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Methods for developing motivational and value-orientated readiness of math students at teacher training universities for implementing educational innovations

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Abstract. The present article considers the issue of developing motivational and value-orientated readiness of Math students at teacher training universities for implementing educational innovations. The method, chosen for the present research is the analysis of the scientists' viewpoints, on-line resources and reports regarding the issue of designing and using Rich Tasks when teaching Mathematics, methods and means for developing students' motivation for implementing educational innovations. This paper describes the methods, aimed at developing in students motivation and ability to systematize, devise, use Rich Tasks in their professional activity and to combine them with other innovational learning methods and means. The analysis of the teacher training internship results and the surveys in the experimental group give ground to make a conclusion about efficiency of the methods offered.

1. Introduction

1.1. Problem statement

When characterizing current situation in education in Ukraine and its development strategies, United Nations Children's Fund (UNICEF) [29] highlights the necessity of implementing innovations into educational process. Constant improvement of educational technologies, as well as higher societal demands regarding a Math teacher are among the factors that encourage introducing innovations into mathematical education at schools. Meanwhile, a significant part of Ukrainian Math teachers, when introducing new syllabi, tools, technologies, methods of learning, face various challenges at the stage of the adaptation to the demands, needs of a concrete group of students and own possibilities. As a result, the effectiveness of implementing innovations into school mathematical education decreases. This, in turn, urges universities in Ukraine not only to develop a theoretical background for devising educational innovations, but also to prepare Mathematics teachers for making an informed choice, approbation, adjustment and implementation of innovations into the educational process.

1.2 Literature review

When devising a theoretical background for developing readiness of Mathematics students in teacher training Universities for introducing innovations, it was central to define, what is meant by "educational innovations". Such researchers as Kirkland and Sutch [18], Christensen et al. [7], Warford [36] consider innovations to be a dynamic process, which results in new approaches to achieving the goals.

As it is highlighted by Rerke et al. [21], no matter from which perspective you look at innovations, factor connections between innovations and educational system development are maintained. Other scholars also put emphasis on the issue of innovative educational activity of teachers. Aguiar et al. [1] look into developing and implementing innovations, based on information technologies, into university education, examine various approaches to applying innovative activities by teachers. The scholars believe that the key prerequisite for holding Mathematics student's professional training is an adequate level of their motivation for innovative educational activity.

Various didactical aspects of developing motivation in students are considered in a number of research papers. For instance, Andrade et al. [3] describe motivation as an educational strategy for teaching Mathematics in different educational institutions in Ecuador. Mercado et al. [20], Vlasenko et al. [35] focus on using ICT in order to foster motivation for self-teaching Mathematics in first-year students. Barrientos Jiménez et al. [4] analyze the issue of developing internal motivation for learning, as well as correlation between academic excellence and level of motivation in place in law students.

Irrespective of the area of research, all the scholars adhere to the opinion that developing motivation in course of learning depends on their values formed. Hence, it was paramount to analyze the scientific papers on developing values in course of obtaining education in universities. We join the scholars, who believe that nowadays it is virtually impossible to implement innovations efficiently into mathematical education in secondary and high schools without developing values and beliefs. Vlasenko et al. [33] consider the issue of motivational readiness to be all-important, as motivation of a Mathematics teacher results from their professional interests, values and beliefs.

Markova et al. [19] classify motivation, based on the source of instigation into external and internal, the latter depending heavily on a personality's stimulus. We share this point of view and consider that the central incentives for innovative educational activity are financial incentives, need for self-affirmation, professional incentives and need for personal development. Added to that, we agree with Barrientos Jiménez et al. [4], that internal motivation is more efficient and sustainable, it prompts an individual to search for novelties, to face challenges and overcome them. In order to develop internal motivation for creating and introducing innovations, the counselors of the platform "Technology & Innovation in Education" recommend us to develop a technology that enables using an intrinsic approach to learning. As far as Ruppel and Harrington [22] are concerned, efficiency of such a technology implies engaging each and every student into devising an innovative solution. According to a research by Gojak [12], engaging students into devising an innovative solution can occur in the process of solving certain types of problems.

