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G. Syzdykova [1*], G. Zhampeissova [2], S. Janabekova [3]

[1]Nazarbayev Intellectual School of Physics and Mathematics Almaty, Kazakhstan
[2]Nazarbayev Intellectual School of Physics and Mathematics Astana, Kazakhstan
[3]Abai Kazakh National Pedagogical University Almaty, Kazakhstan
[*]*e-mail: syzdykova_g@fmalm.nis.edu.kz*

DEVELOPING STUDENTS' REFLECTION SKILLS THROUGH THE INTEGRATION OF PROBLEM-BASED LEARNING AND THE METHOD OF BUILDING ALGORITHMS

Abstract

This article describes how problem-based learning and algorithm design methods were integrated in action research and how effective this integration was in developing students' reflective skills. Literature related to problem-based learning, as well as the method of creating algorithms and reflection skills, was studied and analyzed. During the observation of lessons, it was found that difficulties arose with fully describing the ways to solve tasks. The purpose of the study was to develop students' reflection skills when solving a problem situation by creating algorithms for completing tasks. Research objectives: clarification of the research question; formation of a strategic plan; data collection; reflection; determination of new steps for the completed research. The study consisted of the following stages: study, analysis, selection of topics and educational goals in a calendar-thematic plan according to the eleventh grade curriculum; development of structured tasks; identifying solution steps; presentation and comparison of ready-made algorithms and evaluation tables; defining a joint solution; reflection and evaluation. The results of our previous study on identifying occupational dynamics were combined with this study. The study took into account the results of external summative assessment after the tenth grade, as well as the physiological, general and personal abilities, and practical abilities of students. The research process included four main cycles, including methods of problem-based learning and algorithm creation. Analyzing students' written reflections after each round of inquiry helped determine next steps. In general, according to the results of the study, we were able to promote the formation of reflective skills in students and the development of design and research skills.

Keywords: action research, integration of methods, problem-based learning method, algorithm development method, reflection skill.

Г. К. Сыздыкова [1], Г.Д. Жампеисова [2], С.К. Джанабекова [3]
[1]Назарбаев Интеллектуальная школа физико-математического направления, г. Алматы, Казахстан
[2]Назарбаев Интеллектуальная школа физико-математического направления, г. Астана, Казахстан
[3]Казахский Национальный педагогический университет имени Абая, г. Алматы, Казахстан

РАЗВИТИЕ У УЧАЩИХСЯ НАВЫКОВ РЕФЛЕКСИИ ЧЕРЕЗ ИНТЕГРАЦИЮ ПРОБЛЕМНОГО ОБУЧЕНИЯ И МЕТОДА ПОСТРОЕНИЯ АЛГОРИТМОВ

Аннотация

В данной статье описывается, как методы проблемного обучения и создания алгоритмов были интегрированы в ходе исследования действия, и насколько эффективна была эта интеграция в формировании навыков рефлексии учащихся. Была изучена и проанализирована литература, связанная с проблемным обучением, а также методом создания алгоритмов и навыками рефлексии. В ходе наблюдения за уроками было установлено, что возникли трудности с полным прописыванием путей решений заданий. Целью исследования было развитие у учащихся навыков рефлексии при решении проблемной ситуации путем создания алгоритмов выполнения заданий. Задачи исследования: уточнение вопроса исследования; формирование стратегического плана; сбор данных; рефлексия; определение новых шагов по выполненному исследованию. Исследование состояло из следующих этапов: изучение, анализ, выбор тем и учебных целей в календарно-тематическом плане согласно учебной программе одиннадцатого класса; разработка структурированных задач; определение шагов решения; представление и сравнение готовых алгоритмов и таблиц оценок; определение совместного решения; рефлексия и оценивание. Результаты нашего предыдущего исследования по определению профессиональной динамики были объединены с этим исследованием. В ходе исследования учитывались результаты внешнего суммативного оценивания после десятого класса, а также физиологические, общие и личностные способности, практические способности учащихся. Процесс исследования включал четыре основных цикла, включающих методы проблемного обучения и создания алгоритмов. Анализ письменных рефлексий учащихся после каждого цикла исследования помог определить следующие шаги. В целом, по результатам исследования, нам удалось способствовать формированию у студентов рефлексивных навыков и развитию проектно-исследовательских навыков.

