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The case classification and their development for would-be mathematics teachers' training

V V Achkan[1], K V Vlasenko[2], I V Lovianova[3], R Yu Kaluhin[3] and T S Armash[3]

[1] Berdyansk State Pedagogical University, 66 Zhukovski Str., Zaporizhzhia, 69600, Ukraine
[2] National University of 'Kyiv Mohyla Academy', 2 Hryhoriya Skovorody Str., Kyiv, 04070, Ukraine
[3] Kryvyi Rih State Pedagogical University, 54 Universytetskyi Ave., Kryvyi Rih, 50086, Ukraine

E-mail: vvachkan@ukr.net, vlasenkokv@ukr.net, lirihka22@gmail.com, kaluhin@ukr.net, armash@i.ua

Abstract. The article looks into the issue of the case classification for the training of Mathematics teachers. The analysis, which was carried out, and the survey of 47 University teachers of methodical disciplines allowed to highlight the classification features of cases in the process of teaching methodical disciplines: the amount of time to complete, the way of presentation, the level of complexity and the breadth of the covered problem. Classifying cases by the amount of time for their implementation contributed to the separation of mini-cases, medium-term cases, and long-term cases. Classification by the method of presentation of cases in the process of studying methodical disciplines ensured their use in printed (handwritten) form, multimedia presentation of cases, and video cases. According to the level of complexity, the cases were divided into reproductive-training, partial-research, and creative-innovative cases. Thematic and integrated cases ensured the breadth of coverage of the problem during the teaching of methodical disciplines. The article presents general requirements for the selection and development of cases in the process of studying methodical disciplines. These requirements are based on the principles of accessibility, scientificity, contextuality, systematicity, methodological expediency, and practical orientation. The classification and specific requirements became the basis for the development of cases that can be used in the process of teaching methodological disciplines of would-be Mathematics teachers.

1. Introduction

1.1. Problem statement and its topicality substantiation

As noted in the Standards for Training Mathematics Teachers, developed by the Association of Mathematics Teacher Educators [1], an effective Mathematics teacher must take into account the existing social contexts of learning, and actively use and adapt existing innovative developments to the needs of a specific group of students. As rightly pointed out by Barkai [2] and Mainali [3], the use of the case method provides would-be Mathematics teachers with ample opportunities to acquire and analyze practical experience. It is the analysis and modeling of specific situations that allow a would-be Mathematics teacher to be trained to find effective ways to overcome problems in teaching Mathematics, to correspond to society's order.

The basis of the professional training of would-be Mathematics teachers is methodological disciplines, such as Methods of Teaching Mathematics, Technologies of Teaching Mathematics, and several disciplines of students' free choice [4]. It is in the process of learning methodical disciplines that students get acquainted with the fundamental foundations of the organization of Mathematics education, learn to combine traditional and innovative types, methods, techniques, and technologies of pedagogical activity, reflect on their own experience, and analyze how to correct their professional activity [5, 6]. Therefore, the problem of using the case method in the process of teaching methodical disciplines is relevant, which involves the classification and development of cases that should be used in the training of would-be Mathematics teachers.

1.2. Analysis of the latest research and publications

The implementation of the case method is associated with Harvard University. Research by Amaratunga and Baldry [7], Feagin et al. [8], Tellis [9] are devoted to generalized theoretical positions of the case method in education. Amaratunga and Baldry [7] substantiated the importance of using the case method in education. We agree with scientists that the case method should be used only after students have acquired a certain system of basic knowledge. Feagin et al. [8] studied the methodological foundations of the implementation of the case method and gave examples of its use in the process of training specialists in the social sphere. We took into account the scientist's opinion regarding the methodology of creating and conditions for using cases in the educational process. As Tellis rightly noted [9], the case should be focused on the organization of students' quasi-professional activities.

Easton [10] and Schrittesser [11] were interested in organizing such activities during teacher training. Schrittesser [11] analyzed the importance of using the case method for organizing reflection and correction by teachers of their professional activity. We were fascinated by the scientist's opinion that cases should be created taking into account the level of practical abilities of teachers and be oriented towards professional self-improvement. We share the views of Easton [10] about the importance of the case method in the process of training teachers for professional activities. We took into account the recommendations proposed by Easton [10] regarding the use of the case method in the process of teacher training. Our research follows recommendations regarding the orientation of cases to the development of critical thinking of active teachers and the need to have several ways of solving the case. To sum up, all scientists agree that the systematic use of the case method helps to increase the readiness of working and would-be teachers to effectively perform professional activities and to find new non-standard, creative ways to solve educational tasks.

