xIlkogretim Online - Elementary Education Online,2021; Vol 20 (Issue 5): pp.3479-3496
http://ilkogretim-online.org
doi: 10.17051/ilkonline.2021.05.383

The Effect of the P5BL Model on the Development of Scientific Thinking Skills and Academic Perseverance in Physics among First-grade Secondary School Students

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ABSTRACT- The current study aims to identify the effect of the P⁵BL model on developing scientific thinking skills and academic perseverance in physics among first-grade secondary school students. It used the experimental approach with a quasi-experimental design for the two groups: experimental and control. The research sample consisted of (45) secondary school students in Hail, Kingdom of Saudi Arabia: (23) students in the experimental group and (22) students in the control group. It used the following tools: Scientific Thinking Skills Test in States of Matter Unit. These skills include observation, interpretation, measurement, conclusion, prediction, classification, formulating hypotheses, and experimentation. It also used an Academic Perseverance Scale. It includes three dimensions: insistence on achieving goals, and assuming responsibility for learning, and academic ambition. The scale statement (24) were formulated on a three-step scale: often, sometimes, and rarely. The study found a statistically significant effect of the P5BL model on developing scientific thinking skills in physics and academic perseverance among first-grade secondary school students. It concluded that the P5BL model plays an important role in developing students' scientific thinking and academic perseverance. The study ended with a set of recommendations.

Keywords: P5BL Model- Scientific Thinking - Academic Perseverance

I. INTRODUCTION

Scientific thinking has gained great importance due to its close connection with scientific and technical development. This is reflected in scientific education as it is concerned with developing inquiry skills, science andresearch processes relatedthe learner, together with using them in problem-solving. Scientific thinking refers to both thinking about the content of science and a group of thinking processes that are closely related science, such as induction, deduction, experimental design, causal thinking, concept formation and hypothesis testing. Indeed, scientific thinking and scientific discovery can be conceived as a form of problem solving (Dunbar and Klahr, 2016).

Scientific thinking is a purposeful behavior geared towards studying the phenomenon with all its facts and dimensions in order to reach explanations that clarify the relationships that the phenomenon may contain and then give judgments related to it. It is also known as a cyclic and cumulative process of intentionally searching for knowledge (Zimmerman, 2007).

Scientific thinking skills refer to the basic competence of problem-solving skills.They play a role in developing higher-order thinking skills. In addition, they also affect the learner's logical and organized thinking. In this regard, scientific thinking skills not only help the learner in acquiring scientific knowledge, but also help him in being able to have accurate scientific observation, collecting, classifying and analyzing data, and building correct scientific interpretations.They are among the goals of science education in general, and teaching physics in particular.

Many studies have emphasized the importance of developing thinking skills, using learner-based teaching strategies and models that encourage the learner to be positive, not to be a passive recipient of knowledge.

Rather, he/she should try to solve scientific problems (Spisak& Collins, 2019; Ratnasari, Suciati, &Maridi, 2019; Koerber& Osterhaus, 2019; Woolley et al., 2018)

In addition, the focus in physics education is no longer based on how much the learner gets from the cognitive structure of the learning material: "facts, concepts, laws and theories". Rather, he/she should go beyond the affective aspects. Therefore, studies have recently tended to pay attention to some non-cognitive variables that have proven their effective role in influencingthe learner's cognitive variables, including academic perseverance variable. Actually, academic perseverance is seen as "strengthening the focused effort in order to achieve success in a task, regardless of the challenges that face us, as well as the ability to overcome failures.It reflects personality traits, as perseveringindividuals are characterized by the ability to adapt and face obstacles,"Liptak(2019) considers it as a positive feature that the learner needs when acquiring some skills. It is reflected in the individual's work as he/she exerts continuous effort to achieve good performance.The individual's success to reach high levels of performance depends on his/her ability to endure difficulties, and continue exerting effort despite the obstacles he/she encounters.

Given the importance of scientific thinking in physics education, the difficulties that face the learner during learning it, and the importance of academic perseverance that actually leads to playingan effective role in learning,being more focused and engaged in learning, there is a need to use learning models based on the learner's positive activity of and effectiveness in the learning process.This is what constructivism theory argues for. P5BL model is one that is based on the principles of constructivism theory; It is an acronym for (Problem-Project-Process-People-Product) Based-Learning.It is a model based on (Problem-Project-Process-People-Product). It is a development of the project-based learning model PBL (Fruchter& Lewis, 2003; Fruchter, 1998).

Abu Awad (2017, p. 10) indicates that the P^5BL learning model is a methodology for teaching that relies on the existence of a problem, presented to a group of individuals who represent the work team. It is agreed to solve the problem through a project, through specific action steps to produce a final product that can be useful. Fruchter and Lewis (2003) also argue that P5BL model in which learning and group work activities are organized, as there are three types of organized activities: IT-focused lecture, laboratory sessions, and professional training sessions.

In the light of the importance given to the development of both scientific thinking skills and academic perseverance in physics for the learner and their influential role in reaching a high level of learning, the current research is interested in using the P^5BL learning model in teaching physics and recognizing its impact on the development of scientific thinking skills and academic perseverance among first grade secondary school female students.

Research problem

Several studies have indicated that the low rates of academic failure and the lack of gains in scientific thinking ability, and the practice of scientific thinking skills are due to the non-use of student-center approaches and models (Ratnasari,Suciati,&Maridi, 2019; Jensen. & Lawson, 2011; Minner et al., 2009; Rissing& Cogan 2009).