The findings by Gojak [12], and Yeo [37] confirm, that Math problems can change students' attitude to studying the subject and contribute to developing creative thinking. The researchers indicate that developing of creative thinking in students is a basis for students to search new approaches to learning and to be open to innovations. Rich Tasks are among the means that contribute to developing creative thinking in students. Moreover, such tasks are considered by researchers to be innovative, since they allow not only to showcase non-conventional, creative thinking in the course of searching a solution, but also give students an opportunity to "construct" their own product (problems devised). This idea complies with the findings in a research by Vlasenko et al [31]. The researchers consider that Rich Tasks in Elementary Mathematics boost interest to learning Math as a science, owing to the fact that students have an opportunity to "re-discover" Math rules (notions, regularities), to act in a non-conventional way, to develop creative thinking and interest to devising own mathematical product. According to Gojak

[12], solving such types of tasks must be accompanied by engaging a certain system of methods, modes and means of learning. When choosing the learning methods, the authors of the present paper draw on a research by Sato and Rogers [24], who justify the efficiency of applying the case-study method in the course of training teachers for doing research work. The opinion of Kadir [17] concerning a shift in attitudes of primary school Math teachers to the learning process and overcoming the fear of failures with the help of micro-teaching, is of importance for the authors of this paper as well. Kadir [17] considers, that this fear hampers teachers to modify their activity, to introduce new modes of arranging the learning process. Căprioară, Frunză [5] use individualized and differentiated learning through arranging individual and group work to help students cope with such problems and improve their mathematical and methodological competence. In order to implement an individual approach, Sullivan [25] chooses the means of learning, that factor in students' preferences, and students get satisfaction from the process of studying Mathematics. According to the researcher, only under this condition can the means of learning boost students' motivation for studying the subject.

Therefore, the analysis of the experience and expertise of the scientists helped to develop the methods, that will engage students into the process of devising innovative solutions and give them the feeling of accomplishment and satisfaction from this process.

The objective of the present article is to present the methods for developing motivational and value-based readiness of Math students at teacher training universities for implementing innovations; to describe their implementation into the process of teaching Elementary Mathematics, Methods and Technologies of Teaching Mathematics. In order to reach the objective, it is necessary to take the following steps:

1) to analyze the scientists' opinions, on-line resources and reports, which present developing students' motivation for implementing innovations;

2) to devise the methods, using thereof comprises 2 stages:

– in the course of teaching Elementary Mathematics students are propelled to learn how to solve and devise various types of systematized Rich Tasks;

– in the course of teaching Methods and Technologies of Teaching Mathematics, students are propelled to devise Rich Tasks for certain topics of secondary school Mathematics and to justify using each type of Rich Tasks, combined with the active learning methods and means of learning.

3) to check experimentally the efficiency of the developed methods in the course of teacher training internship.

2. Methods

The stage of developing the methods was accompanied by using the method of the analysis of the recommendations by the Organisation for Economic Co-operation and Development (OECD) [16] and reports by Open University Innovation [16]. As a result of this analysis, the basic principles of developing students' motivational and value-orientated readiness were singled out. Based on these principles, the authors of the present paper selected types of Rich Tasks in Elementary Mathematics, singled out open-ended and integrative problems. In turn, open-ended problems were divided into situational problems, open-ended problems, research problems. When solving the situational problems, students have to choose the mathematical apparatus and apply it to solving a certain problem. Solving an open-ended problem, students have to add a certain condition (conditions) to the existing ones, pose a problem and solve it. Using research problems means that students single out the methods for solving it and apply them. Integrative tasks are divided into three types. When solving the problems of the first type, students have to understand and use the content and conceptual link between separate sections of secondary school Mathematics (for instance, between Algebra and Geometry). Solving the tasks of the second type, students understand and use the links between Elementary Mathematics and sections of Higher Mathematics. Using the problems of the third type means that students apply mathematical methods to solving problems that occur beyond the scope of Mathematics. Table 1 presents some examples of a system of Rich Tasks, which are systematized for the purpose of teaching Elementary Mathematics.