The studies of Gay [12], Yuan [13], Puri [14], Takker [15], Barkai [2], Yılmaz [16], Li and Yang [17], Smith and Friel [18] are devoted to the issue of using the case method in teaching Mathematics. Gay [12] and Puri [14] substantiated the importance of using the case method to increase students' motivation to learn Mathematics. Li and Yang [17] investigated similar aspects of increasing motivation to learn Mathematics, as well as increasing the level of students' competencies in the process of studying the course 'Introduction to Mathematics'. We agree with scientists that the case should be formulated in the form of a problem situation. Crucial for our research are the opinions expressed in both studies regarding the feasibility of using the case method at different stages of education. Our study relied on the opinions highlighted in the works of Yuan [13] and Yılmaz [16]. The scientists substantiated the effectiveness of using the case method for the training of Elementary School Mathematics teachers and identified separate provisions for the construction of cases. Takker [15] and Smith and Friel [18] proved that learning based on specific situations or so-called contextual learning is one of the most productive methods. The idea of scientists was taken into account, according to which the use of cases, among other things, lays the foundations for further teachers' self-improvement through the analysis of practical activities.

The use of the case method in the training of a mathematics teacher is a paramount component of the didactic training of the teacher. Various aspects of the Mathematics teacher didactic training are devoted to the research of Guérios and Gonçalves [19], Breda et al. [20], Blanco et al. [21], Nurdiana et al. [22], Achkan et al. [23].

The opinions of Guérios and Gonçalves [19] and Achkan et al. [23] are interesting for our research, which substantiated the expediency of organizing didactic training of would-be Mathematics teachers starting from the first year of study. Such preparation using the case method lays the foundations for the organization of quasi-professional activities in senior courses. It follows the views of Breda et al. [20] that the students' didactic knowledge should be formed in the process of contextual activity. This didactic knowledge is a prerequisite for the formation of the ability for reflection of Mathematics teachers and self-improvement in professional activity. While researching, we relied on the work of Nurdiana et al. [22]. The scientists investigated the issue of the formation of didactic competencies of would-be Mathematics teachers while studying Geometry and emphasized the importance of acquiring subjective contextual experience. Blanco et al. [21] substantiated the importance of methodological and mathematical training for primary school teachers. As the scientists rightly noted, it is the systematic selection of practice-oriented teaching methods that creates the basis for training a competitive and capable teacher. One such practice-oriented method is the case method.

The same idea is supported by Straesser [11] and Vlasenko et al. [24] according to which the study of mathematics didactics is one of the key areas of training would-be mathematics teachers. At the same time, as Marinković and Đokić [25] rightly note, the main goal of the course 'Didactics of Mathematics' and other didactic disciplines is to promote the formation of independent and creative practicing teachers. We share the opinion of Barkai [2] regarding the effectiveness of using the case method for training Mathematics teachers and the main key element of this method is the case.

The analysis of the given views of scientists made it possible to formulate the concept of a case. By the case, it will be understood the educational problem or the situation that may contain additional facts, descriptions, and opinions. Solving such a situation creates conditions for the organization of students' quasi-professional activities. That is, the situation is realistic, and its discussion allows for modeling the content of future pedagogical activity. The case assumes the presence of at least two ways of solving the problem situation. Working with a case requires students to use their knowledge, abilities, skills, subjective Mathematics experience, and mathematics teaching methods. The educational situation is focused on the development of creative personality qualities of would-be mathematics teachers.

Effective implementation of the case method in teaching methodical disciplines requires a convenient case classification. It agrees with Zhang et al. [26], who believe that classification is a crucial method of pedagogical research. The effective classification of methods (students, technologies) is the basis for building an effective education system.