The research also indicated that the most influencing factor in the learner's performance is motivation. There are many factors that affect the learning motivation, including the desire to practice activities and pay more attention to them.Despite many obstacles the learner face, willingness and desire to learn is an important element in the learning process.This behavior is referred to as 'academic perseverance." The research also indicated thatstudent dropout, and not to pursue education, or to pursue it at lower level,they reflect the weakness of academic perseverance and the unwillingness to continue learning. Academic perseverance in education is a strong indicator of the quality of learning. It reflects the learner' self-organization. Based on it,it is possible to predict the behavior and the extent of the learner's continuity in the learning process. The learner with high academic perseverance is most likely to reach high performance in the learning process (Thalib, Hanafi, Aufar, Irbah&Eduardus, 2018; Borghans, Duckworth, Heckman,&TerWeel, 2008).

P^5Bl is a model that allows the learner to formulate questions based on previous knowledge and curiosity. Additionally, it allows the learner to participate in the inquiry process by first developing questions and then searching for evidence and using it in question investigation. In such a way, the learner learns to interact with the content to enhance one's knowledge, learning to continue asking questions and benefiting from new knowledge.He/She learns how to search and use available information sources, enhancing the use of scientific thinking skills. Therefore, the current study sought to identify the effectiveness of the P^5BL model in developing scientific thinking skills and academic perseverance in physics among first-grade secondaryschool female students, by answering the following main question:

What is the effect of the P^5BL model on developing scientific thinking skills and academic perseverance in physics among first-grade secondary students? This main question is divided into the following questions:

1. What is the effect of the P^5BL model on developing scientific thinking skills in physics among first year secondary school students?
2. What is the effect of the P^5BL model on developing the academic perseverance of first- grade secondary school students?

Research Hypotheses

Research hypotheses are formulated as follows:

1. There is no statistically significant difference at the level of significance ($0.05 \geq \alpha$) between the mean scores of the experimental group students, who studied using the P^5BL model, and the scores of the control group students, who studied using the traditional method, in developing scientific thinking skills in physics.
2. There is no statistically significant difference, at the level of significance ($0.05 \geq \alpha$)between the mean scores of the experimental group students,who studied using P^5BL model, and the mean scores of the control group students,who studied using the traditional method, in developing academic perseverance.

Research objectives

The current study aims to:

1. Study the effect of the P^5BL model on developing scientific thinking skills in physics among first-grade secondary school female students.
2. Study the effect of the P^5BL model on developing the academic perseverance of first-grade secondary school students.

II. Literature Review

First axis: Theoretical foundations of the P^5BL model:

The P^5BL model is defined as a process of teaching and learning that mainly focuses on the problem and the project-centered activities that require gathering people from multiple disciplines together.It is also defined as learning based on students' approach to the problem at hand, and then collaboratively carrying out a set of procedures, using the available tools in designing and implementing a project. The project addresses a problem and seeks to provide a tangible product that contributes to solving the problem at hand, under the supervision and guidance of the teacher (Fruchter, 2003; 2000; Fruchter, 1998). It is an educational model based on five basic elements: Problem, Project, Processes, People and Product. It aims to solve the presented problems by designing projects by working in a team to evaluate a final product that benefits the learner, based on guidance by the teacher, so that it will lead to lifelong learners.

In the light of this discussion, the P^5BL learning model is among the teaching models that seek to build an educational environment that works to expand the scope of practice and application of practical skills by providing appropriate opportunities to practice these skills and improve the use of these skills.These skills qualify them for the future labor market. It is an acronym for Problem, Project, Processes, People and Product. It is defined as an approach to teaching that focuses on a problem. It is presented to a group of students who work as a team.They agree among themselves to solve this problem through a project with specific action steps in order to reach a final product that benefits the community.

The objectives of the P5BL are identified as follows (Chinowsky, Brown, Szajnman&Realph, 2006; Fruchter& Lewis, 2003; Fruchter, 2000; 1999; 1998):

1. Training in structured knowledge and understanding the role of knowledge in a multi-disciplinary, collaborative and project-based environment.
2. Learning how to participate in different learning topics, leading learning groups, and building a safe, high-quality and effective learning environment.
3. Working well in multidisciplinary projects, because working on multidisciplinary projects is an attempt to overcome the limitations imposed on different disciplines, especially since education programs rarely provide the opportunity for the learner to participate in collaborative, multidisciplinary projects based on projects in a collective e-learning environment that is done on an international level.
4. Expanding students' competence to benefit from acquired theoretical knowledge and to understand the role of field-specific knowledge in amultidisciplinary learning environment based on P5BL. This is done from a constructivist learning perspective to explore the theoretical constructs and practical implications for developing practice communities that transcend the boundaries of the learning environment.
5. Employing project-based learning through problem analysis, integration of knowledge and practice, collaboration and team work, and participation in learning activities.
6. Making the problem the stimulus and the catalyst for the different learning styles based on (project, problem, process, people, product) and encouraging the learner to be independent in the learning process. The learner learns the skill of dialogue, communication, leadership, and having relationships with people correctly. The learner will be a critical thinker, and have leadership in learning, as he/she works with his colleagues in groups.

P5BL Model Components:

P5BL model consists of five basic stages, beginning with a problem to be agreed upon by the work team (students), building plans and appropriate design to solve the problem through building a project, then applying appropriate processes and steps to complete the project, solve the problem and produce the product, under the supervision of the teacher.Figure 1 illustrates these stages.

