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The Impact of Project- Based Learning Strategy on Jordanian Basic School Students' Action Research Skills in Light of Some Variables

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Abstract

This study aimed to investigating the impact of project-based learning strategy on action research skills of Jordanian basic school students in light of some variables while teaching the unite of "Water". Semi-experimental design was used on a sample of 9th grade female students distributed in experimental group of (40) and a control group of (40), an action research skills scale was applied (pre-post). The results showed that there were statistically significant differences between the two means of the post-measurement of action research skills in favor of the experimental group with effect size of (30.20%) indicated by the value of the squared eta (η2). And significant differences between the means of action research skills attributed to the level of achievement with size effect of (%7.80) in favor of high and medium achievers. Also, there are no statistically significant differences between the means of the post-measurement of action research skills due to the variables (future streaming trends, the interaction between the teaching method and the level of achievement, and the interaction between the teaching method and future streaming trends). It's recommended to activating project-based learning strategy in teaching different science curricula, and examine same variables in different grades levels

Keywords: Project Based Learning Strategy, Action Research Skills, level of achievement, future streaming trends.

Introduction

Educational systems in developing and developed countries alike are striving to ensure that all students acquire the knowledge and skills necessary to promote sustainable development and global citizenship to enable them to participate in projects, and address global social, political, economic or environmental issues. By making teaching methods focus on empowering students as researchers, and providing them with the skills of a student researcher who is capable of self-learning, communicating, and meeting development requirements in various fields (UNESCO, 2017). The systems assert that teachers should help students become researchers by using collaborative teaching methods (Rodrigues & Daly, 2017) and push their students to learn outside the school as well, by conducting researches related to their daily personal and academic challenges, or what is called action research (Morsi & Hamad, 2017).

One of the aims of science education is to help students construct and acquire their own knowledge in a functional way as scientists (researchers) do. For students to learn how scientists think and work with science requires the application of scientific processes in constructing their knowledge through scientific inquiry and research. Scientific processes are referred to by several synonyms, including cognitive process, scientific inquiry skills, and scientific research skills. Bruner pointed out that these skills are mental processes used by both scientists and students to understand the world around them. Its behaviors that can be learned through training, and can be applied in daily life to address problems by proposing proper solutions when applying scientific processes (Zaytoun, 2010). Shehadeh (2022) mentioned that one of the recent trends in thinking and research in contemporary contexts is action research, which combines research and action, and goes through the same steps as traditional scientific research, except that it is less complex and takes a shorter time. Based on above, it's obvious that we can train students to conduct scientific research like scientists, by training them to do scientific research, gradually from the simplest type - like action research- to the most complex ones.

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Action research is defined as a deliberate, problem-oriented investigation that can be conducted by an individual or a group, and goes through the stages of defining the problem, collecting data, interpretation and analysis, taking action in light of the data, and redefining the problem (Efron and David, 2019). It is also known as an applied and democratic approach concerned with individuals' cognitive development and its impact on performance. linking theory and practice, saying and doing, especially when conducted with others; to find an applied solution to a specific problem. It's also tries to link the person to the society in which he lives, and often focuses on community service (Al-Fiqi & Abdel-Samie & Allam, 2014). Abu odeh and Nawfal (2012) defined it as learning by doing, that focuses on the interests of a group of individuals, and engages them in testing solutions to problems and evaluating results, not only by observing the action and evaluating its impact from a distance, as in traditional research, but rather by taking the action.

The importance of action research, as stated in Al-Ani (2012) emerges from its ability to fulfil a number of advantages for the student researcher, as it develops the ability to link, conclude, infer, investigate, analyze and evaluate. The use of action research as a teaching approach also contributed to the development of critical thinking and reflection for teachers and students as well through practicing of discussion, criticism, teamwork, and decision-making (Ali, 2017). Abu odeh & Nawfal. (2012) confirmed that the action researcher feels an improvement in his motivation towards thinking and analytical ability, self-awareness, and critical thinking when he finds solutions to realistic and real problems facing him, and he shows interest in solving them within a short period of time, particularly if he is able to prove the existence of the problem and has observations and scientific evidences the show the aspects of the problem. Al-Dosari (2018) added that action research has two significant purposes; personal purpose to improve the practitioner's skills, and social purpose to embody team spirit, cooperation and problem-solving.

The application of action research requires a set of flexible and logically sequential interconnected steps, as it begins with the intended -direct or indirect- observation, which expresses the researcher's feeling of a problem or issue that deserves research and investigation, and drives him to identify the problem to solve. Secondly, the reflection stage in which the researcher practices deep critical thinking in order to extract information or results. Thirdly, the stage of doing an action or a procedure. in other words, it's the stage of answering the questions posed by the researcher based on what he felt from the beginning. The researcher in the second and third stages collects data to enable him to practice science processes by describing, understanding, predicting, controlling- or all of them combined- classifying, and coding data for the purposes of analysis and interpretation. This is followed by the fourth stage of evaluation, in which the researcher begins to make judgments on the questions he answered, while presenting evidence that proves the accuracy of the results. Fifthly, the stage of modification of the outputs by addition or deletion. Finally, the sixth stage where researcher moves in new directions searching of new ideas (Al-Fiqi & Abdel-Samie & Allam, 2014; Abu odeh & Nofal, 2012).