The researchers Baxter and Jack [27], Crowe et al. [28] Yin [29], and Sinha [30] considered the issues of case classification in the education of students of various specialties. Interestingly our study is the opinion of Baxter and Jack [27], who offered a universal case classification for training students, graduate students, and researchers. The scientists included Explanatory, Exploratory, Descriptive, Multiple-case studies, Intrinsic, Instrumental, and Collective types of cases. The given classification helped us to distinguish two classification characteristics of cases in Mathematics teacher training. We were fascinated by the idea of Tortajada-Genaro [31] regarding the division of cases by execution time. At the same time, the scientist analyzed in detail and substantiated the expediency of using only mini-cases. Our study took into account the results of Crowe et al. [28]. It is about views on this type of case as explanatory one. In general, the classification of cases developed by scientists (internal, explanatory, collective, instrumental) is difficult to use because it does not have a single basis for classification. We share the ideas

of Sinha [30] regarding the expediency of distinguishing Particularistic and Heuristic cases (in addition to them, the scientist also distinguishes Descriptive). Similar views are held by Yin [29], who offered to distinguish search, descriptive, and explanatory cases. Thus, none of the analyzed case classifications is multifactorial and does not take into account the specifics of the would-be Mathematics teacher training. This makes the problem of building a multifactorial case classification relevant.

The aim of the study is a theoretical generalization of the scientists' views and a survey of teachers of methodical disciplines to build classification and develop cases for the training of would-be mathematics teachers.

2. Methods

We invited university lecturers from Berdyansk State Pedagogical University, Kryvyi Rih State Pedagogical University, Vinnytsia Mykhailo Kotsiubynskyi State Pedagogical University, Pavlo Tychyna Uman State Pedagogical University, The Bohdan Khmelnytsky National University of Cherkasy, Ternopil Volodymyr Hnatiuk National Pedagogical University, and Donbass State Engineering Academy to take part in the survey using Google Forms. The survey involved 64 teachers. It worked out the issue of using cases in the process of teaching methodical disciplines. The questionnaire contains 6 questions that require the choice of an answer. One of the questions requires its version of the answer in addition to the choice proposed. The first question made it possible to find out how actively teachers use the case method in the teaching of methodological disciplines. The second question helped to highlight the main classification characteristics of the cases. The other four questions helped to identify the types of cases that should be used within each of the classification characteristics.

The selection of cases in the classification process should be carried out taking into account such requirements.

1. Availability. The choice of the case type should correspond to the level of methodological competence of students, and readiness to produce creative solutions.
2. Scientism. The cases are aimed at students mastering the scientific foundations of general and partial methods of teaching Mathematics, forming the ability to systematically apply methods, forms, and technologies of learning.
3. Systematicity. The use of cases in the process of teaching methodical disciplines should occur constantly, and systematically, supplementing the traditional methods of teaching methodical disciplines.
4. Contextuality and practical orientation. Cases in the process of teaching methodical disciplines as closely as possible (simulate) situations that would-be teachers will encounter in their professional activities.
5. Methodological expediency. The choice of the case type is related to the type of class and the goal pursued by the teacher. Taking into account the requirements described above, the classification and survey of teachers contributed to the structuring of cases according to such characteristics in the process of training the would-be Mathematics teacher (figure 1).

By the amount of time for execution, cases are divided into mini-cases, medium-long cases, and long-term cases. Mini-cases require 15 to 25 minutes to find solutions. It is possible to find solutions and discuss at least two mini-cases during one class. Medium-long cases require from 30 minutes to 1 hour to find solutions. Usually, one medium-long case or three such cases in paired classroom sessions are solved and discussed during the class. Long-term cases require more than an hour to find solutions. They are used for extracurricular students' self-work.

It is advisable to use mini-cases as a means of creating a problem situation during lectures on methodical disciplines and in the process of practical class. It is appropriate to use medium-