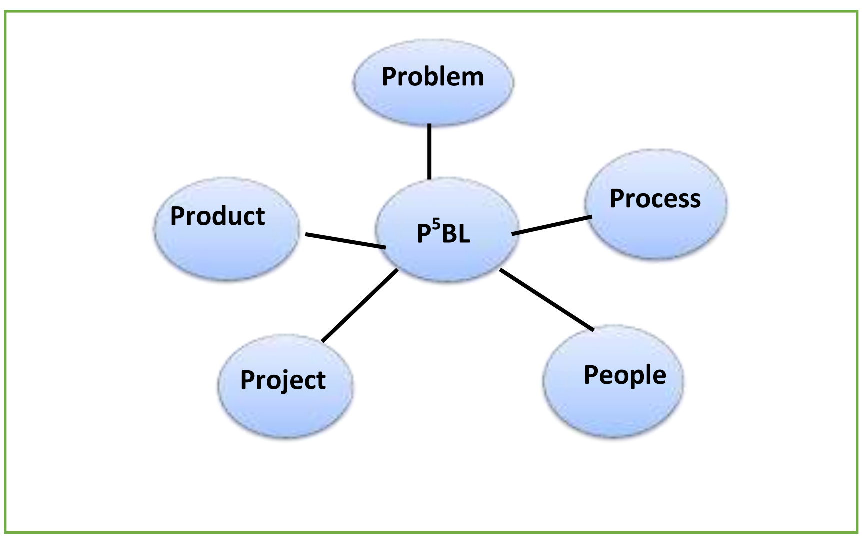

Figure 1: Illustration of components of P5BL Learning Model (Abu Awad, 2017)

First: Problem based learning

This type of learning focuses on active learning, problem finding and identification, the ability to think, and problem-solving processes. As for the teacher, it helps him/her in teaching and building a safe learning environment for students.When problem-based learning is integrated into the educational curricula, these approaches help the learner to build new knowledge concepts and integrate them with basic knowledge "knowledge building" (Şendağ, &Odabaşı, 2009).

In fact, educational systems have sought to integrate problem-based learning into curriculum design to help the learner focus more on the connection between real problems and knowledge of the subject matter, and to help students improve their critical thinking (Cheng, She, &Annetta, 2014).

The problem-based learning approach represents an effective tool that provides the learner with adequate opportunities to discover new knowledge. This knowledge is a prerequisite for solving the problem.The current research recommended the need to adopt PBL because it allows the learners to engage in an active learning process to find innovative solutions to the problems they face during the learning process.There isa need to combine innovative and critical thinking skills in problem-based learning (PBL) because multiple thinking skills cooperate and synergize together in reaching different solutions. The process of proposing possible solutions in one of the problem-based learning stages refers to innovative thinking and its skills, while subjecting these solutions to logic, analytical thinking and looking into ideas without bias in one of the stages of problem-based learning indicates critical thinking. Innovative and critical thinking complement each other when solving a problem (Birgili, 2015).

The characteristics of problem-based learning are determined by the following: learning must necessarily be student-centered. Learning takes place in small groups of students under the supervision and direction of the teacher. The teacher's performance is determined by being a trainer and facilitator of the learning process.Learning begins with an authentic problem, and the problems presented to the learner are used as a tool to achieve and investigate the required knowledge.It is necessary to employ problem-solving skills to reach the solution (Shinde&Inamdar, 2013).

Second: Process-Based Instruction

Researchers have recommended the importance of process-based instruction as a means by which scientific concepts can become meaningful to the learner, providing him/her with sufficient guidance in his/her study of science to develop research skills and scientific process skills such as measurement, observation, classification and prediction. The main goal behind the new curriculum projects that were launched in Western countries at the end of the last century were mainly aiming to present science in a way that science would progress and evolve. According to this, the new curricula are designed to shift the focus significantly from the old methods of presenting science as a mere set of facts and terms that are memorized by students to being a way of thinking, building and developing a useful and fruitful understanding of basic concepts and principles. This is done by the appropriate use of investigative processes, and then achieving experience in an effective use of scientific procedures to solve problems and apply scientific understanding in the life of the learner (Arlianty, Febriana&Diniaty, 2017; Ango, 2012; Mari &Shaibu, 2003).

The goal of process-based instruction is to train the learner in developing the ability to apply science processes and scientific principles, such as science process-skills to solve a wide range of problems. Science education is thus the structured training of the learner so that he/she can lead a productive life by solving his/her daily problems (Samuel, Libata&Sabitu, 2018).

Process-based learning is defined as a strategy that simplifies science learning through the use of scientific process skills, giving the learner a sense of responsibility in his/her learning, and increases the permanence of learning (Samuel, Libata&Sabitu, 2018).

Third: People Based Learning

P^5BL model depends on the work team.They are the ones who complete the project, as the learners cooperate with each other, forming one team, to accomplish certain tasks collectively, as they agree on the problem and then determine the steps to solve it and implement the project to reach a product that benefits all members of the team. The model aims to create a culture that brings together the educational institution, practitioners and students from different disciplines, each of whom has a role in the implementation of the project (Fruchter, 1998). Team-based learning is defined as an active and collaborative learning strategy that focuses on the learner, in which students bear the responsibility for their preparation and participation during the class.They should apply their knowledge in solving original problems, employing discussion as a means to reach agreement on the outcomes, i.e. it provides an opportunity to discuss and apply knowledge (Lin, 2019; Parmelee; Michaelsen; Cook &Hudes, 2012; Parmelee, &Michaelsen, 2010).

P^5BL model should be viewed in the sense that it is the means by which people innovate and re-innovate knowledge.It contains problem-based learning, which is an active mental process to access previous knowledge, establish connections between old and new concepts, and expand conceptual relationships to engage in building theory. Learners build their knowledge together, and shape their experiences.Fruchter and Lewis (2003) argue that with P5BL model the interaction between “student” team and the teacher is facilitated in order to advance the learning process and facilitate the process of reflection on cognitive processes. Students are expected to interact with other team members to define the role of specific knowledge presented in a multidisciplinary environment focused on the project, plus practicing newly acquired theoretical knowledge. Through multidisciplinary interaction, the team becomes a community of practitioners as mastery of knowledge and skill requires individuals to move towards full participation in the socio-cultural practices of a larger society.