Table 1. The examples of a system of Rich Tasks in Elementary Mathematics

Principles	Categories and sub-categories of Rich Tasks in Elementary Mathematics	Examples of Rich Tasks
Problematic nature	*Open-ended problems* Situational problem	In order to renovate the house, the owner has to measure the internal diagonals of a brick. He forgot Pythagoras theorem, but there were enough bricks and the problem was quickly solved with the help of a ruler. How to do this?
	Research problem	Based on the analysis of manuals in Elementary Mathematics and secondary school manuals, single out the methods for solving trigonometrical equations and tentative tenets for applying these methods.
Ambiguity	*Open-ended problems*	The height of a parallelogram equals 8 and 12 m respectively. Devise 2 problems of different levels of difficulty, using these conditions (no more than 1 condition can be added) and solve them.
Integrative nature	*Integrative problems* Problems of the first type, based on using the content and conceptual link between separate sections of secondary school Mathematics	Using the Square Coordinates application, formulate and describe a general instruction for the construction of a square when you are given two: 1) adjacent angles; 2) opposite angles. Decide, whether any of the sets of points given below, are vertices of the square. If so, which ones? Can you do this without plotting the points on a grid? 1. (8,3), (7,8), (2,7), (3,2). 2. (3,3), (7,4), (8,8), (4,7). 3. (16,19), (18, 22), (21, 20), (19, 17). 4. (4, 20), (21, 19), (20, 2), (3, 3). How can you check by means of Vector Algebra that the resulting figure is a square? Draft an action plan for constructing a square, if specified: 1) only one vertex of the square; 2) only two vertices, if it is known that they are adjacent; 3) only two vertices, if it is known that they are not adjacent; 4) three vertices. Is it always possible to find the fourth vertex? Why? How do you set three vertices to make this possible? What figure might these three given vertices form? How to check this fact by means of Vector Algebra?
	Problems of the second type, based on using the links between Elementary Mathematics and sections of Higher Mathematics	Given two positive numbers which do not exceed 2, find the probability that the sum of these numbers is not less than two. Analyze what questions can be asked in the context of this problem in order to use information from Geometry to

	solve it. The following question can serve as an example: find the probability that the difference between these numbers does not exceed 1. Are there any possibilities to solve the problem, applying knowledge of Higher Mathematics? Draft variants of such tasks. The following question can be an example: find the probability that the product of these numbers does not exceed 2. Think carefully and give variants for problems with this specification, but with more tasks. For example: find the probability that the sum of these numbers is greater than 1 and the product is less than 2. The following is an example: find the probability that the sum of these numbers is greater than *a* and the product is less than *b*. Find the conditions under which the problem will have no solution.
Problems of the third type, based on applying mathematical methods to solving problems that occur beyond the scope of Mathematics	One of the students in the group started coming to the first lesson too tired. When the teacher asked why that was happening, the girl replied that she had started taking another way to school. She said, the road is much shorter than the first one, but very steep. The teacher decided to give the students a task to find out how steep the student's new way to school is. The students found that the sidewalk on which the girl walks every morning is a staircase consisting of small stepping stones. They counted the number of stepping stones, their depth and height. Using the information about right triangles, similarity of triangles, information from trigonometry, students easily determined the inclination of the road. Think carefully and give general instructions for solving this problem. It is advisable to present several ways to solve this. Give variants of tasks in the context of this problem. The following can be an example: stepping stones on the sidewalk of a fairly steep street have a height of 7 cm and a depth of 52 cm. Find the inclination of the sidewalk. Now let the sidewalk be designed for 25 m of road with an angle of 12 degrees. Build a scale diagram of the corresponding section of the road. Find the depth of the stepping stones, if each of them has a height of 10 cm. How many steps must be taken on this part of the road? How many 15 cm high stepping stones will it take to cover this section of the sidewalk if the angle is 8 degrees? What depth of the 15 cm high stepping stones will be needed for a street with a gradient of 0.25 or 0.3?

At the next stage the authors of the present paper used the Deductive Approach to Content Analysis of the resources, that present developing students' motivation to implementing innovations. Selecting methods, modes and means of learning, a focus was placed on the ones that ensure students' value-orientated attitude to implementing innovations (table 2).

Table 2. Analysis of the resources presenting the on-line courses, focused on motivating students to innovate.