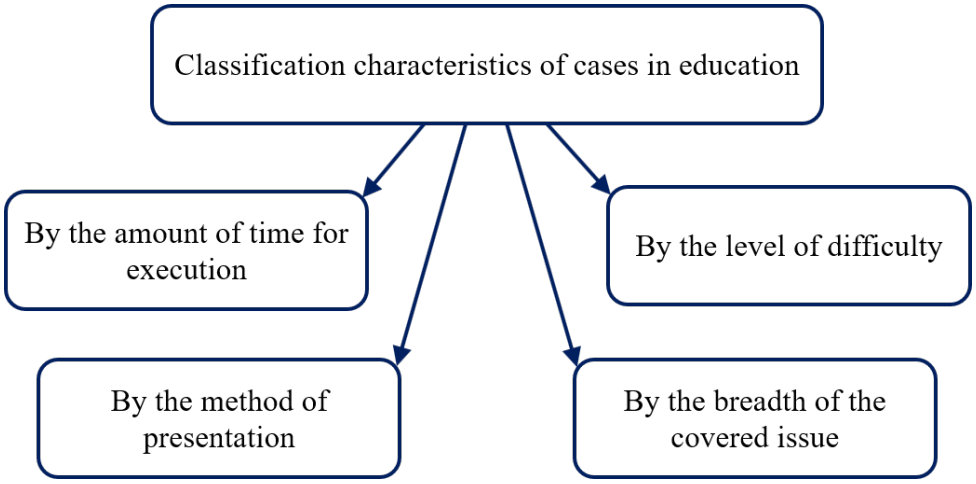

Figure 1. Characteristics underlying the case classification.

long cases in the process of practical classes on methodical disciplines. There is a sense to offer long-term cases to students for extracurricular individual or collective work.

According to the level of complexity, the cases are divided into reproductive-training, partial-research (heuristic) and creative-innovative. Reproductive and training cases contain structured information, a standard situation, which provides for the presence of two or three models of pedagogical activity to achieve an optimal result. Information in partial search (heuristic) cases is not exhaustive. Such cases require additional analysis and modification of standard models of pedagogical activity. They may contain some absolutely unnecessary facts for finding a solution, information that distracts attention from key point. The task in creative and innovative cases requires students to propose a new, creative solution based on the acquired knowledge, skills and subjective experience.

The choice of the case type by the level of complexity depends on the purpose of its use and the level of preparation of the students. For example, it is advisable to use reproductive training cases in lectures on methodical disciplines to create a problem situation. There is a sense of starting separate practical classes with a collective discussion of such cases. It is appropriate to use partial research cases in lectures on certain topics, provided the students have a high level of preparation. It is also possible to use partial research cases during practical classes for both face-to-face and group work. It is advisable to offer creative and innovative cases in practical classes and for self-work outside the classroom to individual students.

By the method of presentation, cases were divided into cases in printed (handwritten) form, multimedia presentation, and video cases. The choice of presentation method depends on the form of education and the teacher's technical capabilities. During distance learning, it is worth giving preference to two extreme types of cases. During face-to-face training in classrooms, it is appropriate to offer individual cases, mostly short ones, in printed form. At the same time, if technical capabilities are available, multimedia presentation and video cases should prevail.

Based on the breadth of the covered problem, cases are divided into thematic and integrated ones. Thematic cases are related to the method of introducing concepts, proving statements, and studying a certain content line of the high Mathematics course. Integrated cases require reliance on knowledge, skills, and subjective experience of one or more methodological disciplines. It is advisable to use thematic cases lecturing methodical disciplines to create a problem situation. Also, their application is useful during practical classes devoted to considering methods of teaching Mathematics. It is appropriate to use integrative cases when students have already studied the basic course of Mathematics teaching methods and are mastering other methodical

disciplines. Also, their application is useful in final practical classes.

Note that a case from methodical disciplines can refer to cases of several types. For example, a reproductive training, thematic mini-case is presented in printed form.

Case 1 (reproductive and training, thematic, mini-case presented to students in printed form). In the next semester, you will have an Internship, during which you will conduct classes. It is given an example of your colleague's activity. Intern student Petrenko Oleksiy taught geometry classes in the seventh grade. These classes were devoted to the study of the triangles' equality. All of them were conducted according to the same scheme: formulation of the theorem, drawing, quick proof on the board (explanations are minimal), and transition to solving problems on the theorem application. Do you think this approach is methodologically appropriate? Describe the possible methodical techniques for familiarizing students with proofs of the theorem of the triangles' equality. Suggest your plans for conducting such classes.

Case 2 (reproductive and training, thematic mini-case, presented in printed form). In the Algebra class, the teacher asked the students to calculate the value of cos 15°. Suggest different methods of calculating this expression depending on the profile of the class. In the process of learning, what topics can such tasks be used? What role does performing calculations in different ways (techniques) play in learning Mathematics?

Case 3 (heuristic, medium-long, thematic, presented in printed form). During the Algebra class, the teacher offered the students to solve the problem: the amount of tourist tax receipts in August 2019 increased by 10% compared to July tourist tax receipts and amounted to UAH 510,000 (the statement is not finished). Formulate several problems using the given preamble. These problems can be used in the process of studying different Algebra topics while learning Mathematics in schools. List these topics and typical mistakes that students may make when solving such problems.