Fourth: Project based learning

Project-based learning is considered one of the most important instructional models that give the student a fundamental role in the educational process as it develops his/her skills and knowledge. It creates cooperation and a sense of community at the school level, and brings dexterity and mastery in learning; taking responsibility for learning and setting goals, independence and discipline, negotiation, and follow-up; continuing to learn more deeply, developing ideas, and strengthening multidisciplinary links(Aksela&Haatainen, 2019). Ergül and Kargın(2014) point out that project-based learning is one of the learner-centered strategies, so that the learner builds his/her knowledge and seeks to achieve the project goals, starting from choosing projects that fit his/her inclinations and represent a real problem.The learner bears the responsibility of learning and solving problems, in addition to dealing with different educational situations. It also provides opportunities to use different environments for learning, and help develop personal and social skills.

Syarifah and Emiliasari (2019), andUmmah, In'am and Azmi (2019) indicated that project-based learning not only improves the learner's language skills but also other skills associated with critical and innovative thinking with its originality, novelty and flexibility aspects. It also provides students' perceptions about how to implement the project, collaborative learning, and teamwork, together with learning processes;that can be of great benefit to the learner. Hugerat (2016) emphasizes that project-based learning has an effective role in making the learner effective and positive in the learning situation by practicing the various activities that he/she undertakes while working on the project. It also develops a positive attitude towards learning and increases the learner’s self-confidence and motivates him/her; to acquire positive behaviors, to adopt different thinking styles and to solve problems.

Fragoulis(2009) sees it as an instructional method that focuses on students to deal with real issues and problems that are beneficial to them. In the learning process, projects or activities are used as mediums, and then the learner explores, evaluates, interprets, synthesizes and transmits information about the completed project.It is an activity that is implemented in the long term and centered on the learner, in which he acquires knowledge and skills through cooperation with others in an agreed period of time to produce a real product (Syarifah&Emiliasari, 2019).

Project-based learning is divided into three stages, namely: planning, implementing, and presenting. In the planning stage, students are divided into groups, then selecting topics, issues and problems of learning, searching for necessary information sources, and arranging the required resources. At the implementation stage, students undertake developing project ideas, gathering data, sharing roles in groups, and implementing the project. At the presenting stage, students, in group, present their project results and receive feedback (Aksela&Haatainen 2019).

Fifth: Product-based learning

The purpose of the P^5BL model is to reach a final product of benefit to the learners, so attention should be paid to the work environment because of its impact on the progress of the project and then to obtain a product of value to the learners. Fruchter (2000) emphasized that the output that occursshould be examined. The work team should reopen the visions that were previously closed. The output is an indication that students are active in the learning process, conducting an organized and systematic work.There is positive interaction between the work team, and they are able to achieve the goals. In the light of the product-based learning model, learning is defined as an addition to knowledge, and students are given opportunities to develop outcomes by developing thinking, skills, and cooperation (Ganefri&Hidayat, 2013). According to Ganefri (2013), product-based learning is defined as procedures or steps undertaken by the teacher to make the learner active and actively involved in the learning process, with an orientation towards competence to produce a specific product of value.

In product-based learning, problems play a major role in the educational process;the dialogue is the main tool for problem-solving.The important part of the work is determining what should be discovered in order to progress, together with building small working groups that form a collaborative team and work to solve the problem (Bereiter&Scardamalia, 2000; Marx et al, 1997).

Second axis: Scientific thinking

Abu Hamdan (2006) defines scientific thinking as a wide range of mental and psychological practices and processes that the individual performs in a logical, organized and interdependent manner, through which he/she reflects his/her capabilities that enable him/her to discover and justify scientific knowledge. Al-Juhouri et al. (2010) stress that it is a mental activity directed towards studying the problems presented in the activities of practical lessons.The learner uses the skills of observation, hypothesis, experimentation, and deduction to reach problem solving. The Next Generation Science Standards (NGSS) describes scientific thinking as composing of four processes: inquiry, investigation, interrogation, data collection and analysis (Spisak& Collins, 2019).

Kuhn (2002) argues that the ability to think scientifically has four main aspects, namely: (1) inquiry: it involves the scientific method, including the steps of searching for the main idea of the problem, formulating the problem, designing the hypothesis and finding a solution to the problem. (2) Analysis: the process of confirming the obtained data with existing theories in order to obtain the truth; (3) Inference: the process of confirming the truth in terms of the theories used to find the idea and use of data to come up with conclusions accordingly; (4) argumentation: the process of the learner uses to present findings, as well as the use of the findings in everyday life.Kuhn also argues that scientific thinking skills are the actions of seeking intentional knowledge and coordination between theory and evidence.The scientific thinking skills are involved in investigation, experimentation, evaluation of evidence, induction, problem solving, and causal thinking that lead to scientific understanding (Dunbar &Klahr, 2016; Zimmerman, 2007). Woolley et al. (2018) argue that scientific thinking consists of a set of skills needed to solve a specific problem, such as the skills of observation, classification, interpretation, communication, predicting results, concluding and procedural definition, identifying questions and proposing hypotheses, controlling variables, modeling and using mathematical reasoning and interpreting graphs.

Scientific thinking skills in science education allow the learner to understand and acquire the rational side of the process of producing scientific knowledge, to build expressions according to the scientific nature of practical knowledge and to acquire the skills of scientific debate.In addition, they play an important role in making the learner develop scientific understanding and conduct research, acquiring knowledge, taking effective makings, and solving problems (Boğar, 2019; Zeineddin&Abd-EL-Khalick, 2010; Lawson et al., 2007; Williams et al., 2004; Tytler& Peterson 2003; Kuhn, 1989).

Third axis: Academic perseverance

Kutlu, Kula-Kartal, Simsek (2017) indicate that perseverance means the ability of an individual to strive for success and achieve long-term goals, and continue to face the difficulties and challenges that one faces in learning. It is an enhancement of focused effort to achieve success in a task, regardless of the challenges that appear, as well as the ability to overcome failures (Sturman&Zappala, 2017, p. 1).