Ключевые слова: исследование в действии, интеграция методов, метод проблемного обучения, метод разработки алгоритма, навык рефлексии.

Г.К. Сыздыкова[1], Г.Д. Жампеисова[2], С.К. Жаңабекова[3]
[1]*Физика-математика бағытындағы Назарбаев Зияткерлік мектебі, Алматы қ., Қазақстан*
[2]*Физика-математика бағытындағы Назарбаев Зияткерлік мектебі, Астана қ., Қазақстан*
[3]*Абай атындағы Қазақ Ұлттық Педагогикалық университеті, Алматы қ., Қазақстан*

ПРОБЛЕМАЛЫҚ ОҚЫТУ ЖӘНЕ АЛГОРИТМДЕРДІ ҚҰРУ ӘДІСІН КІРІКТІРУ АРҚЫЛЫ ОҚУШЫЛАРДЫҢ РЕФЛЕКСИЯЛАУ ДАҒДЫЛАРЫН ДАМЫТУ

Аңдатпа

Бұл мақалада іс-әрекеттегі зерттеуді жүргізу барысында проблемалық оқыту және алгоритм құру әдістерін өзара кіріктіру қалай жүргізілгені, әрі бұл кіріктірудің оқушылардың рефлексиялау дағдыларын қалыптастыруда қаншалықты тиімді болғаны жазылады. Проблемалық оқыту, алгоритм құру әдістеріне және рефлексиялау дағдыларына қатысты әдебиеттер зерделеніп, талданды. Сабақтарды бақылау барысында тапсырмалардың шығарылу жолдарын ашып жазу бойынша қиындықтар туындағаны анықталды. Зерттеудің мақсаты тапсырмаларды орындауда алгоритмдер құру арқылы проблемалық ситуацияны шешуде оқушылардың рефлексия жасау дағдыларына ықпал ету болды. Зерттеудің міндеттері: зерттеу сұрағын нақтылау; стратегиялық жоспарды қалыптастыру; мәліметтерді жинақтау; рефлексия; игерілген зерттеу бойынша жаңа қадамдарды анықтау. Зерттеу келесі кезеңдерді қамтиды: он бірінші сыныптың оқу бағдарламасына сәйкес күнтізбелік-тақырыптық жоспардағы тақырыптар мен оқу мақсаттарын зерделеу, талдау, іріктеу; құрылымдалған тапсырмаларды әзірлеу; шешу қадамдарын айқындау; дайын алгоритмдер мен балл қою кестелерін ұсыну және салыстыру; бірлесе шешімін анықтау; рефлексия жасап, бағалау. Кәсіби тұрғыдағы динамиканың айқындалуында алдыңғы зерттеу нәтижелеріміз осы зерттеуге өзара ұштастырылды. Зерттеу барысында оныншы сыныптан кейінгі сыртқы жиынтық бағалау нәтижелері және оқушылардың физиологиялық, жалпы және жеке қабілеттері, практикалық іске қабілеттіліктері ескерілді. Зерттеу үдерісі проблемалық оқыту және алгоритмдерді құру әдістерін кіріктіре отырып негізгі төрт циклді қамтыды. Зерттеудің әрбір циклінен кейін оқушылардан алынған жазбаша рефлексиялардың талдануының нәтижесінде келесі қадамды анықтауға септігін тигізді. Жалпы, зерттеу нәтижесі бойынша оқушылардың рефлексиялау дағдыларының қалыптасуына, әрі жобалық-зерттеу дағдыларының дамуына ықпал ете алдық.

Түйін сөздер: іс-әрекеттегі зерттеу, әдістерді кіріктіру, проблемалық оқыту әдісі, алгоритм құру әдісі, рефлексиялау дағдысы.

Main provisions

Action research was conducted with the participation of high school students from the Nazarbayev Intellectual School. One of the peculiarities of these schools is that after the tenth grade, students choose specialized subjects, and in the eleventh grade, the composition of students in each class is formed anew. Based on observations of eleventh-graders in the classroom, the following problems were identified: students write down short answers to problems without detailed solution steps, and also find it difficult to choose solution methods. This prevented them from putting theory into practice, justifying their answers, and completing homework assignments fully. This also led to a decrease in intrinsic motivation and activity. Therefore, a model was conceived for integrating problem-based learning methods and methods for constructing algorithms to develop students' self-regulation, as well as develop their ability to reflect. In addition, the study was based on the results of previous studies, which demonstrates professionalism in a dynamic sense.