Gordon and Edward (2012) argued that enhancing action research skills among students takes place by providing them with the skill of doing action research projects in virtual environments, which helps students to acquire the skill of project management and to obtain the experience of participating in the work of a student research project. Which will be evaluated later through the students' ability to demonstrate the skill of project management, information management, project control, and the quality of the final product presented by the students participating in the action research project. Meeran and Nurazidawati (2010) added that training students on research skills should begin at the different stages of basic schools' education, so that they have research experience and acquire the characteristics of a good researcher before joining university education, which focuses more on students conducting research, thesis, and dissertations. Besides, they both agreed with Gordon and Edward (2012) and emphasized that it is necessary to activate several strategies to inculcate a culture of research among students, including the project-based learning strategy which learning outcomes are linked to high-level thinking skills in cognitive domain, and research skills that include problem-solving, critical thinking, analysis, and dissemination of results.

Project-based learning is a constructive approach for promoting student-centered, and problem-oriented learning that is constructed around projects where learning of new content and skills occurs through the project that students implement in groups (Markula & Aksela, 2022). Project-based learning according to Miller & Krajcik (2017) is an inquiry-based teaching method in which students integrate, apply, and construct their knowledge as they work collaboratively to create Solutions to real problems, in a supportive environment to implement activities. The project-based learning strategy also defined as a teaching method in which students acquire knowledge and skills through scientific inquiry and investigation for a period of time, as a response to attractive challenge, by development of a product or presentation (Buck Institution for Education, 2022). Gianchandani (2021) argued that Project based learning is an approach in which students take responsibility for their own learning through active exploration of real-world challenges and problems, as they work over a period of time to investigate and respond to a complex question, challenge, or problem. Chin (2014) added that the project-based learning approach is teaching strategies that enable teachers to guide students through in-depth

investigation of the real world that deserves the student's attention and efforts. Göloğlu (2020) believed that project-based learning is a student-centered process which begins with real life challenge or problem and ends with the final product through teacher guidance, where the process must be designed and implemented in line with specific criteria to ensuring developing learners in the cognitive, affective, and social domains.

According to Al-Taban & Naji (2019), the stages which the project-based learning strategy goes through begin by choosing the project that is in line with students interests and ability to accomplish it, and originated from their needs, which make it beneficial for them. Secondly, the planning of the project by defining the objectives, expected outcomes, the proposed time for project completion, and the tools to be used in achieving the outcomes. The teacher at this stage is a guide who listens to learners' opinions and points of view in order to evaluate and assist them. And thirdly, the project implementation, in which the theoretical aspect is transformed into a practical and functional reality, whereby students implement the project plan under the teacher's supervision and guidance. Finally, the project evaluation in which the project is judged by teacher or audience. This stage is a continuous process in all of the project stages, where students also participate in it actively through peer evaluation.

The teacher roles during implementation of project-based learning are: supporting, raising students' enthusiasm, and encouraging them to work in groups, following up on their learning patiently, planning projects with considering authentic products that will be accomplished by students and ensuring the availability of proper resource, integrating the twenty-first century skills such as research skills, critical, reflective, and creative thinking, collaboration. Providing continuous feedback on students' performance, and activating professional learning communities inside and outside the school to deepen understanding of teaching practices in this type of learning (Department of Educational Guidance at the Ministry of Education and Higher Education, 2017). While the roles of students in project-based learning, as mentioned in Zyoud (2016) are: choosing the project that aligns to their interests, developing a detailed plan and amending where necessary, citing information sources, presenting and discussing the project in front of an audience, and participating in Peer evaluation process.

Project-based learning literature reveals its clear impact on the students' learning progress whether in different school curricula or science curricula particularly, even for different stages as well. At university level education, Al-Sayed (2022) stated that a program based on project-web learning approach enhanced action research skills among mathematics students- teachers. And at secondary school level education, Salybekova et al. (2021) detected the role of the project-based learning model in developing research skills in biology among students of the eleventh grade and basic stage (8-10), Meerah & Nurazidawati (2010) as well observed that Project-based learning helped Malaysian high school students to develop research skills and strengthen some values such as the spirit of teamwork, cooperation, and creativity.

And finally at basic school level education, Al-Khataiba and Bani Issa (2021) Noted the impact of the project-based learning strategy on enhancing critical thinking among primary school students in science, where critical thinking includes the five skills: developing hypotheses, interpretation, conclusion, inference, and evaluating arguments, which are the same skills needed to implement action research as well. moreover, Fitria & Tarhun (2021) realized the role of the project-based learning model in developing the critical thinking skills of basic school students through participatory action research approach in the English language. As for Al-Rawi (2016), who noticed the impact of a project-based learning in developing scientific thinking skills among basic school students with different motivation levels, whereas scientific thinking included: observation, classification, measurement, communication, inference, experimentation, prediction, and formulating hypotheses. Data interpretation, planning, and inference, which are the skills needed to carry out any action research as well. Koparan & Güven (2014), emphasized that teaching students' statistics (the science of collecting, analyzing, and interpreting data) should be through projects and student-centered; Students learn more when they collect and process their own data rather than just working on pre-collected data. They also pointed out that the students learned more deeply through projects related to the real world and increased their motivation towards learning, in addition to developing the skill of understanding concepts and building knowledge, specifically among students who participated in all areas of statistical research from data collection, analysis, interpretation, codification and presentation of results.