Perseverance is linked to motivation to achieve goals.It is related to the individual’s pursuit of the goals that one sets for himself/herself. The difference between individuals who are able to set long-term goals and individuals who have set long-term goals but are unable to reach them, is in the degree of persistence and determination to overcome the barriers and obstacles that occur between setting a goal and achieving it. It is important to reinforce the characteristic of perseverance of the individual who works to achieve a goal, but is unable to overcome the obstacles that prevent him/her. Although many students face obstacles that prevent them from reaching success and achieving their goals, some of them are able to persevere and persist in overcoming these barriers and reaching their educational goals. Perseverance involves self-awareness, the desire to reach the goal, and clarity of goals (McCutcheon, 2014).

Miller, Walton, Dweck, Job, Trzesniewski and McClure (2012) argue that persistence or willpower are essential features necessary for success in achieving educational goals.Motivation and cognitive processes are closely linked and interacted. Academic perseverance is the determination to achieve learning goals, and is considered a predictor of success more than conscience and self-control.

It is a non-cognitive characteristic and necessary for success in achieving goals, and it has nothing to do with intelligence. It is known as enthusiasm for work and flexibility in the face of pressures and setbacks (Mangan, 2012).It is the extent through which a learner can continue to engage in academic activities despite the difficulties and obstacles that prevent the achievement of goals (Kwong, Mokand, &Kwong, 1997).

It is important to consider academic perseverance as a series of repeated choices instead of a fixed ability. A person with high academic perseverance is defined as one who exerts a great effort, and his/her perseverance remains focused on difficult tasks, hard work and non-surrender (Bettingera, Ludvigsenb, Regec, Sollic, & Yeager, 2018).

One of the characteristics of academic perseverance is that it reflects the academic engagement of the learner, which is defined as the time and energy that the learner devotes to practicing various educational activities inside and outside school to achieve the goals he/she wishes to reach (Kuh 2003). It is a behavior that indicates a psychological investment in work performance, orschoolwork, including being attentive in class and undertaking specific work.It also means taking initiatives to ask questions, participating in group activities and regularly attending class.

Additionally, one of the characteristics of perseverance is that it reflects the cognitive processes practiced by the learner in the learning process, as Pike, Kuh and Gonyen (2003) indicated that there is a positive correlation between perseverance, cognitive processes and thinking processes. This means that in order for the learner to benefit greatly from school academic activities, one should be involved and engaged in an active learning process via listening, writing, asking questions, contributing to discussion, exchange of ideas and group work (Oluremi, 2014).

Factors affecting academic perseverance include the use of teaching models that focus on the learner's exertion of greater effort.It was found that students' academic perseverance can be increased by using teaching models that shape students’beliefs in terms of their ability to learn and benefit from the exerted effort. In addition, it develops the mind.These teaching models should be accompanied by tasks and activities that lead to the improvement of the neural connections in the brain and its growth. It makes the brain persistently seeks to achieve personal goals and set more goals in order to exert effort in difficult tasks, moving away from teaching models that focus on activities of learning facts and forcibly memorizing them.

Actually, activities should activate mental functions and lead to mental flexibility to learn (Bettingera et al., 2018). Besides, using active learning methods and cooperative learning activities enhance learner participation, and lead to improved learner performance, persistence and perseverance (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, &Wenderoth, 2014).

III. RESEARCH METHODOLOGY AND PROCEDURES

Research Methodology
The experimental method with its quasi-experimental design was used to find out the effectiveness of the independent variable (P^5BL model) in the dependent variables (scientific thinking and academic perseverance).

Research sample
The research sample was selected, (45) female students, from the intermediate secondary class in Hail, Kingdom of Saudi Arabia, by a simple random method, with (23) female students in the experimental group and (22) female students in the control group.

Preparing(States of Matter) Unit from Physics Course (2), using P5BL model:
A *Teacher's Guide* was prepared using P^5BL model with the aim of developing scientific thinking skills and academic perseverance of second-grade secondary school students in the subject of physics. The *Guide* included an introduction, objectives, an idea about the P^5BL model, a general idea of developing scientific thinking and academic perseverance, general goals to teach *States of Matter Unit*, educational activities and aids, time distribution of the subjects of the material cases unit, and the planning of lessons in *States of Matter Unit*, according to the P^5BL model. The*Teacher's Guide* was presented to a group of jurors.The necessary modifications were made.

Scientific Thinking Skills Test

A *Scientific Thinking Skills Test* was prepared on *States of Matter Unit*.These skills include observation, interpretation, measurement, conclusion, prediction, classification, hypothesis, and experimentation. Multiple choice questions were prepared.The test was presented to a group of jurors to ensure its validity.It was tested on a sample of (25) students in third-grade secondary school. The test reliability coefficient was measured using the Cronbach alpha method.The reliability coefficient for these skills and the test as a whole came as follows (0.611, 0.697, 0.699, 0.802, 0.553, 0.716, 0.757, 0.552, 0.716). It is a good reliability coefficient for this test.The validity of internal consistency was measured by using the internal consistency coefficients between the scores of the pilot study sample students at each level separately with the test scores as a whole and the value of the consistency coefficients for observation, interpretation, measurement, conclusion, prediction, classification, hypothesis, and experimentation skills. They are (0,400), (0,437), (0.635), (0.791), (0.617), (0.834), (0.800), (0.537) respectively. The test time reached (60) minutes. The test items, in its final form, were (34).The final score of the test was (34).

Academic Perseverance Scale

An *Academic Perseverance Scale*was designed to measure the extent of determination to continue effort and ability to take responsibility and overcome obstacles and difficulties, together with ambition to achieve a high level of performance.It includes three dimensions: determination to achieve goals, responsibility for learning, and academic ambition. A three-point scale with (24) statements was prepared, including "often, sometimes, rarely."Scores (3, 2, 1) indicate positive statements and scores (2, 1, 3)indicate negative statements.The highest score a learner gets in the scale is (72), and the lowest score is (24).The middle degree that can be obtained is (36). The Academic Perseverance Scale was presented in its initial form to a group of jurors to ensure the validity of the content, and to determine the extent to which the statements relate to each dimension of the scale, and the extent to which each dimension relates to the scale as a whole. In the light of this, some necessary modifications were made.