Introduction

The issue of action research in education has been ongoing since the mid-XX century. Organizing and conducting research is found in the work of Kurt Lewin (2002) as "action research." This process involves problem, action and inquiry and is used in social psychology for group research. Action research identifies teaching principles and the relationship between student achievement and teacher instructional actions. Moreover, it shows that these two activities are constantly evolving together [1]. Stephen Corey was one of the first to use action research in his practice. In his 1953 work, he concluded that innovations in qualitatively oriented research on teachers lead to changes in teaching. As described in the book Action Research (1999) by Linda Dickens and Karen Watkins, our research was based on Kurt Lewin's action research model. That is, it is a cyclical process involving fact-finding, planning, action and evaluation of the results of actions.

Presenting a problem situation according to the purpose of the study leads students to assimilate new knowledge based on their basic knowledge and joint analysis [2]. When working in a collaborative environment, students are more active than in a regular, traditional environment. We tried to raise open questions rather than provide new knowledge in a ready-made form. Open-ended questions encourage students to formulate an idea based on the information provided and present an expanded answer. Students practice free expression of their opinions, the range of answers expands, and feedback is also effective, leading to deeper exploration and comparison of answers. At the same time, open questions lead to the search and analysis of ways to complete a task. As a result of active dialogue implemented in this way, students' internal motivation to learn new knowledge increases [3].

According to research, the method of creating algorithms develops students' algorithmic thinking, and also allows the teacher to determine the dynamics of students' algorithmic thinking. The components of algorithmic thinking are: knowledge of the concepts, understanding how to create an algorithm using basic knowledge, understanding the conditions of the problem, structuring it, dividing the problem into several parts by analyzing it, considering ways to solve it and achieve results through analysis and synthesis [4] . This contributes to the systematic structuring of students' thoughts during creative work.

Ready-made algorithms for solving the problem situation were presented in accordance with the purpose of teaching the topic in the first cycle. In other topics, students have already begun to develop algorithms themselves. Four formative assessment tasks were offered on the topic of each cycle. This made it possible to determine ways to implement research objectives in action. To achieve the goal of the study, students reflected after each cycle. This helps to identify the desired object in a problem situation, divide solution paths into several steps, compile algorithms based on these steps, achieve results from the algorithms, clearly disclose and write a solution, analyze and formulate and evaluate ways to solve the problem. achieve the right result. Constant reflection and critical analysis leads to systematization of thinking by connecting and comparing one action with another. Only then it will help them master the acquired knowledge and use it in practice [5]. Reflection involves the researcher considering a formulated key idea in the future by connecting external conditions with his/her thoughts and the current situation and comparing them with the past [6]. Thus, reflection turned out to be a key component of the research process, which was effective in planning each subsequent step of our research strategy [7].

Research methodology

According to the diagnostic test of the dominant perceptual modality (Efremtsev S.), among the 55 students who took part in the study there were 17 audials, 26 visuals, 8 kinesthetes and 4 digitals. Therefore, we have developed structured, differentiated tasks and materials in the form of handouts, videos and presentations. Students were provided with instructions, references, and reference words.

The topics in the series of studies were the following: 1) «Degree with a rational exponent and its properties», 2) «Bezout's theorem. Its consequences», 3) «Cone. Truncated cone. Total surface area of the cone», 4) «Study of a function and construction of its graph».

In accordance with the topic of the study, a problem situation was given; students learned new knowledge based on their basic knowledge [2] and analyzed it together. Ready-made algorithms for solving the problem situation presented in the first topic were given. Working together, they found a solution to the problem [8] . We tried not to provide new knowledge in a ready-made form, but to raise questions. The questions led to the search and analysis of ways to complete the task [3] , the implementation of active dialogue increased the internal motivation of students.