Case 4 (creative and innovative, thematic, long-term, presented in the form of a multimedia presentation). The young Mathematics teacher was summoned by the director of the school: 'The day after tomorrow we are expecting distinguished guests at our school who will check the organization of extracurricular activities. And you just have group classes in the seventh grade. I hope you will support the high image of the school and pleasantly surprise your colleagues with innovative approaches to organizing group work'. It is expected you suggest a possible title for a Maths club that matches the innovative trends in Mathematics education, and present a class plan using innovative learning technologies.

Case 5 (heuristic, integrated, medium-long, presented in the form of a multimedia presentation). The teacher started the Geometry class with a story giving an example of a construction situation. While building, walls, in the absolute majority, are created vertically. There are exceptions, but the construction of such buildings is associated with significant difficulties and increases their cost. A plumb line is used to check the verticality of the walls at the construction site. This is a device consisting of a thin thread and a load on it. The question may arise: is such a check sufficient? Which topic of a school Mathematics course can use this story as the introduction? What technology does the Math teacher use to start the class this way? Offer methodological recommendations for the continuation of the class (10-12 minutes). Describe other methodological approaches within the framework of technology used by the teacher. Illustrate one of them using the example of other topics of the Mathematics course of a specialized school.

Case 6 (heuristic, long-term, integrated, presented in printed form). A young Mathematics teacher got a position at a school that works on the system of concentrated education. On the next day, the teacher will have to conduct three Mathematics classes in a row in the tenth grade of the chemical and biological profile. He decided to conduct the first Mathematics class of the school year in the form of a lecture. He took as a pattern a traditional lecture, which he repeatedly attended during his studies at the university. Evaluate the methodical expediency of choosing

this form of conducting the class. Offer your vision regarding the types and methodological features of the organization of this kind of class. Develop a class plan for one of them.

3. Results

The results of the online survey of university teachers of methodological disciplines, which was carried out during the research, proved the following. The majority of respondents use (57.5%) or plan to use (29.7%) the case method in the process of teaching methodological disciplines. Among the key characteristic features of case classification, the respondents attributed the level of complexity (71.9%), the amount of time for implementation (64.1%), the breadth of coverage of the problem (60.9%), the method of presentation (51.6%) and the purpose of the activity (45.3%). The results of the questionnaire regarding the use of the case method in the process of studying methodical disciplines and the characteristic features of the cases are shown in figure 2 and figure 3.

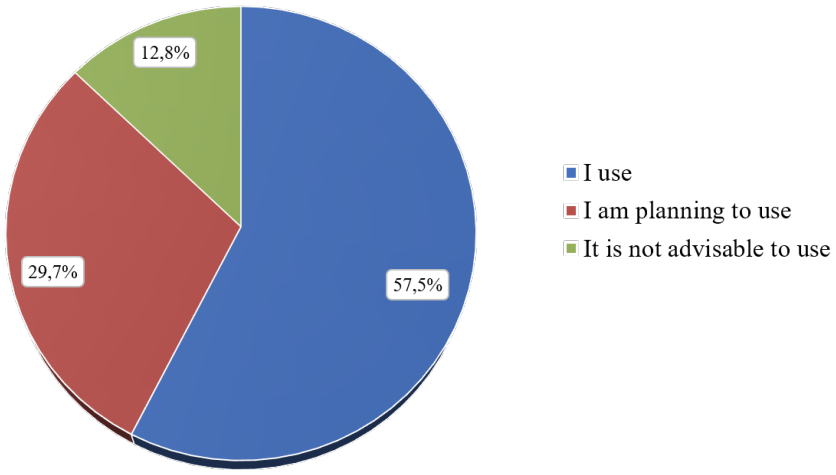

Figure 2. Respondents' answers regarding the use of the case method.

Also, according to each classification characteristic, teachers were asked to rate their attitude towards a certain type of case on a ten-point scale. According to the level of complexity, the partial research (7.5) and reproductive-training (7.1) cases received the highest average score from the respondents. Creative and innovative cases scored 6.2 points (figure 4).

According to the amount of time spent on the case, the teachers consider medium-long (7.6 points) and long-term cases (7.3 points) to be the most appropriate. The mini-cases received a slightly lower score of 6.2 points (figure 5).