The reliability of the academic perseverance scale was verified using Alpha-Cronbach method on a sample of (60) students in third-grade intermediate school.It was found that the reliability coefficient for the scale and scale dimensions as a whole are equal to (0.60), (0.665), (0.733), and (0.693) respectively. It is a high and acceptable reliability coefficient.The validity of the scale was measured using the internal consistency method, by measuring the correlation coefficient between each of the scale statements and the dimension to which it belongs, which ranged between (0.299 - 0.653); this is significant at the level of (0.05) and (0.01). The correlation coefficients between the dimensions of the *Academic Perseverance Scale*and the scale as a whole ranged between (0.449 - 0.843); this is significant at the level of (0.05) and (0.01), indicating that the *Academic Perseverance Scale*has a high degree of validity.Table 1shows the data in detail.

Pre-application of research tools

The research tools were applied to the two experimental and control groups in the (1442 - 1441 AH) academic year.Table 1 shows the results of the pre-application of the research tools.
Table 1: Results of the pre-application of the Scientific Thinking Skills Test and the Academic Perseverance Scale of the experimental and control groups

Variable	Group	No.	Mean	Standard deviation	T value	Statistical significance
Scientific Thinking Skills Test	Experimental	23	0.54	0.07	1.085	0.284
	Control	22	0.46	0.07		
Academic Perseverance Scale	Experimental	23	1.51	0.28	1.916	0.062
	Control	22	1.63	0.11		

It is evident from Table 1, usingt-test for unrelated groups that the differences between the mean scores of the experimental and control groups in the research tools are not statistically significant, indicating the equivalence of the two research groups in the*Scientific Thinking Skills Test,* and the *Academic Perseverance Scale*.

Teaching for the two research groups

The science teacher who teaches the experimental group was interviewed and trained for two consecutive days on how to apply the P^5BL model: explaining the main themes in the *Teacher's Guide*in detail, answering the teacher's inquiries about the research and its tools, and practically modeling on how to apply the P^5BL model. Training the teacher on how to implement it, move among the model stages, and adhere to the specified time to implement the activities of each stage of the model.It was agreed with the science teacher for the control group to teach according to the established procedures without the student having a positive role in the learning process.

Post-application of research tools

After the completion of teaching, *States of Matter Unit* for the experimental and control research groups, research tools were post-applied.The results of this application were obtained.

IV. RESEARCH RESULTS AND INTERPRETATION

In the light of the research problem and the hypotheses on which it is based, the results of the research are shown as follows:
1. The effect of the P^5BL model on developing scientific thinking skills in physics among first-grade secondary school students:

To answer the first question of the research questions: "What is the effect of the P⁵BL model on developing scientific thinking skills in physics among first-grade secondary school students?" The first hypothesis was tested, which stated that "There is no statistically significant difference at the level of significance (α≤ 0.05) between the mean scores of the experimental group students, who studied using the P^5BL model, and the scores of the control group students, who studied using the traditional method, in developing scientific thinking skills in physics". Table 2 explains that:

Table 2: t-value for the differences between the mean scores of the experimental and control groups in the*Scientific Thinking Test*and its skills

Variable	Group	No.	Mean	Standard deviation	t-value	Statistical significance	η2
Scientific Thinking Skills Test	Experimental	23	0.70	0.04	19.07	0.01	0.01
	Control	22	0.43	0.06			
Observation	Experimental	23	0.67	0.15	5.895	0.01	0.01
	Control	22	0.36	0.20			
Interpretation	Experimental	23	0.65	0.23	3.322	0.01	0.01
	Control	22	0.41	0.21			
Measurement	Experimental	23	0.62	0.18	3.228	0.01	0.01
	Control	22	0.43	0.24			
Conclusion	Experimental	23	0.76	0.16	4.996	0.01	0.01
	Control	22	0.43	0.27			
Prediction	Experimental	23	0.71	0.18	5.609	0.01	0.01
	Control	22	0.40	0.20			
Classification	Experimental	23	0.76	0.19	4.738	0.01	0.01
	Control	22	0.43	0.27			
Hypotheses	Experimental	23	0.70	0.16	4.294	0.01	0.01
	Control	22	0.45	0.22			
Experimentation	Experimental	23	0.75	0.21	5.214	0.01	0.01
	Control	22	0.40	0.24			

The results of Table 2 indicate that the t-values are statistically significant at the level of (0.01). This indicates that there are statistically significant differences between the mean scores of the students of the experimental and control groups in the*Scientific Thinking Test*as a whole and its different skills in favor of the students of the experimental group.Then, the first null hypothesis can be reject, and the directed alternative hypothesis can be accepted: there is a statistically significant difference, at a level of statistical significance (0.05), between the mean scores of the experimental group students, who were taught using P^5BL model, and the mean scores of the control group students, who were taught using the traditional method, in developing scientific thinking as a whole and its different skills in favour of female students of the experimental group who were taught using the P^5BL model.

It is also evident from Table2 that the effect of using the P^5BL model inScientific Thinking Test as a whole and its various skills is large (with effect size >0.14). The previous results generally indicate the effectiveness of the P^5BL model in Scientific Thinking Test among first-grade secondary school students.This may be due to the fact that The P^5BL model sees that learning does not happen out of thin air, but there should be a problem that drives the learning process.This problem represents the heart of the project-based learning process. The problem is the core of the learning process, and by working on it, the learner exercises the scientific thinking skills represented in skills of observation, formulating hypotheses, experimenting, deducing, defining questions, proposing hypotheses, controlling variables, modeling, using mathematical thinking, and interpreting graphs to reach problem solving. It also expands students'competence to benefit from acquired theoretical knowledge and understand the role of field-specific knowledge, and employ project-based learning to analyze the problem, together with integration of knowledge and practice, cooperation and team work, and participation in learning activities.