In the section «Degree with a rational exponent and its properties», the learning goal is considered as the properties of a degree with an integer exponent, constructing a graph of an exponential function with an integer exponent. Ready-made algorithms were presented in the form of repetitions of some functions and their graphs: give an example of a linear function, write its degree; give an example of a quadratic function, write its degree; give an example of a cubic function, write its degree; give an example of an inverse proportionality function and write its degree. Problem situation: 1) What unites these functions? 2) To which set does the exponent belong? 3) What do you think these functions should be called? 4) Give the definition of a degree function with an integer exponent. It was planned to analyze the solution to this problem situation in groups and independently acquire new knowledge. Students are offered cards with the functions $y = x$, $y = x^2$, $y = x^3$, $y = x^4$, $y = x^5$, $y = x^6$, $y = x^{-1}$, $y = x^{-2}$, $y = x^{-3}$, $y = x^{-4}$, $y = x^{-5}$, $y = x^{-6}$ and it is recommended to divide them into four groups. After grouping them into four groups, the question is formulated: «On what basis did you divide these functions?» Each group was given prepared schematic tables in which they could draw graphs of functions, formulate their properties, and show the function record in general form.

Table 1. A schematic table for formulating the properties of functions. Properties of positive even, odd functions and negative even, odd functions

Function	$y = x^2; y = x^3;$ $y = x^{-2}; y = x^{-3}$	$y = x^4; y = x^5$ $y = x^{-4}; y = x^{-5}$	*Write the formula of the function in general form*
Domain of definition $D(f)$			
Range of values $E(f)$			
Increase interval			
Decreasing interval			
Function zeros: $f(x) = 0$			
Sign constancy interval: $f(x) > 0$			
Sign constancy interval: $f(x) < 0$			
y_{max}, y_{min}			
Asymptotes			
Axis of symmetry			
Center of symmetry			

Group 1. Among these functions, the exponents are even positive integers;

Group 2. Functions which exponent is an odd positive number;

Group 3. Functions with even negative exponent;

Group 4. Functions with an odd negative exponent.

After presenting their work in groups, students discuss and supplement the information received, and draw conclusions for each type of function.

Practical reports were presented:

№1. Dollar value V of a \$5,000 certificate of deposit with annual interest x after ten years is given by: $V = 5000\ (1 + x)^{10}$. What is the cost of a certificate at 5%, 10% per annum in ten years?

Suggested algorithms:

- find x by interest rate; calculation of the cost of the certificate;
- if the interest rate is 10%, calculate the cost of the corresponding certificate;
- justify the choice of a certificate with a higher interest rate in ten years.

№2. The amount received as a result of investing \$10,000 after 10 years at an annual interest rate x is determined by the expression $P = 10000(1 + x)^{-10}$. If the interest rate is 5%, 10%, how much should you invest?

Algorithms:

- calculation of interest rate 5%;
- calculation of interest rate 10%;
- comparison of values;
- justification and formulation of the correct result.

For other topics, students built algorithms on their own. The method of creating an algorithm develops students' algorithmic thinking and allows the teacher to determine the dynamics of students' algorithmic thinking [4]. Components of algorithmic thinking [9] : knowledge of concepts, understanding how to create an algorithm using background knowledge, structuring a problem, dividing a problem into several stages by analyzing it, considering ways to solve it, and achieving a result through analysis and synthesis. This encouraged students to systematically structure their thoughts during creative work [10] .

«Bezout's theorem. Its consequences». The learning objective was to use Bezout's theorem to find the roots or coefficients of a polynomial. Task: solve the equation $x^3 - 2x^2 - 6x + 4 = 0$.

Problem situation: the left side of the equation should be factorized. Only then we will find a solution by equating each factor to zero. How is this implemented? Is it possible to group or bracket the common divisor? Of course not. As a guide, the teacher suggested solving the equation $x^2 - 2x - 3 = 0$ and considering the relationship between the roots and the intercept. This tutorial will help students develop their own algorithms. Algorithms created by students:

1) factor quadratic trinomials;
2) use Vieta's theorem or discriminant formulas or grouping method to solve a quadratic equation;
3) find the roots of this equation, equating each factor to zero;
4) find the divisors of the free term of a square triangle;
5) identify the roots of the square trinomial among the divisors;
6) draw a conclusion (the roots of the trinomial are divisors of the free term).

