores of the post and pre-tests of scientific thinking, the variance, and the T-value (for two correlated samples) calculated for the differences in scores between the post and pre-tests of scientific thinking among the students of the two research groups. That is in Table 6.

Table 6
Results of the T-test of the two research groups in the post and pre-tests of scientific thinking

Sig	T-Value		df	Variance	Mean dif.	Mean	Test	No.	Group
	Tabulated	Calculated							
Signify	1.703	2.57	27	5.73	2.78	17.46 14.67	Post Pre	28	Experimental
Not signify	1.706	0.222	26	11.25	0.481	15.037 14.55	Post Pre	27	Control

Table 6 shows that the value of (T-Test) for the calculated experimental group is (2.57) which is greater than the value of the tabular (T-Test) which is (1.703). Among the students of the experimental group, the Thelin model had an effect on the scores of the post and pre-tests of scientific thinking for the tenth-grade students while the value of (T-Test) for the computed control group (0.222) was less than the tabulated (T-Test) value of (1.706). It indicates that there is no statistically significant difference in the average differences between the scores of the post and pre-tests of scientific thinking.

5. CONCLUSIONS

In light of the results of the current research, the researcher reached the following conclusions:

• Steps (Thelen's Model) can be highly effective in developing the learner's skill abilities by encouraging him to think and analyze problems and issues.

• Thelen's Model contributes to giving the teacher a new role in reorganizing the content away from randomness and in proportion to the goals he wishes to achieve.

• Thelen's Model works on developing the knowledge structure by providing the students with new information so that they develop their scientific knowledge.

RECOMMENDATIONS

In light of the results and conclusions of the current research, the researcher recommends the competent authorities to:

• The necessity of using the (Thelen's Model) in teaching physics at the secondary stage because of its effective impact in acquiring concepts for this subject and in developing scientific thinking.

• Preparing a guide for the teacher explaining how to use cooperative learning models in general and the group investigation Thelen's Model in particular.

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