Study Problem and question

This study researchers recognized how basic school students lack thinking independency. This recognition originated from observing how the students deal with daily problems at personal or social level, where they tend to rely on random and quick solutions from those around them without validating them using scientific methodology. In addition, researchers believed that providing students with basic skills like the researcher student skills has become a necessary not a luxury for the current generation. Also, the researchers detected a link between the stages of the project-based learning strategy (planning, implementation, and evaluation) and the stages of action research (observation and reflection, data collection and analysis, evaluation and modification), where each of these can contribute to providing students with a set of skills,

such as research, investigation, teamwork, critical thinking, creative thinking, exploration, and analysis. Therefore, this study investigated the impact of project-based learning on basic school students action research skills in light of some variables such as the level of achievement (high, medium, low) and future trends (scientific, literary), which were not mentioned clearly in previous studies in accordance of the researchers knowing. In light of the above, the study problem was summarized in answering the following main question:

- Do action research skills of basic school students differ according to: teaching method (project-based learning, conventional method), the level of achievement (high, medium, low), and future streaming trends (scientific, literary), and the interaction between them?

Study hypothesis

- There is no statistically significant difference at ($\alpha = 0.05$) between the performance averages of action research skills of basic school students attributed to the teaching method (project-based learning, conventional method), or the level of achievement (high, medium, low), or future streaming trends (scientific, literary), or the interaction between them.

Study Objectives

The study aimed to achieve the following:

- Investigate the impact of the project-based learning on the action research skills of ninth grade students in Jordan.
- Investigate the impact of the variables (level of achievement, future streaming trends) on the action research skills of ninth grade students in Jordan.

Study Significance

The importance of this study is realized through:

- It in line with previous studies recommendations such as (Salybekova et al., 2021; Al-Khataiba and Bani Issa ,2021; Al-Rawi, 2016; and Meerah & Nurazidawati, 2010).
- reveals the impact of the project-based learning, the level of achievement, and future streaming trends on the action research skills of ninth grade students in Jordan.
- Its attempt to add new knowledge to what others have provided, and informing officials, decision makers, and educators to the importance of the project-based learning strategy in helping teachers to enable students to acquire and develop twenty-first century skills, including problem-solving at personal and social level through taking action based on research (action research).

Study terms and procedural definitions

Impact: The extent of the ability to achieve targeted results, which is affected by the extent of success in selecting and using a proper mix of inputs and resources without waste (Hamid, 2014). The researchers defined it (procedurally) as the amount of change caused by the independent variable (project-based learning strategy) in the dependent variable (action research skills).

Project Based Learning (PBL) Strategy: Al-Ali and Abu Loum (2015) defined it as an activity carried out by the student in order to achieve the specific goals, where the student naturally perform it in a social context that resembles the real working environment. The researchers defined it (procedurally) as an organized and specific educational method that is planned in advance and implemented under the supervision of a science teacher for the basic school (specifically for the ninth grade) within a specified period of time to achieve and complete projects, based on learners interests and needs to acquire knowledge and skills that meet the curriculum objectives and final product specified in each project.

Action Research Skills: Action research is defined as a problem-oriented investigation that can be conducted by an individual or a group, and goes through stages: defining the problem, collecting data, interpretation and analysis, taking action in light of the data, and redefining the problem (Efron and David, 2019). The researchers defined it (procedurally) as the final score obtained by the student in the action research skills scale that was prepared for the purposes of this study.

The basic school: the unified education provided by the state through the Jordanian Ministry of Education for all children of school age and for a period of nine years in which the basic educational needs of knowledge, skills, and attitudes enable learners to continue education and training according to their interest, readiness, and abilities to meet the challenges and conditions of the present and aspirations of the future (Jordanian Ministry of Education, 2022). The researchers defined it (procedurally) as ninth grade students.

Method

Study Design

To achieve the study objectives, the researchers used the quasi-experimental design with two groups (an experimental group and a control group) as shown in Table 1. The study included independent variables, which are the teaching method with two levels: the project-based learning strategy, and the conventional method. The level of achievement with three levels: low (less than 70), medium (70-80), and high (more than 80). And future streaming trends which has two levels: scientific and literary. While the dependent variable is action research skills.

- R: Random Assignment
- EG: the Experimental Group that was taught by project-based learning strategy
- CG: the Control Group that was taught in conventional method.
- X: Intervention by applying the project-based learning strategy.
- O: pre- post-action research skills scale.

Population and Sample

The study sample were chosen purposely from Umm Warqa Al-Ansariyya Basic school for girls affiliated to the Directorate of Education of Marka District in Amman, where two classrooms out of (5) classrooms were chosen randomly with total of (80) students. One of the classrooms randomly chosen to be a control group of (40) students who were taught the "Water" unite by conventional method, while the other classroom was the experimental group of (40) students who were taught the same unit by project-based learning strategy.