In terms of the breadth of the covered problem, teachers preferred thematic cases (8.2). Integrative cases received an average score of 6.9 (figure 6).

Based on the method of presentation, according to respondents, the cases were distributed as follows (figure 7): in the form of a multimedia presentation (8.0), cases in printed form (7.1), and video cases (7.4).

Thus, the analysis of the received answers from the interviewees made it possible to clarify the classification characteristics of the cases and to distinguish the types of cases in the teaching of methodical disciplines.

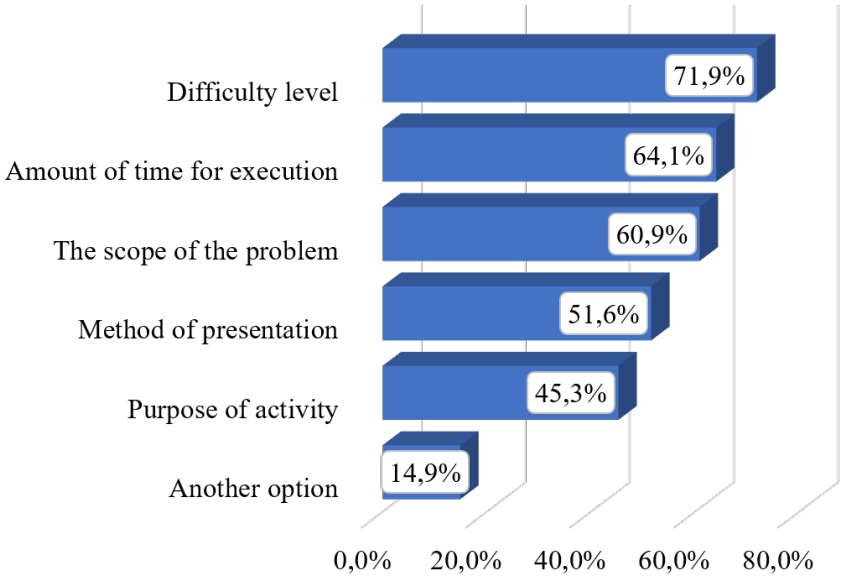

Figure 3. Respondents' answers regarding the expediency of using the case method.

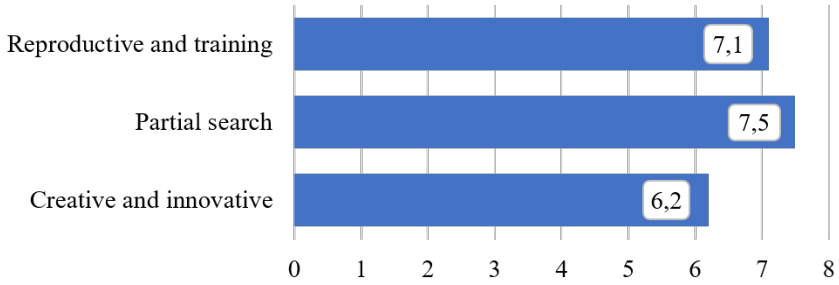

Figure 4. Teachers' attitude to types of cases by level of difficulty.

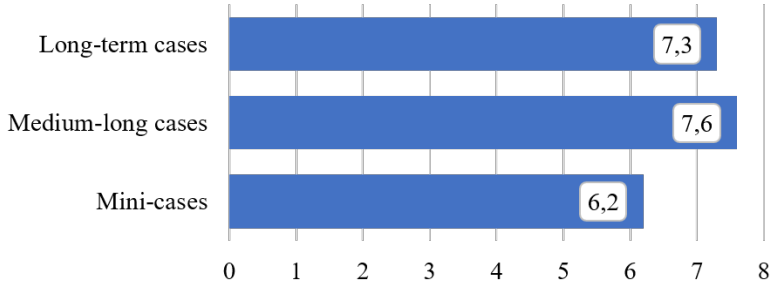

Figure 5. Teachers' attitude to types of cases by the amount of time for completion.