The on-line courses	Methods of learning	Modalities of learning	Tools for learning
Technology & Innovation in Education [27]	Case study, projects, microteaching	Group work	Cloud services
Disruptive innovation [15]	Case study, projects	Individual work	Cloud services
Centre for Innovation in Mathematics Teaching [6]	Microteaching, simulation games	Group and individual work	Programs of dynamic Mathematics and cloud services
Teaching mathematic with technology [28]	Projects, role-plays	Group work	Programs of dynamic Mathematics and cloud services
Creativity, Innovation, Motivation and new Teaching Methodologies [11]	Case study, business games, projects	Individual work	Cloud services
Specialization Innovation Management and Design Thinking [9]	Microteaching, case study	Individual work	Programs of dynamic Mathematics and cloud services
Innovation Essentials [14]	Case study	Individual work	Cloud services

The analysis of the recommendations, developed by the experts (table 2), contributed to working out the methods. The authors of this study took into account not only experts' opinions but also their own experiences.

Using a vast array of interactive learning methods, such as "Microphone", "Brainstorm", "Situational Analysis" the authors in the present paper consider that changing those methods in the course of solving and devising open-ended Rich Tasks adds an element of surprise, develops readiness for changes in learning and further on – in future professional activity. Case study and microteaching were also used in course of teaching students. To arrange the learning process with the help of the case study method, a problem situation was devised. This situation meant using Rich Tasks, combining them with active learning methods and innovative means of learning; it also had at least two solutions. The realistic nature of the problem situation allows to design the content of the future educational activity. Using the method of micro-teaching meant that students had to devise a fragment of a Math lesson, using integrative Rich Tasks, active learning methods and information technologies.

Innovative learning implies transition to group and individual work of students, so we arranged group work in homogeneous and heterogeneous groups of variable composition and individual work of students during tutorials and laboratory work classes, for which teachers used the method of creating a team product. It aimed at arranging group activity of students mainly in homogeneous groups.

One of the innovative learning modalities, which boosted students' activity, was running an experimental counseling point "The First Session". In October-December undergraduate students counseled freshmen on a group and one-to-one basis. Within the framework of a vertical interaction of students, we arranged collaboration between freshmen, studying Elementary Mathematics and undergraduates. Undergraduates also did peer assessment for the first-year students.

Information technologies, such as dynamic Mathematics software (GeoGebra), graph constructors (Advanced Grapher); cloud services (Google+ and Google Classroom) were used to make the learning process visual and to boost students' motivation.

The key constituent of our research was integration of mathematical and methodological training of students in course of teaching Elementary Mathematics. Developing motivational and value-orientated attitude towards Mathematics as a science and a learning subject, getting familiarized with the potential of innovative learning methods, modalities and tools, developing willingness and ability to introduce changes into own activity were the central objectives of learning Mathematics in first and second-year students. Later on, students in year three and four, while learning Methods of Teaching Mathematics and Technologies for Teaching Mathematics fostered a positive attitude to innovations thanks to complementing the content with topics, related to devising and implementing innovations. The topics were chosen by the students themselves from a list of 3-4 topics. More often students chose topics "Innovations in School Mathematical Education" and "Innovative Technologies for Teaching Mathematics".

3. Results

The experiment took place from 2014 till 2019, the number of respondents totalling 211 students from major Ukrainian universities: Berdyansk State Pedagogical University, H. S. Skovoroda Kharkiv National Pedagogical University, Uman State Pedagogical University named after Pavlo Tychyna, Glukhiv National Pedagogical University, East-European National University named after Lesia Ukrainka and East-Ukrainian National University named after Volodymyr Dal.

At the beginning of the experiment the participants were divided into two groups – the control group (105 students) and the experimental group (106 students). In the control group (CG) teaching was done, following a traditional methodology. The academic staff, working in the experimental group (EG), were briefed on the methodology, developed by the authors of this paper and were provided with the guidelines on teaching each of the three methodological subjects.

To prove the homogeneity of the groups, the Ryan and Deci questionnaire [23] was used at the beginning of the experiment. The students had an opportunity to take part in the survey with the help of a free on-line service. Figure 1 presents the results of measuring the level of motivational and value-orientated readiness of students in the experimental and the control groups for implementing innovations at the beginning of the experiment.

As can be seen on the chart, there is almost no difference between the students' motivation for success and for failure in the control and the experimental groups at the beginning of the experiment. The biggest number of students (almost 56% in the experimental group and 55% in the control group) had ulterior motivation.

At the end of the experiment in order to study the impact of the developed methods, certain types of activities, done by the students during their internship were assessed. The students in the experimental and in the control groups received the same tasks and the academic staff, working with the students at the second stage of the experiment were at the same time supervisors.