The data collected by using action research skills scale which prepared referring to relevant studies. Particularly, (Al-Fadali, 2021; Cortes, 2021; Pardede, 2018; Iwamoto et al., 2016; Posch, 1993). The scale consisted of (30) items distributed over five domains: Problem identification, Data collection, interpretation, action, and reflection, Proper usage of data collection tools, Technology utilization, and Research ethics. The validity verified by a panel of judges working in Jordanian universities and Ministry of Education. In the light of their feedback, linguistic wording of some paragraphs has been modified, and the adopted version of action research skills scale consisted of (30) paragraphs distributed over five domains: defining the problem with (10) paragraphs, collecting data, interpretation, action and reflection with (10) paragraphs, proper usage of data collection tools with (3) paragraphs, technology application with (4) paragraphs, and research ethics with (3) paragraphs.

In order to verify the indicators of construct validity, the scale was applied on pilot sample consisting of (30) students from the study Population and outside study sample. Indicators of construct validity were calculated using the Pearson correlation coefficient; To find the values of the paragraph's correlation with the degree on the domain to which it follows and the total degree on the scale on the other hand, as shown in Table 2.

The values of the inter-correlation coefficients were also calculated for the domains of the action research skills scale, using the Pearson correlation coefficient. The values of the inter-correlation coefficients between the domains of the action research skills scale ranged between (0.42 -0.68), and between the domains and the scale as a whole ranged between (0.58 -0.88), all of which are statistically significant at the significance level ($\alpha = 0.05$), and this is an indicator of the validity of the construction of the scale, as shown in Table 3.

To estimate the reliability of the internal consistency of the action research skills scale and its domains; Cronbach's Alpha equation was used on the data of the pilot samples' first application. Two weeks later the second application took place, then calculated the Pearson correlation coefficient between

Table 1: Study Design

Group	Assignment	Pre-measurement	Intervention	Post- measurement
G1 Experimental group	R	O	X	O
G2 Control group	R	O	-	O

Table 2. *The values of the action research skills paragraph correlation coefficients with the domain to which it follows, and the total scale score.*

Number	*Correlation with Domain*	*Correlation with total scale score*	*Number*	*Correlation with Domain*	*Correlation with total scale score*	*Number*	*Correlation with Domain*	*Correlation with total scale score*
1	0.68	0.53	11	0.61	0.50	21	0.60	0.49
2	0.59	0.48	12	0.64	0.47	22	0.74	0.66
3	0.69	0.60	13	0.80	0.65	23	0.68	0.49
4	0.78	0.68	14	0.81	0.69	24	0.65	0.56
5	0.64	0.54	15	0.62	0.50	25	0.78	0.68
6	0.77	0.67	16	0.65	0.59	26	0.54	0.47
7	0.79	0.69	17	0.63	0.45	27	0.72	0.68
8	0.73	0.56	18	0.66	0.44	28	0.69	0.61
9	0.71	0.58	19	0.75	0.71	29	0.58	0.53
10	0.59	0.53	20	0.49	0.43	30	0.77	0.69

the first and second applications, as shown in Table (4). The reliability of the repetition of the scale as a whole was (0.85), and the scale domains ranged between (0.79 - 0.83). stability of the internal consistency of the scale as a whole was (0.81), and of the internal consistency of its domains ranged between (0.76 - 0.79), which is acceptable for the purposes of the study.

Adopted version of action research skills scale consisted of (30) paragraphs distributed over five domains using a five level Likert scale 1-5 to correct the scale by giving each of its paragraphs one of the (strongly agree, agree, hesitant, disagree, strongly disagree), represented respectively (5,4,3,2,1).

To verify the equivalence of the study groups in the pre- measurement of action research skills; the mean and standard deviations of the study sample performance on the pre-measurement were calculated, according to the study group (control, experimental), and the independent samples T-test was used to reveal the significance of the differences between the means, as shown in Table 5. It is that there are no statistically significant differences at the level of significance ($\alpha = 0.05$) between the means of the performance of the pre study sample on the action research skills scale and its domains according to the study group (control, experimental), and for more statistical control, accompanying analysis of variance was used. (ANCOVA)

The educational material guide was prepared by researchers, for both the teacher and the student after reviewing the educational literature and studies that investigated the impact of using the project-based learning strategy, for the unit "Water" of the Earth and Environmental Sciences textbook for the ninth-grade students for the first semester (2022/2023) and reviewed by a panel of judges. The unit included the following topics: water cycle in nature, surface water basins and underground reservoirs, porosity and permeability, and underground water basins in Jordan.

Study Procedures

In order to achieve the objectives of the study, the researchers reviewed the literature and studies related to the study instruments which is action research skills scale, and constructed the initial form. The population and sample of the study were determined, and the validity and reliability of the scale were verified and adopted the final form. Followed by obtaining approval from the school that was intentionally chosen to apply the scale (pre- measurement) for both experimental and control group. Trained the science teacher of the ninth grade on how to apply the procedures for project-based learning strategy while teaching the chosen unit, and asked her to teach the experimental group according to the project-based learning strategy, while the control group according to the conventional method. After 6 weeks the scale applied again on both groups (post- test), and the responses processed by (SPSS) statistics software.