It is shown that based on the constructed algorithm it is possible to achieve a solution to the problem situation that has arisen. This means that for a polynomial, $P_3(x) = x^3 - 2x^2 - 6x + 4$ the divisors of the free term are written as follows: $\pm 1, \pm 2, \pm 4$. For each divisor, the value of the polynomial is calculated: $P_3(-1) = 7$; $P_3(1) = -3$; $P_3(-2) = 0$; $P_3(2) = -8$; $P_3(-4) = -68$; $P_3(4) = 12$. The value of the polynomial is zero at $x = -2$. To find the two remaining roots, algorithms from the same group are used:

1) divide the polynomial by a binomial $x + 2$;
2) using the discriminant formula, find the roots of the quadratic trinomial and write solutions to this equation.

Algorithms created by the second group:

1) use binomial $x + 2$, build diagrams;
2) apply Horner's scheme;
3) find roots.

Based on this problem situation, students perform practical work, generalize and study the following types of practical applications of Bezout's theorem:

1) They can use Bezout's theorem to determine the solution to equations in cases where the leading coefficient of the polynomial is an integer other than 1. To do this: determine the integer denominators of the main coefficient; find the divisors of the free term $q = \frac{a_n}{p}$ using the formula; calculate the value

of the polynomial for each divisor of the free term; select divisor values at which the value of the polynomial is equal to zero; write down the answer.

2) Given a polynomial $P(x)$ and its root – the number a: divide the polynomial $P(x)$ by a binomial $(x-a)$; determine the remainder; conclude that the remainder is $P(a)$.

3) If the number a is the root of a polynomial $P(x)$, then this polynomial is divisible by a binomial without remainder $(x-a)$.

The following tasks were completed:

№1. Find the roots of a polynomial $P(x)=6x^2-5x+1$ using Bezout's theorem.

№2. Find the sum of the coefficients of the polynomial $P(x)=(x-1)^{30}(x^2+24)$.

№3. Prove that this number $2^{81}+1$is divisible by 9 without a remainder.

№4. A polynomial $P(x)=x^{2017}+ax-5$ is divisible by a binomial $(x+1)$ without a remainder. Find the value a.

№5.

The remainder when dividing a polynomial $P(x)=x^3+ax^2+2x-3$ by $(x-2)$ is 5.

The remainder when dividing a polynomial $Q(x)=x^3-bx+1$ by a binomial $(x-3)$ is 4.

The remainder when dividing a polynomial $R(x)=x^5+cx^4+3$ by a binomial $(x+2)$ is 3.

Find the remainder when dividing a polynomial $P(x)Q(x)R(x)$ by $(x-1)$.

№6. Prove that the polynomial $P(x)=x^5+11x^4+37x^3+35x^2-44x-40$ is divisible by a polynomial without remainder $Q(x)=x^2+3x+2$.

In the section «Cone. Truncated cone. Total Surface Area» we defined the learning goal: to calculate the surface areas of cylinders, cones and truncated cones. The problematic situation was the following: how to calculate the total surface areas of a cylinder, cone and truncated cone? Groups are given paper models of cylinders, cones and truncated cones.

Each group displays corresponding entries on these layouts; transfers measurements from space to plane; calculates the areas of the lateral surfaces and bases of the corresponding body of revolution based on its dimensions; finds the total surface area of the corresponding body of revolution. It is necessary to pay attention to the following points: calculation of the central angle in the net when using the sector area formula when calculating the lateral surface of the cone; when calculating the lateral surface of a truncated cone, add the image of the cone net to a sector, subtract the area of the smaller sector from the area of the larger sector.

Students create algorithms for calculating the areas of the total surface of a cylinder, cone and truncated cone from their nets: studying the net of a spatial figure; side surface and base/bases; use of planimetry formulas; calculation of the required area.

Practical tasks:

№1. The roof of the tower is conical, height 2 m, tower diameter 6 m. If 10% of the material is used for the joints, then how many rectangular sheets of roofing felt $0{,}7\ \text{м} \times 1{,}4\ \text{м}$ will be needed to cover the tower?

Algorithms:

1) draw the sketch;

2) calculate of the side surface according to given dimensions;

3) calculate of the area of covering material;

4) define the amount of coating material;

5) calculate of 10% adhesive material;

6) define of a given volume of adhesive material;

7) define of the total amount of rectangular covering material, taking into account the joints.

№2. The bucket has the shape of a truncated cone, the diameters of the bases are 30 cm and 20 cm, and the generator is 30 cm. If 200 g of paint is needed per 1m^2 , how much paint will it take to paint both sides of 100 of these buckets? (The thickness of the walls of the bucket is not taken into account).