The assessment of the students' motivational and value-orientated readiness was done, based on doing the following tasks.

1. Analysing the experience of the university, where the students did their internship (the most recent, innovational works of the academic staff) – 10 points.

2. Applying innovations in Math class and after-class activities. The assessment criteria were – students' initiative in using innovative learning methods, modes, means, technologies (Rich Tasks

included); the students' activism, consistency, coherence in using innovations, their readiness for experimenting, changes in own activity – 20 points.

3. Devising learning materials in the course of doing the internship. The usage of innovations was assessed (designing Rich Tasks, using cloud services, programs of dynamic Mathematics, web-quests, excursions, etc.) – 10 points.

4. Participation in arranging training research activity of secondary school students. The students' activism and initiative in preparing the secondary school students for Math contests, developing the research topics for the Junior Academy of Sciences and helping to get the research papers published were assessed – 10 points.

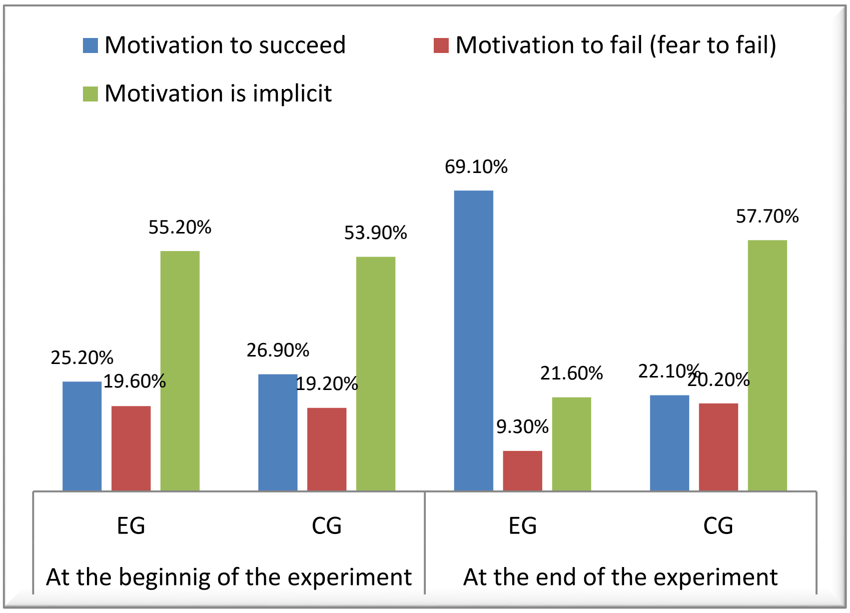

Figure 1. The results of the students' answers to the questions in the Ryan and Deci questionnaire [23].

The average score for a definite activity in the control and the experimental groups was calculated as an average of scores of each student in this group.

An intern could score 50 points, if he or she:

– got actively interested in, analysed, compared the innovative experience of an institutions, where the internship was done, with the methods and techniques, already known to this intern;

– proactively, consistently and systematically tried to implement innovations into the process of doing the internship; had no fear to experiment with the learning methods, modes and techniques;

– proactively designed educational materials, using innovations;

– got actively engaged into arranging the training scientific activity of secondary school students; came up with proposals concerning topics and content of research papers for secondary school students, as well as methods, modes and means of preparing them for contests.

The assessment results of the students' motivational and value-orientated readiness in the control and the experimental groups are shown in figure 2.

The average score of all four internship tasks in the experimental group (10.0 points) is higher than in the control group (6.4 points) by 56%. This proves the effectiveness of the developed methods of forming the motivational and value-orientated readiness of students, majoring in Mathematics, for implementing innovations. EG students more actively studied and more consciously analyzed the innovative pedagogical experience of the of the university, where they did their internship. They showed

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more initiative in introducing Rich Tasks and other innovations into teaching, and more actively and creatively helped students in preparing research papers, in preparing for mathematical competition.