Data Analysis Technique

The statistical processing of the data in this study was carried out using the (SPSS) statistics software, where the means and standard deviations of the scores of the study sample were calculated from the pre and post measurement of the action

Table 3. The correlation coefficient of the domains of the action research skills scale with the scales' overall score and their inter-correlation coefficient.

variable	*Defining the problem*	*Collecting data, interpretation, action and reflection*	*Proper usage of data collection tools*	*Technology application*	*Research ethics*
Collecting data, interpretation, action and reflection	0.68				
Proper usage of data collection tools	0.44	0.66			
Technology application	0.46	0.55	0.48		
Research ethics	0.52	0.59	0.42	0.58	
Scale (As a whole)	0.78	0.88	0.62	0.66	0.58

Table 4: The values of the repetition reliability coefficients and the internal consistency stability of the action research skills scale and its domains.

The scale and it's domains	*Recurring stability*	*The stability of the internal consistency*	*The number of paragraphs*
Defining the problem	0.83	0.78	10
Collecting data, interpretation, action and reflection	0.82	0.79	10
Proper usage of data collection tools	0.79	0.76	3
Technology application	0.81	0.78	4
Research ethics	0.80	0.77	3
Scale (As a whole)	0.85	0.81	30

research skills scale, in addition to the use of the analysis of variance (ANCOVA) and the analysis of multiple variances (MANCOVA).

Results and Discussion

This study's main question was: Do the action research skills of basic school students differ according to: teaching method (project-based learning, conventional method), achievement level (high, medium, low), future streaming trends (scientific, literary), and the interaction between them?

To answer this question, whose hypothesis states: "There is no statistically significant difference at (α = 0.05) between the performance means in the action research skills of basic school students attributed to the teaching method (project-based learning, conventional method), or the level of achievement (high, medium, low), or future streaming trends (scientific, literary), or the interaction between them."; The values of the means and standard deviations of the pre and post measures and the modified of the action research skills (as a whole) were found for the participants of experimental and control groups, as shown in Table (5).

It is clear from Table (6) that there are differences between the means of the post-measurement of the action research skills (as a whole) in the experimental and control groups. Action research (as a whole), for each of the two groups, as an associated variable, as shown in Table (7).

From Table (7) it's clear that there are statistically significant differences at the level of significance (α = 0.05) between the two means of the post-measurement of action research skills (as a whole) attributed to the group (experimental, control) in favor of the experimental group that was taught using the project-based learning strategy; The size of the effect resulting from the application of the project-based learning strategy in raising the level of action research skills (as a whole), which is indicated by the value of the eta square (η2) (30.20%), and this value is considered high, according to what was indicated by Al-Kilani & Al-Sharifin (2014). In general, this means that the project-based learning strategy has contributed to raising the action research skills of the study sample. Also, there were no statistically significant differences at the level of significance (α = 0.05) between the means of the post-measurement of the action research skills (as a whole) due to the variables (future streaming trends, the interaction between the teaching method and the level of achievement, and the interaction between the teaching method and future directions).

Thus, the results above are in line with what Salybekova et al. (2021) revealed about the project-based learning model which showed an important role in developing research skills in biology among students in both basic and secondary grades in Turkistan. Also, it agrees with Koparan & Güven (2014), which confirmed that teaching statistics (the science of collecting, analyzing, and interpreting data) should be through projects

Table 5: Results of the Independent Samples T-test to reveal the significance of differences between the means of the performance of the pre- study sample on action research skills scale and its domains according to teaching method

Domain	*Group*	*Mean*	*Standard deviation*	*T - value*	*Degree of Freedom*	*Statistical Significance*
Defining the problem	Experimental	3.06	0.46	0.125	78	0.98
	Control	3.08	0.43			
Collecting data, interpretation, action and reflection	Experimental	3.11	0.47	0.455	78	0.65
	Control	3.07	0.42			
Proper usage of data collection tools	Experimental	2.79	0.64	-1.664	78	0.10
	Control	3.02	0.56			
Technology application	Experimental	3.16	0.75	-0.742	78	0.46
	Control	3.27	0.51			
Research ethics	Experimental	3.24	0.70	1.228	78	0.22
	Control	3.05	0.71			
Scale (As a whole)	Experimental	3.07	0.45	-0.207	78	0.84
	Control	3.09	0.32			

Table 6: The means, standard deviations of the pre, post, and modified measures of action research skills (as a whole) according to the group variable

		Pre		*Post*		*Modified*	
Group	*N*	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*Modified mean*	*Standard Error*
Experimental	40	3.07	0.45	4.21	0.37	3.72	0.05
Control	40	3.09	0.32	3.21	0.43	3.18	0.05

Table 7. The results of the triple variance analysis associated with the post-measurement of the action research skills (as a whole) among the study sample according to the variables (the teaching method, the level of achievement, and future streaming trends)

Source of Variance	*Sum of Squares*	*Degree of Freedom*	*Mean Squares*	*F value*	*Significance level*	*Eta squared (η2)*
Pre measurement	15.738	1	15.738	76.189	*0.000	
Teaching method	12.061	1	12.061	58.265	*0.000	**0.302
Level of Achievement	2.631	2	1.315	6.368	*0.002	**0.078
Future streaming trends	0.142	1	0.142	0.686	0.409	
Teaching method * Level of achievement	0.210	2	0.105	0.509	0.602	
Teaching Method * Future streaming trends	0.032	1	0.032	0.157	0.692	
Error	14.697	71	0.207			
Total	45.511	79				

* Statistically significant at level (0.05)
**(The size of the effect according to Al-Kilani and Al-Sharifin, 2014: weak (less than 0.06), medium (0.15-0.06), large (0.16 and above)).

related to the real world and student-centered; Students learn more when they collect and process their own data rather than simply working on ready-made data previously collected by others. They emphasized that the students learned more deeply through projects and increased their motivation towards learning, specifically among students who participated in all areas of statistical research such as data collection, analysis, interpretation, codification and presentation of results. The results are also similar to Meerah and Nurazidawati (2010), which showed that the projects contributed to the development of students' research skills and the promotion of some of their values, such as the spirit of teamwork and cooperation through the implementation of the research project.