Constructed algorithms:
1) define the necessary surfaces, that is, the side surface and the base;
2) calculate the lateral surface, double it;
3) calculate the area of the base, double it;
4) find the sum of the two previous values;
5) calculate the amount of paint needed for the resulting area;
6) calculate the mass of paint required to paint both sides of 100 buckets;
7) pay attention to the units of measurement.

When studying the section «Studying functions and constructing graphs», the learning objective was chosen – understanding the relationship between the graph of a function and the graph of the derivative of a function. The groups were given the task of determining the graph of a function from the graph of the derivative of the function. To do this, it is recommended to use Calculus Grapher, Derivative Simulation from the PhET Interactive Simulations Math website. The student should understand that the graph of a function increases in the interval when the graph of the derivative of the function is above the *Ox axis*, the graph of the function decreases in the interval when the graph of the derivative of the function is below the Ox axis , and the point of intersection of the graph of the derivative of the function with the *Ox axis* is the extremum point.

Task: The figure shows a graph of the derivative of the function on the interval$-5 \leq x \leq 5$.

A graph of the derivative of the function on the interval $-5 \leq x \leq 5$

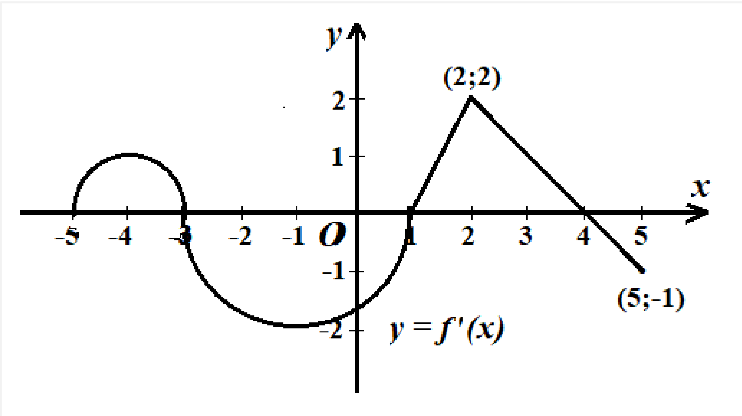

Figure 1. A graph of the derivative of the function $f(x)$

For a function $f(x)$ on an interval $-5 \leq x \leq 5$ determine:
a) maximum points;
b) minimum points;
c) inflection points;
d) intervals of increase and decrease;
f) intervals of concavity and convexity and justify each interval.

Working with simulations has proven to be effective for students in developing algorithms. Students wrote down their reflections after each cycle. Reflection and critical analysis lead to systematization of thinking by identifying connections between actions and comparing one action to another [4]. Only then will they have the opportunity to master the acquired knowledge and apply it in practice. For the first cycle, we used N.G. Alekseev's scheme «Stopping-fixation-objectification-detachment» [11]. During the «stopping» period, students paused and reflected; showed the main points during the «fixation» period; determined their effectiveness in «objectification» period; during the period of «detachment» they wrote about the effectiveness of methods, resources and how they achieve the learning objective. For the remaining research cycles, we used activity and discussion maps [12]. This was helpful in effectively analyzing and re-planning our next research cycle.

Results of the study

In each cycle of research, formative evaluation work was carried out. In the first cycle, the percentage of tasks completed by different groups of students using the proposed algorithms to solve a problem situation was respectively: 65 % , 69%, 67% and 70%. In the next cycle, these indicators increased by 8 %, 2 % , 3 % and 2 %, respectively; in the third cycle, the percentage of completion was 80%, 82%, 81% and 80%, respectively. According to the results of the last cycle, these figures increased by 12%, 13%, 12% and 17%, respectively. It can be said that this is an indicator of the development of students' self-regulation (Diagram 1).