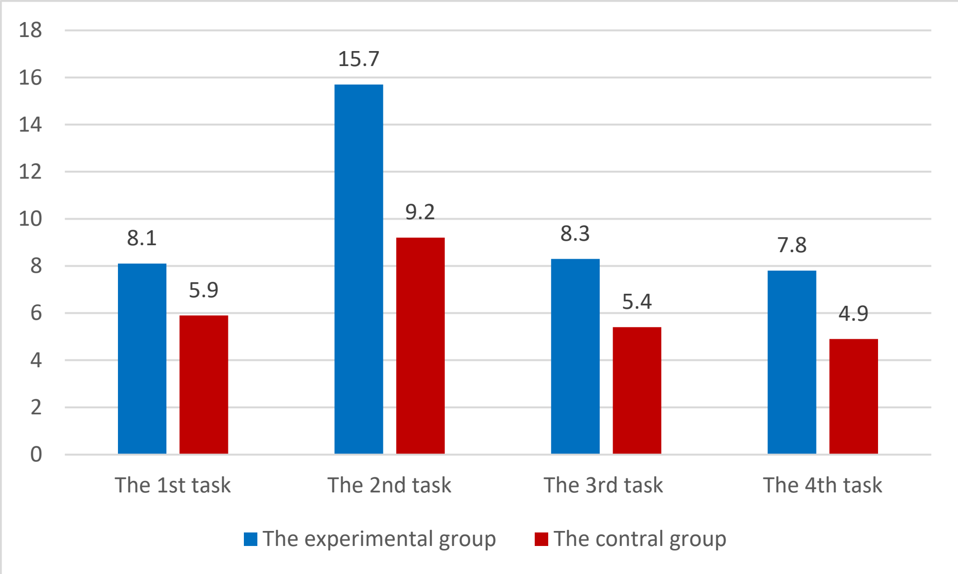

Figure 2. The results of assessing the internship tasks in regard to motivational and value-orientated readiness for implementing innovations.

A repeat survey, using the Ryan and Deci questionnaire [23] was done at the end of the experiment. The questionnaire was uploaded to the platform "Higher School Mathematics Teacher" [13]. The results of assessing the teacher training internship tasks are proved by the analysis of the students' responses (figure 3).

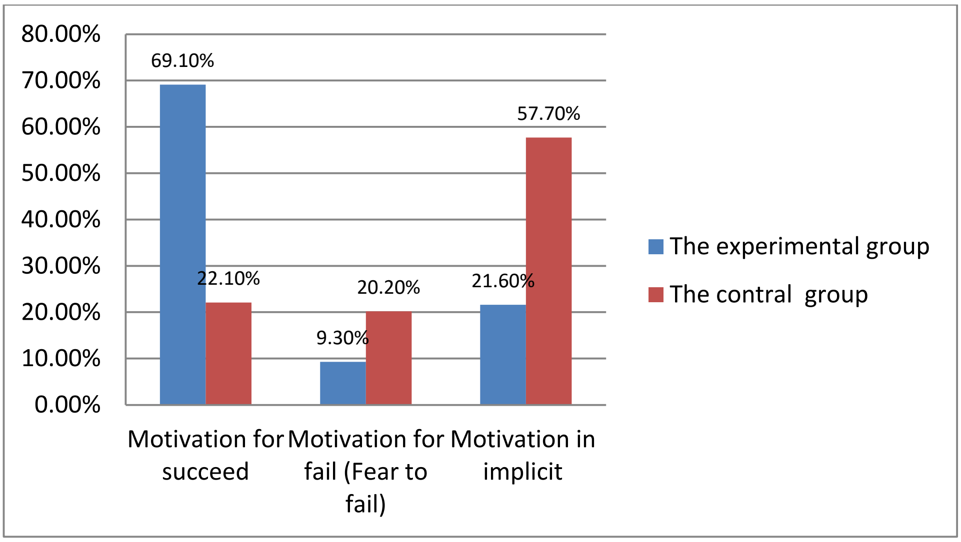

Figure 3. The results of the students' responses to the Ryan and Deci questionnaire [23] at the end of the experiment.

As can be seen in figure 3, the students in the EG have three times higher motivation for success, than the students in the control group. Meanwhile, the number of students with ulterior motivation is 2.5

times lower than in the CG.

During the International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020) [32] we presented the above mentioned methods. The idea of its introduction into the process of teaching in order to develop motivational and value-orientated readiness of Mathematics students for using innovations received approval.