This was indicated by Carter (2021), who focused on the importance of experiential learning experience such as project-based learning in supporting students' acquisition of statistical skills, and developing quantitative research skills necessary for the labor market and professional environments. Aziz & Rosli (2021), indicated that the project-based learning strategy enhances students' self-confidence and increases their interest in what they do while applying their statistical skills during conducting research and scientific investigation.

This study researchers attribute the improvement of all action research skills to the teaching material they have prepared according to the project-based learning strategy. It helped students to modify their cognitive structure in a social context through working in groups. As researchers observed in experimental group classroom, the activities and forms associated with teaching material contributed to improving students' abilities to ask questions, formulate hypotheses, collect data, verify the reliability of information sources, interpret and analyze data in their groups. They started thinking about the different components of the project-based learning, such as thinking about the research question, developing the detailed plan for the research project, distributing roles among the group members, reviewing their notes and data, and the level of achievement in presence of the teacher who was a facilitator, mentor, trainer, and evaluator which gave the students to practice their roles as researchers responsible for their learning process.

Table 8: The results of the (LSD) test for the post-comparisons of action research skills (as a whole) among the study sample according to the variable (level of achievement).

	Level of Achievement		Low	Medium
Action Research	LSD	Mean	3.233	3.558
Skills	Medium	3.558	-0.325*	
(As a whole)	Low	3.562	-0.329*	-0.004

* Statistically significant at level (0.05)

Table (8) shows that there are statistically significant differences at the level of significance (α = 0.05) between the arithmetic means of the action research skills (as a whole) due to the variable level of achievement, in favor of the study sample with a medium level of achievement compared to the study sample with a low level of achievement, and in favor of the study sample with a high level of achievement compared to the study sample with a low level of achievement. This means that the higher the level of achievement, the greater the action research skills of the sample.

It is clear from Table (9) that there are differences between the means of the post-measurement of action research skills in the experimental and control groups. In order to verify the significance of the differences, a Three-way MANCOVA was used to find out the impact of the project-based learning strategy on each of the action research skills, after taking into consideration the pre-measurement scores of the action research skills for each of the two groups. as an associate variable, as shown in Table (10).

Table 9. The means and standard deviations of the pre, post, and the modified measures of the action research skills according to the group variable

			Pre		*Post*		*Modified*	
Domain	*Group*	*N*	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*	*Mean*	*Standard Error*
Defining the problem	Experimental	40	3.06	0.46	4.20	0.37	3.65	0.06
	Control	40	3.08	0.43	3.10	0.38	3.10	0.06
Collecting data, interpretation, action and reflection	Experimental	40	3.11	0.47	4.26	0.41	3.73	0.06
	Control	40	3.07	0.42	3.10	0.44	3.11	0.06
Proper usage of data collection tools	Experimental	40	2.79	0.64	4.01	0.59	3.51	0.08
	Control	40	3.02	0.56	3.10	0.61	3.11	0.07
Technology application	Experimental	40	3.16	0.75	4.27	0.58	3.81	0.08
	Control	40	3.27	0.51	3.30	0.74	3.33	0.08
Research ethics	Experimental	40	3.24	0.70	4.32	0.62	3.86	0.09
	Control	40	3.05	0.71	3.13	0.68	3.10	0.08

Table 10: Results of the triple-variance analysis associated with the post-measurement of the action research skills among the study sample according to the variables (the teaching method, level of achievement, and future streaming trends)

Source of Variance	*Domain*	*Sum of Squares*	*Degree of Freedom*	*Mean Squares*	*F value*	*Statistical significance*	*Size Effect (η2)*
Pre measurement	Defining the problem	9.342	1	9.342	38.495	0.000*	
	Collecting data, interpretation, action and reflection	11.011	1	11.011	41.582	0.000*	
	Proper usage of data collection tools	3.592	1	3.592	8.885	0.003*	
	Technology application	8.364	1	8.364	17.858	0.000*	
	Research ethics	14.098	1	14.098	28.862	0.000*	
Teaching method Hotelling's Trace= 0.383 F= 11.256 Sig=0.000*	Defining the problem	12.615	1	12.615	51.914	0.000*	**0.296
	Collecting data, interpretation, action and reflection	13.167	1	13.167	49.687	0.000*	**0.279
	Proper usage of data collection tools	23.329	1	23.329	57.744	0.000*	**0.305
	Technology application	22.972	1	22.972	49.086	0.000*	**0.274
	Research ethics	24.778	1	24.778	50.774	0.000*	**0.287
Level of achievements Wilks' Lambda= 0.831 F= 2.851 Sig=0.002*	Defining the problem	0.301	2	0.151	0.621	0.539	0.008
	Collecting data, interpretation, action and reflection	0.997	2	0.498	1.882	0.156	0.024
	Proper usage of data collection tools	6.033	2	3.016	7.462	0.001*	**0.081
	Technology application	5.771	2	2.885	6.161	0.003*	**0.075
	Research ethics	4.233	2	2.117	4.333	0.015*	**0.064
Future streaming trends Hotelling's Trace= 0.072 F= 2.115 Sig=0.067	Defining the problem	0.690	1	0.690	2.843	0.094	
	Collecting data, interpretation, action and reflection	0.027	1	0.027	0.101	0.751	
	Proper usage of data collection tools	0.229	1	0.229	0.567	0.453	
	Technology application	0.548	1	0.548	1.171	0.281	
	Research ethics	1.529	1	1.529	3.129	0.079	