4. Discussion

The analysis of the scientists' papers Baškarada [32], Kelch and Malupa-Kim [33] confirmed the relevance of using the case method in the training of would-be Mathematics teachers. Also, these studies contributed to clarifying the classification of cases that should be used in the process of such training. We were fascinated by the idea of Kelch and Malupa-Kim [33], according to

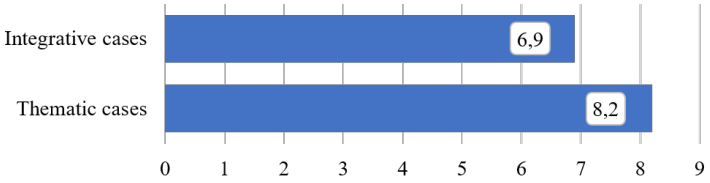

Figure 6. Teachers' attitude to types of cases by the breadth of coverage of the problem.

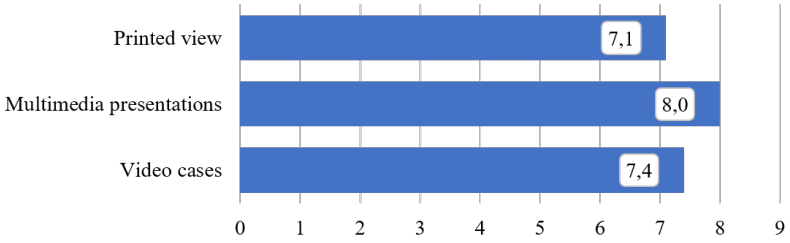

Figure 7. Teachers' attitude to types of cases by the presentation method.

which the case method is the basis for the formation of the teacher's professional competence. We fully agree with the opinion of Baškarada [32] regarding the expediency of classifying cases depending on the didactic purpose of the class. At the same time, we believe that the specifics of Mathematics as a science and the peculiarities of Mathematics didactics should be taken into account in the process of classifying cases.

The classification was chosen as the research method. The idea of Shigang and Sheng [34] that classification is an important and effective tool of pedagogical research is taken into account. At the same time, the development of the classification was coordinated with the opinion and experience of teachers of methodical disciplines. A questionnaire was created for this purpose. The need for its development is consistent with the studies of Nurdiana et al. [22], [12], Crowe et al. [28], and Lovianova et al. [35]. The analysis of respondents' answers made it possible to single out the main qualifying characteristics of the cases and the types of cases within each characteristic.

This study offers the cases classification based on level of complexity, amount of time to complete, breadth of problem coverage, and method of presentation. For example, types of cases by level of complexity (reproductive training, partially-research, and creative-innovative cases) allow for taking into account the level of student training and the purpose of the training session. Such types of cases as mini-cases, medium-term, and long-term cases allow rational planning and use of study time.

While creating the case classification, the authors of this study determined the main requirements for the selection of cases: accessibility, scientificity, systematicity, contextuality and practical orientation, and methodological expediency. The authors' choice of such a system of requirements is consistent with the views of Feagin et al. [8], Li and Yang [17], who offered some of these requirements.

5. Conclusions

The analysis of scientific papers confirmed the relevance of the study of the case classification, which is expedient to use while teaching methodical disciplines training would-be mathematics teachers. Based on the classification and survey of respondents, the authors of the study determined the classification characteristics of cases: the amount of time to complete, the way of presentation, the level of complexity, and the breadth of the problem covered.

It has been established that it makes sense to use mini-cases, medium-long cases, and long-term cases in the process of studying methodical disciplines according to the amount of time required to complete them. According to the method of presentation in the process of training would-be mathematics teachers, it is advisable to use cases in printed (handwritten) form, multimedia presentation of cases, and video cases. According to the level of complexity, it is appropriate to use reproductive training, partial research, and creative-innovative ones. Thematic and integrated cases should be used for the breadth of coverage of the problem. For each type of case, examples are provided that can be used while teaching methodological disciplines of would-be Mathematics teachers, and general requirements for case selection are offered. These requirements are based on taking into account the principles of accessibility, scientificity, contextuality, systematicity, methodological expediency, and practical orientation.

An important direction for future research is to study the effectiveness of the given case classification while methodical training would-be Mathematics teachers.

ORCID iDs

V V Achkan https://orcid.org/0000-0001-8669-6202
K V Vlasenko https://orcid.org/0000-0002-8920-5680
I V Lovianova https://orcid.org/0000-0003-3186-2837
R Yu Kaluhin https://orcid.org/0000-0001-8339-4428
T S Armash https://orcid.org/0000-0002-9212-6027

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