4. Discussion

Research done by Rerke et al. [21], Álvarez Aguilar [2], Dyczkiwska [10] prove significance of the issue of implementing innovations by students, who choose teaching as their future job. The expert opinions were taken into consideration, when developing the methods for facilitating the students' motivational and value-orientated readiness for implementing innovations. The scholars emphasize, that training teachers for implementing innovations is based on their motivation and values. Thus, Rerke et al. [21] look into psychological aspects of developing teachers' motivation for implementing innovations. Álvarez Aguilar [2] highlights the necessity of value-orientated attitude of a University teacher to implementing innovations, analyses the factors, which hamper training teachers for implementing innovations.

Of interest for us was a research done by Dyczkiwska [10], who devised a technology for developing students' internal motivation for implementing innovations in infant schools. Devising the methods for developing motivational and value-orientated readiness of Mathematics students in teacher training Universities for implementing innovations was based on views of Clewell and Villegas [8], who came up with an innovative program of training teachers. In the program the researchers offered to value diversity of opinions, methods, ways of achieving a goal, to establish a connection between theory and practice, which was taken into consideration.

We also share the opinion of Tarasenkova and Akulenko [26] and Vlasenko et al. [34] concerning the necessity to integrate mathematical and methodological training of students, majoring in Mathematics in teacher training Universities. At the same time, we believe that the training is to start in year one, as it is a key prerequisite for improving motivational and value-orientated readiness of students for implementing innovations. Teaching students how to solve, systematize, devise Rich Tasks in the course of learning Elementary Mathematics provides the basis for the methods, developed by the authors of this research. When studying Methods and Technologies of Teaching Math, students must learn how to devise and apply Rich Tasks in their professional activity, how to combine them with other active learning methods and innovative learning means. Reasonable alternating of teaching methods, modeling future professional activity of students, contributes to creating an effect of novelty, increasing internal motivation, providing a role model for students in their future job, which is why a method of microteaching was used alongside case studies. Using microteaching and combining it with case studies during laboratory work classes and tutorials, added to developing a steady interest and psychological orientation at implementing innovations, improving students' self-esteem.

5. Conclusions

Analysis of scientific and methodological papers proved relevance of the research into the issue of developing motivational and value-orientated readiness of Mathematics students in teacher training universities. The key prerequisite for this is integration of Mathematical and methodological training of students in course of learning Elementary Mathematics, Methods of Teaching Mathematics, and Technologies for Teaching Mathematics.

The joint activity of the academic staff, teaching Math and methodological subjects contributed to developing requirements and guidelines, following thereof added value to positive dynamics of the interest in and focus on implementing innovations

1. Consolidated efforts of all the teachers, engaged into teaching in experimental groups shall be aimed at devising guidelines on innovative teaching. Those teachers, who take part in the experiment, are to be familiarized with all the materials well in advance. To meet this requirement, the teachers shall undergo a series of seminars and workshops so as to get answers to all the questions that might arise.

Searching the answers to those questions, as well as reviewing curricula and materials shall be done in collaboration with all the teachers, engaged in the experiment.

2. The first step to take in the experiment must be surveying students, using the Ryan and Deci questionnaire [23], combined with assessing their motivational and value-orientated readiness for implementing innovations, as well as ensuring the homogeneity of the experimental and the control groups. At the end of the experiment, it is advised to assess the tasks, done by the students during their internship in regard to their motivational and value-orientated readiness for implementing innovations

3. Introduction of the methods is to take place during the whole four-year period of learning. It comprises two stages: an introductory stage (years one and two) while learning Elementary Mathematics and the main stage (years three and four), while learning Methods of Teaching Mathematics and Technologies for Teaching Mathematics.

4. During the first stage, the academic staff should use both, group and individual mode of work in order to solve and devise Rich Tasks, to change reasonably active learning methods, means of information technologies. Also, the teachers should arrange innovative modalities of supporting students, such as "The First Session".

5. It makes sense to use the same methods, modes and means of innovative learning at both, the first and the second stages, channeling them to developing the students' motivation and ability to apply Rich Tasks, combined with other innovations. Added to that, it makes sound sense to use case study, microteaching in course of running tutorials, laboratory work classes and extra-class work.

Following the above mentioned recommendations and requirements, while implementing the methods in experimental groups, contributed to increasing the level of development of motivational and value-orientated readiness of students, majoring in Mathematics for implementing innovations.

Further research work in this domain will be focused on developing a module on the educational platform "Higher School Mathematics Teacher" [13], which will present the materials devised for implementing motivational and value-orientated readiness of students for implementing innovations.

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