Source of Variance	*Domain*	*Sum of Squares*	*Degree of Freedom*	*Mean Squares*	*F value*	*Statistical significance*	*Size Effect (η2)*
Teaching method * Level of achievement Wilks' Lambda = 0.862 F= 1.258 Sig=0.124	Defining the problem	0.033	2	0.016	0.067	0.935	
	Collecting data, interpretation, action and reflection	0.442	2	0.221	0.835	0.436	
	Proper usage of data collection tools	0.318	2	0.159	0.394	0.675	
	Technology application	2.109	2	1.055	2.252	0.109	
	Research ethics	2.787	2	1.393	2.852	0.061	
Teaching method* future streaming trend Wilks' Lambda = 0.965 F= 1.073 Sig=0.378	Defining the problem	0.240	1	0.240	0.991	0.321	
	Collecting data, interpretation, action and reflection	0.028	1	0.028	0.107	0.744	
	Proper usage of data collection tools	0.203	1	0.203	0.501	0.480	
	Technology application	0.602	1	0.602	1.285	0.259	
	Research ethics	0.329	1	0.329	0.674	0.413	
Error	Defining the problem	16.281	67	0.243			
	Collecting data, interpretation, action and reflection	17.755	67	0.265			
	Proper usage of data collection tools	27.068	67	0.404			
	Technology application	31.356	67	0.468			
	Research ethics	32.696	67	0.488			
Total		44.997	79				
	Collecting data, interpretation, action and reflection	47.912	79				
	Proper usage of data collection tools	65.907	79				
	Technology application	68.013	79				
	Research ethics	80.652	79				

Table (10) reveals that there are statistically significant differences at the level of significance (α = 0.05) between the means of the post-measurement of all action research skills in favor of the experimental group that was taught using the project-based learning strategy; The size of the effect resulting from the use of the project-based learning strategy in raising the level of action research skills, which is indicated by the value of the eta square (2η) (29.60%) for the skill (defining the problem) and (27.90%) for the skill (collecting and interpreting data, conducting and reflecting) (30.50). %) for the (proper usage of data collection tools) skill, (27.40%) for the (technology application) skill, and (28.70%) for the (research ethics) skill. This means that the project-based learning strategy used in this study has contributed to the improvement and development of all action research skills among the study sample, and was more influential in the skill of proper usage of data collection tools.

Agrees again Koparan & Güven study (2014), which indicated that students learn more when they collect their own data through projects related to the real world and process it instead of just working on previously ready-made data collected by others. The researchers attribute the reason why proper usage of data collection tools is more improved skill among other action research skills relates to prepared project based learning strategy teaching material based on, which included many activities that provided opportunities for students to use different data collection tools such as questionnaires, interviews and observation in a way that contributed to the development of this skill for them, as the researchers observed that students showed curiosity and interest in using more than one data collection tool, to increase the accuracy of information they were gathering. In addition to their constant questions to the teacher about the reason why data collection tools are differed from one to another.

This was followed by the skill of defining the problem, which came in the second place. the researchers attribute that as it is a daily skill where students use continuously in their

daily lives to deal with the problems they face, which made them reach the point of mastering it. Besides, the researchers noticed that the students have a good ability to reflect on the problems that are around them, define them, and express them clearly for others, even if they do not have sufficient ability to solve them because they did not practice solving problems on levels wider than their personal levels.

Third skill improved was of research ethics, followed by the skill of data collection, interpretation, action, and reflection, and lastly was the skill of technology application. According to the researchers, this is can be attribute to the possibility of student's poor knowledge and technological skills, specifically among low achievers, and vulnerable students who have low access to technological devices outside the school due to poverty and economic situation as indicated by the school principal. Or as researchers expect, it can be attributed to students' negative attitudes towards technology and its role in supporting their learning, as it was observed by researchers that students with low achievement were not engaged actively during implementation of tasks that have technological nature.

The table also shows that there are no statistically significant differences at the level of significance (α = 0.05) between the means of the post measurement of all action research skills attributed to the variables (future streaming trends, the interaction between the teaching method and the level of achievement, and the interaction between the teaching method and future streaming trends), which means, according to the researchers, that the project-based learning strategy is suitable for all students, regardless level of achievement or future streaming trends. And there are no statistically significant differences at the level of significance (α = 0.05) between the means of the post-measurement of the action research skills (problem identification, data collection, interpretation, action, and reflection) attributed to the variable of the level of achievement, which means that the major action research skills can be performed by all students without exception.