This can be attributed to the fact that the P^{5}Bl learning model aims to make the problem the stimulus and the catalyst for the different learning styles based on: project, problem, process, people, and product.It encourages the learner to be independent in the learning process, and to learn the skills of dialogue, communication, leadership, and interpersonal relationships correctly; to be a critical thinker, to have leadership in learning and to practice scientific thinking skills. Besides, this model enhances the importance of scientific thinking skills in science education in the sense that it allows the learner to understand and acquire the rational side of the process of producing scientific knowledge. This happens in the stage of problem-based learning, process-based learning, constructing expressions according to the scientific nature of practical knowledge, and acquiring scientific debate skills as in team-based learning.In addition, it plays an important role in the learner's ability to develop scientific understanding, conduct scientific research, acquire knowledge and processes of conceptual change as in process-based learning, together witheffective decision-making and problem-solving as in project-based learning (Boğar, 2019; Zeineddin&Abd-EL-Khalick, 2010; Lawson et al., 2007; Williams et al., 2004)).

This result can be explained that problem-based learning included in the P^{5}Bl model has several basic characteristics, namely that learning is learner-based, and occurs in small groups of students under the supervision and direction of the teacher.The teacher's performance is determined by being a trainer and facilitator of the learning process. Learning begins with a real problem.The problems presented to the learner are used as a tool to achieve and investigate the required knowledge (Shinde&Inamdar, 2013), and thus the learner can employ problem-solving skills to reach the solution within which he/she practices a wide range of scientific thinking skills represented in observation, classification, conclusion, prediction, interpretation, hypothesis, and laboratory experimentation.

The outperformance of the experimental group students can also be traced back to the process-based instruction included in the P^{5}Bl model that trains the learner to develop the ability to apply science processes and scientific principles, such as practical science skills to solve a wide range of problems. Hence, science process instruction is the structured training of the learner in practicing scientific thinking skills through problem solving (Samuel, Libata&Sabitu, 2018). Moreover, process-based instruction does not focus on the outcome but rather on the processes that the learner handles and encourages the learner to find: what he/she thinks; what he/she does; and what he should take into account. He/She learns how to arrange and sequence thinking processes, pay attention to these processes and their occurrence, and be able to explain and express these processes efficiently (Arici&Kaldirim, 2015). This confirms that the learner exercises a wide range of scientific thinking skills, intentionally starting from processing information and data to achieving educational goals, varied from remembering information, describing things, and taking notes, to predicting, classifying things, evaluating evidence, solving problems and arriving at conclusions. He/She practices a wide range of intentional knowledge seeking behaviors, coordination between theory and evidence, as well as the use of a wide range of skills involved in investigation, experimentation, evidence evaluation, inference and solving problems and causal thinking that serve the occurrence of scientific understanding (Dunbar &Klahr, 2016; Zimmerman, 2007).

In general, this result confirms that the P^{5}BL model should be viewed in the sense that it is a learner-centered model. It is the means by which the learner innovates and re-innovates knowledge, as it contains problem-based learning, which is an active mental process to access previous knowledge, establish connections between old and new concepts, and use expanding relationships to engage in building theory. In this way the learners build their knowledge together, and shape their experiences. This is consistent with what has been indicated by many studies regarding the importance of learner-centered approaches and models in increasing performance,developing the ability to think scientifically and practicing scientific thinking skills (Ratnasari; Suciati; &Maridi, 2019; Jensen & Lawson, 2011; Minner et al., 2009; Rissing& Cogan 2009).

2. The effect of the P^{5}BL model on developing the academic perseverance of first-grade secondary school students:

To answer the second research question: "what is the effect of the P^{5}BL model on developing academic perseverance among first-grade secondary school students?", The second hypothesis was tested: "there is no statistically significant difference,at the level of significance (0.05 ≥α), between mean scores of the students of the experimental group, who studied using the P⁵BL model, and the mean scores of the control group students, who studied using the traditional method, in developing academic perseverance".

Table 3: t-value for the differences between the mean scores of the female students in the experimental and control groups in Academic Perseverance Scale

Variable	Group	No.	Mean	Standard deviation	t-value	Statistical significance	η2
Academic perseverance scale	Experimental	23	2.38	0.07	4.991	*0.000	0.367
	Control	22	2.26	0.08			
Perseverance to achieve goals	Experimental	23	2.4	0.16	3.23	*0.006	0.176
	Control	22	2.3	0.19			
Taking responsibility for learning	Experimental	23	2.45	0.14	5.107	*0.000	0.377
	Control	22	2.32	0.18			
Academic ambition	Experimental	23	2.29	0.19	3.11	*0.007	0.165
	Control	22	2.2	0.21			

The results of Table 3 indicate thatt-values of are statistically significant at the level of (0.01). This indicates that there are statistically significant differences between the mean scores of the students of the experimental and control groups in *Academic Perseverance Scale*and its different dimensions in favor of the students of the experimental group.Then the second null hypothesis can be rejected and the directed alternative research hypotheses can be accepted: there is a statistically significant difference, at the level of significance (0.05 ≥α), between the mean scores of the experimental group students, who were taught using the P⁵BL model, and the mean scores of the control group students, who were taught using the traditional method, in developing the academic perseverance in favour of the experimental group students

It is evident from Table3 that the effect of using the P⁵BL model in Academic Perseverance Scale is large (with an effect size > 0.14). The previous results generally indicate the effectiveness of the P⁵BL model in the perseverance scale of first-grade secondary school students.This may be due to the use of the P⁵BL model, with its learning styles such as problem-based learning, project-based learning, process-based learning, people-based learning, and product-based learning. It aims to solve the problems presented by designing projects in terms of working in a team to evaluate a final product that benefits the learner. Additionally, the model leads to producing lifelong learners. This enhances the dimensions of academic perseverance, such as the determination to achieve goals, and assume responsibility for learning, and academic ambition.