Indicators of 11 grades for each cycle

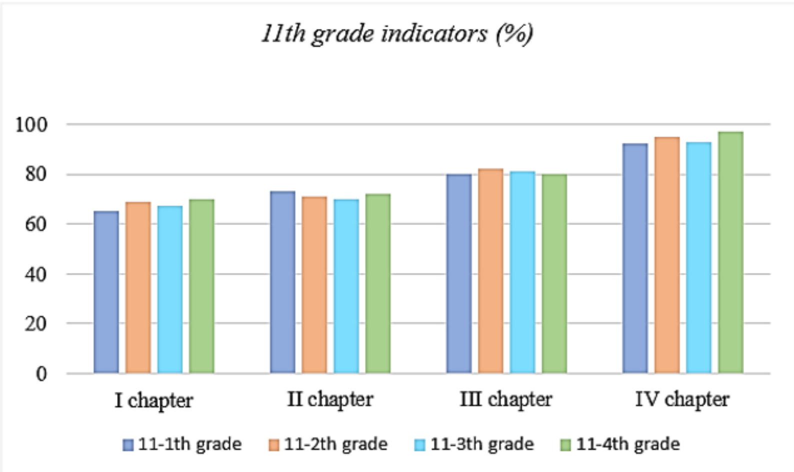

Figure 2. Indicators of 11 grades for each cycle (chapter) (%)

The following diagram shows the dynamics of the results of students completing tasks in the corresponding chapters of the four cycles.

Indicators by chapters of 11th grade students

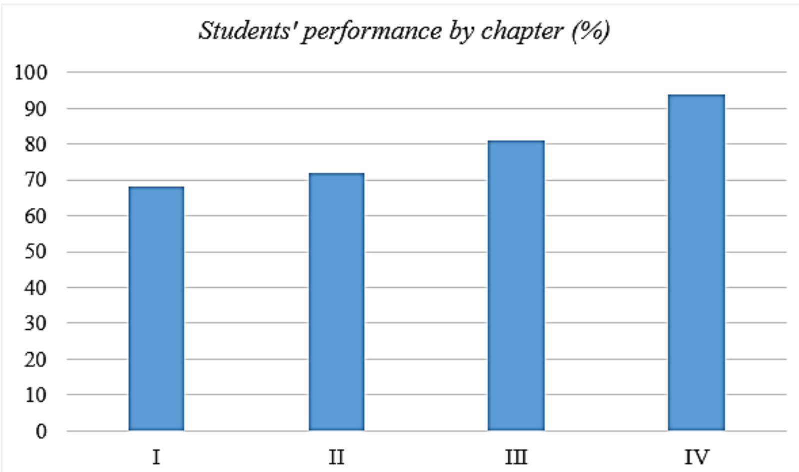

Figure 3. Indicators by chapters

The material of exercise 3 «Useful prompts to support student reflection» from the methodological recommendation «Students reflecting on their learning» was used in organizing students' reflection [12]. Planning our next steps: Planning sheet and Discussion card 1 were useful for planning our next steps and assessing the stage of the process. The materials in Discussion Card 2, 4, 6 helped students think through their own observation and evaluation of their actions in the cycle.

According to O.S. Anisimov's methodology, eight questions were formulated to assess students' reflexive abilities:

1) After finding a solution to a problem, how often do you go back and think about the solution?

2) If the problem situation is complex, how often do you analyze the steps to solve it before performing the task?

3) How often do you need support in determining steps to solve a problem situation?

4) To what extent do you look within yourself for the reasons for the difficulties that arose during the development of algorithms (shallow theoretical knowledge, inability to effectively apply theory, untimely completion of tasks, etc.)?

5) How often do you turn to feedback from your classmates or teacher in a problematic situation?

6) If the task is very important, to what extent do you participate in shared decision making as a group?

7) If you have difficulties in finding a solution together, what kind of teacher support do you need in identifying the reasons and easing the difficulties?

8) How often do you think about the steps to achieve the right result by developing algorithms or performing a task using ready-made algorithms?

The answers to these questions are: a) always, b) often, c) if necessary, d) rarely, e) never. The scale will have a high, above average, average, below average, low level, respectively. It was found that this is a fairly effective tool for developing students' reflection skills at each cycle of the research process, as well as assessing the effectiveness of students' actions. For the analysis of testing data, points were awarded according to the criteria for the levels of personal reflection, self-criticism and collectivism: Reflection – № 1, 2, 3, 8, self-test – №4, and the level of collectivism was determined by adding up the points for questions №5, 6, 7 and filling out the tables.