There is a statistically significant difference at the level of significance (α = 0.05) between the means of the post-measurement of action research skills (proper usage of data collection tools, technology application, and research ethics) attributed to the level of achievement variable, and the size of the effect resulting from the level of achievement in raising the level of action research skills, which is indicated by the value of the Eta square (2η) (8.10%) for the skill (proper usage of data collection tools), (7.50%) for the skill (technology application) and (6.40%) for the skill (research ethics). This value is considered medium according to what was indicated by Al-Kilani and Al-Sharifin (2014), in order to reveal the significant differences between the means; The LSD test was performed for multiple comparisons, as shown in Table (11).

It is clear from Table (10) that there are statistically significant differences at the level of significance (α = 0.05) between the means of the action research skills (proper usage of data collection tools, technology application, and research ethics) attributed to the variable of the level of achievement, in favor of the study sample students with high and medium level of achievement compared to the study sample students with low level of achievement. The results in line with Meerah & Nurazidawati (2010), which also showed that high achieving students were enthusiastic and showed their creativity in implementing the project, while the average achieving students were working with high spirit to successfully complete the task only. As for the low achieving students, they did not show any progress in the skills of reasoning and writing the results report because they did not have enough prior knowledge related to data and how analyze it.

The researchers attribute this for the reason that students with high level of achievement show less resistance to work and carry out the tasks assigned to them even outside the school, and a lower level of boredom and despair compared to low-achieving students whose internal and external motivations for learning are low, and who have weakness from the beginning in knowledge and technological skills. Also, low achievement

Table 11: The results of the (LSD) test for the post-comparisons of action research skills among the study sample according to the variable (level of achievement).

	level of achievement		Low	Medium
Skill Proper usage of data collection tools	LSD	Mean	2.983	3.502
	Medium	3.502	-0.519*	
	High	3.429	-0.446*	0.073
Technology application	LSD	Mean	3.282	3.750
	Medium	3.750	-0.468*	
	High	3.788	-0.506*	-0.038
Research ethics	LSD	Mean	3.212	3.531
	Medium	3.531	-0.319*	
	High	3.714	-0.502*	-0.183

* Statistically significant at level (0.05)

level students tend to have negative attitudes towards technology, as indicated by Mioduser & Nadav (2008). They show less engagement with the tasks assigned to them as the researchers noted, they also show dependency on students with higher achievement in carrying out tasks of a technological nature or that need search from an experienced person. In addition, they have a high level of fear due to the learning difficulties resulting from the weakness of one or more of their cognitive skills, in contrast to high level of achievement students who depend on their cognitive skills to understand what is around them (Hirt & Karlen & Maag & Suter.2021).

Also, the researchers attribute this to the fact that that low level of achievement students do not trust their abilities to use data collection tools properly and apply technology, as their behavior depends on their low self-efficacy expectations, as stated by Al-Zahrani (2020). Also, Zaytoun (2008) stated that students with low level of achievement are likely to lean towards literary streaming trend, and thus weaken their interest in science, which is negatively affect their cognitive and operational performance.

Regarding research ethics, the reason for the statistically significant differences in favor of students with high and medium level of achievement attributed by the researchers to what Samadi & Al-Baqawi (2015) pointed out, there is a positive correlation between the level of student achievement, social responsibility and moral thinking in favor of students with high achievement. Whereas, social responsibility means the individual's actual and self-commitment towards the group to which he belongs, sensing their needs and the other societies' needs. Which also agrees with the definition of research ethics as stated by Arab Journal Foundation and Research Publishing (https://blog.ajsrp.com/?p=7587) and Bos (2020) it's a set of ethical guidelines that govern our expectations about our behavior and the behavior of others and guide us to conduct scientific research, and protect the interests of others, the subject of research and the researchers themselves. From the researcher's observation in the 6 weeks of study implementation it was noticed that students with high level of achievement were keener to obtain the approval of the principal and school administration on each stage they undertake during the implementation of their action research, specifically if the matter requires collecting data and taking pictures within the school borders, particularly with teachers or students.

Conclusion

Based on the previous results, the researchers recommend the necessity of activating the project-based learning strategy in teaching science curricula for its effectiveness in developing students action research skills, enhancing their curiosity for research and investigation. And training science teachers on how to implement the project-based learning strategy, and preparing special guides for that. Its highly recommended to conducting comparative studies between the impact of the project-based learning strategy and other strategies on developing action research skills of students in the different educational stages and in light of other variables such as gender, nationality, school context (public or private).

Limitation

The generalization of this study results depends on the following limits:

- This study applied to a purposive sample of students from a schools affiliated to the Marka District Directorate - Ministry of Education due to the availability of supportive learning environment, and science teachers' high quality teaching performance.
- Measurement is limited to the action research skills scale before and after applying the project-based learning strategy.
- The application of the project-based learning strategy limited to unite of "Water" of Earth and Environmental Sciences textbook for the first semester of the academic year 2022-2023.
- The action research skills scale is limited to five domains (Problem identification, Data collection, interpretation, action and reflection, Proper usage of data collection tools, Technology application, and Research ethics).

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