This result is consistent with what was indicated by Bettingera et al. (2018) that it is possible to increase students'academic perseverance through the use of teaching models that shape students' beliefs about their ability to learn, benefit from the effort exerted, and persistently strive towards achieving personal goals and setting more goals. In order to exert effort with difficult tasks, this is what the P⁵BL model achieves, which aims to make the problem the stimulus and motivation for different learning styles based on: project, problem, process, people, and product. It seeks to encourage the learner to be independent in the learning process, possess leadership of learning (taking responsibility for learning), being a thinker, more effective, and persistently striving to acquire, impart, and apply knowledge in the context of real-world problems, together with determination to achieve goals (academic ambition).

This result is also consistent with what was indicated by Freeman et al. (2014) that the use of active learning methods and cooperative learning activities that enhance learner participation lead to improved learner performance, persistence and perseverance in learning.This is evidenced by the use of problem-based learning, project-based learning and team-based learning within the P⁵BL model.

The outperformance of the experimental group students in academic perseverance can also be attributed to the fact that the P^5BL model reflects through the learning styles contained in it many characteristics and aspects of academic perseverance, such as continuous participation in an activity through the problem-based learning style, team-based learning, renewed commitment, and intensification of work. This happens when facing obstacles through problem-based learning and project-based learning, striving to achieve current and long-term goals and repeating unrealized goals through a product-based learning style. It also reflects the learner's academic preoccupation as an essential characteristic of perseverance through problem-based learning, project-based learning and team-based learning, in which the learner is allowed time and energy to devote to the practice of various educational activities inside and outside the school to achieve the goals he wishes to reach (Kuh, 2003), taking initiatives to ask questions, participate in group activities and attend class regularly through team-based learning.

This result can be interpreted in the light of problem-based learning as one of the learning styles included in the P^5BL model.It allows the learners to engage in an active learning process to find innovative solutions to the problems they face during the learning process (insistence on achieving goals and academic ambition), and process-based learning (process) as a strategy that simplifies science learning through the use of scientific process skills, giving the learner a sense of responsibility for learning (taking responsibility for learning). It increases the permanence of learning (Samuel, Libata&Sabitu, 2018). In this style of learning, the learner becomes self-directed, responsible for his/her learning process; to have an internal catalyst, and have a great desire to dothe process of brainstorming, thinking in the process, and attracted towards building the things he/she loves. He/She is interested in the knowledge he/she aspires to have. This gives him/her an opportunity to work (insist on achieving academic goals and ambition, and taking responsibility for learning). It is also interpreted in the light of team-based learning as an active and collaborative learning strategy that focuses on the learner. In this way, students bear the responsibility for their preparation and participation during the class (taking responsibility for learning), and the pursuit of implementation of their knowledge of original problem-solving, and the use of discussion as a means of reaching agreement on outcomes. Further, it provides an opportunity to discuss and apply knowledge (determination to achieve goals and academic ambition) (Parmelee et al., 2012; Parmelee, &Michaelsen, 2010). It is also interpreted in the light of project-based learning as one of the strategies that center around the learner, in which he/she builds knowledge, and seeks to achieve the goals of the project, starting with choosing projects that suit his/her inclinations and represent a real problem. Besides, the learner bears the responsibility for learning and solving problems (insistence on achieving goals and academic ambition - taking responsibility for learning). Hugerat (2016) emphasized that project-based learning has an effective role in making the learner effective and positive in the learning situation by practicing the various activities that he/she performs while working on the project. It develops positive attitude towards learning and increases the learner's self-confidence, and motivation to acquire positive behaviors. It can also be explained through product-based learning that emphasizes examining the outcomes obtained by the work team and reopening the visions that were previously closed. In this way, the outcomes are an indication that students are active in the learning process and have the determination to reach these outcomes (insistence on achieving academic goals and ambition - taking responsibility for learning).

The low dimensions of academic perseverance among students of the control group can be attributed to the use of the traditional method of teaching that focuses on activities that teach the student facts and forcibly memorizing them. It does not activate mental functions nor address the ability and flexibility of the brain to learn and thus weakens the desire to practice activities and have an interest in them.Then, students have unwillingness to learn or continue learning.

V. CONCLUSIONS AND RECOMMENDATIONS

In the light of the results of the study, it can be concluded that the P^5BL model plays an important role in the development of scientific thinking and academic perseverance among students due to its characteristics represented in building organized knowledge. It is important to understand its role in a multi-system, cooperative and project-based environment, as it increases the degree of learner participation in learning situations, creating effective learning moments, as well as that it establishes the importance of the existence of a problem around the learning process.This can be attributed to the idea that it has five styles of learning related to each other and responsible for the occurrence of the learning process: problem-based learning, project-based learning, process-based learning, people-based learning, and product-based learning. Within these modes of learning, the learner practices scientific thinking skills, such as observation, interpretation, measurement, deduction, prediction, classification, hypothesis, and experimentation. Additionally, these modes of learning enhance the determination to achieve goals, and bear the responsibility for learning and academic ambition that motivate him/her to perform scientific thinking skills effectively when confronted with a problem related to the learning topic. The study recommends that science curriculum planners and developers should pay attention to teaching models such as the P^5BL model to enhance the various scientific thinking skills and dimensions of academic perseverance when building science curricula at all levels of education. Besides, it is vital to direct the attention of science teachers towards the importance of using the P^5BL model in developing various scientific thinking skills and dimensions of academic perseverance through conducting training courses.

Acknowledgements:

This research is funded according to the regulations of the Scientific Council of the University of Hail, Kingdom of Saudi Arabia, as the sole funding agency for the research project - No. BA - 2010.

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