Table 2. Criteria for determining the level of personality. Criteria for determining the level of personality of students

No	*Scale/ Level*	*Reflection*	*Self-criticism*	*Collectivism*
1	*Short*	*0-2 (2)*	*0 (1)*	*0-3 (4)*
2	*Below average*	*3-6 (1)*	*1 (2)*	*4-7 (3)*
3	*Middle*	*7-11 (4)*	*2 (4)*	*8-11 (3)*
4	*Above average*	*12-15 (9)*	*3 (15)*	*12-15 (19)*
5	*High*	*16-18 (39)*	*4 (33)*	*16-19 (26)*

Discussion

The action research was conducted by mathematics teachers from Nazarbayev Intellectual Schools in Almaty, Astana and Kyzylorda. 11th grade students took part in the study. One of the features of these schools is that after the tenth grade, students choose specialized subjects; ten hours of advanced mathematics per week or seven hours of standard mathematics per week, depending on the major elective subject. Observing students in lessons, we identified common problems: students of different classes have a low level of explaining how to solve problems to each other; they do not show detailed solution steps while completing tasks, performing part of the actions mentally. Virtually every teacher has a professional development goal for the school year to address a problem identified in their classroom. We were looking for ways to solve problems in our classrooms and achieve professional development goals. To do this, we combined the methods used by each teacher based on the purpose of professional development and formulated our overall research question. Our research question was: «To what extent can action research through the integration of algorithm design and problem-based learning techniques support students' reflective skills»? To obtain an answer to this research question, a research cycle was defined: creating a problem situation; using algorithms to solve a problem; reflection on the results. To do this, it was necessary to identify one topic from each chapter in order to include this cycle in one lesson. The objectives of formative assessment were considered in classes conducted using integrated methods on selected topics. Based on the results of formative assessment in four cycles, it was planned to determine the effectiveness of integrated methods and the impact on the development of students' reflective skills. We believe that this plan has systematically achieved its goal. The students' performance and the results of reflections on the chapter, cycle show the effectiveness of using the integrated method. Thus, through this integrated model, we were able to influence the formation of students' reflective skills. In the future, by improving the research, it is aimed at practical application in the professional development of teachers.

Conclusion

A ready-made algorithm for solving the problem given in the first chapter was presented. The rate of correct completion of the task was 68%. Students reflected that the pre-made algorithms were effective in getting them to break down a problem into multiple steps and work together to master each step, but we found that the pre -made algorithm prevented them from thinking broadly. Dialogue and writing skills are developed based on ready-made algorithms. Students' development of algorithms facilitated understanding, formulation, and practice of each step.

For the remaining three topics, the results turned out to be higher compared to the first, since the students themselves created the algorithm. Using the problem-based learning method, students conducted research independently, jointly prepared theoretical materials and presented their hypotheses. Therefore, in the second cycle, students worked according to the following plan: identify a problem situation, divide the problem into parts and create algorithms accordingly. Then the overall level of completion of the task of the second chapter by all students participating in the study was 72%. And the indicators of the level of completion of the tasks given in the third and fourth chapters reached 81% and 94%, respectively. After the first cycle, students noted that due to the novelty they have it took too long to understand and do everything. At the next stage, they tried to do everything themselves and were able to verify the correctness of each action; at the last stage they mastered new knowledge and did it quickly [13] . After each cycle, students' reflections were analyzed . At the end of the study, based on the results of reflection obtained from four cycles, students wrote that these research cycles turned into a small project work, and in the next semester they were asked to choose topics within the framework of this project.

To diagnose the level of reflexivity of students after research cycles, we used the methodology of O.S. Anisimov. This diagnostic included elements of problem-based learning, algorithm creation, and eight questions with five answer options each . Taking into account the individual abilities and age characteristics of students, we have made changes to some questions. We considered the levels of reflexivity on the following scales: low 0-2, below average 3-6, average 7-11, above average 12-15, high 16-18 points. We further found out that 39 students have high reflection skills, 9 students have above average skills. This indicates that students' reflective skills are sufficiently developed.

New aspects of our action research were discovered, which included four cycles: developing students' skills in constructing algorithms for solving a problem situation, students' participation in choosing lesson topics aimed at integrating methods, and developing students' reflection skills. This study was effective in developing students' reflective skills as well as developing their design and research skills. In addition, the study contributed to the development of the following skills:

- predict the result based on the problem situation;
- develop algorithms that determine the stages of task execution;
- discuss and show effective aspects;
- present the results of the work to other groups.

In summary, we believe that we have been able to contribute to students' reflective skills through problem-based learning and algorithm development.

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