

Investigation of teachers' understanding of differentiated approach in teaching mathematics

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Abstract

This article describes research on the use of a differentiated approach in assessing students' academic achievements during mathematics lessons. The study used theoretical and empirical research methods. In particular, normative documents and scholarly literature were reviewed, and in 2021, the study conducted a survey of online mathematics teachers from Kazakhstan on a differentiated approach to teaching. The study then analyzed the collected data using Spearman's Rank Correlation Test and T-test. Firstly, the research shows that teachers mostly understand differentiation in the lesson as an adaptation of educational material to the needs of students and the use of tasks of different levels of difficulty. Secondly, there is a correlation between the understanding of a differentiated approach and the needs of teachers. This research results expect that it would give an idea of the readiness of mathematics teachers to apply a differentiated approach in assessment and develop recommendations for its application further.

Keywords: differentiated approach, teaching mathematics, assessment, educational survey, correlation.

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1. Introduction

A large-scale reform in the education system, which is updating the content of secondary education, has begun in the Republic of Kazakhstan in September 2016. The introduction of updated curricula aimed at preparing students for future life and developing their competencies. New approaches to the student assessment system have been developed allowing identifying students' needs based on assessment criteria (Muho & Leka, 2022). During assessing students' academic achievements, the emphasis shifts from assessing the ability to remember and reproduce material to assessing the level of understanding of mathematical information and the ability to apply it in practice. Assessment results will allow teachers to provide feedback while providing an individual approach to each student, as well as to develop student competencies and differentiation in the lesson.

Teachers need to pay attention not only to the content of the curriculum, but also to the used assessment strategies that will help develop students' thinking and problem-solving skills which are relevant in modern society (Ukobizaba, Nizeyimana, & Mukuka, 2021). When assessment becomes an integral part of the learning process, students will learn to focus on achieving key learning goals, set their own goals, and determine the timing of their learning. Since students have different abilities and personalities, teachers need to differentiate classroom activities. The use of a differentiated approach in the assessment will allow teachers to define each student's learning path (Tomlinson & Moon, 2013).

1.1. Literature Review

There are enough research papers based on the assessment of the students' academic achievement and the use of a differentiated approach in teaching, including the process of teaching mathematics. However, there is a lack of research on the use of a differentiated approach in assessing students' academic achievement, especially in the context of Kazakhstan. Kazakhstani educators Zhumykbayeva, Bibekov, Ilyassova, Igitmanov, Togys, & Kassenova (2021) studied the attitudes of course participants towards evaluation during the training.

Psychological and pedagogical analysis of assessment systems for developing education and the traditional system conducted by Gordeeva, Sychev, and Sidneva (2021) shows that the first assessment based on differentiated and objective criteria supports the values of search, initiative, reasoning, contributes to the development of competence, autonomy and internal motivation of educational activity. Moreover, mark-free assessment contributes to the motivation of students for self-development, academic independence, and initiative actively developed by Vorontsov and Tsuckerman (2018).

Assessment should be reflected in the activities and teaching methods that the teacher uses in the lesson (Burkhardt & Swan, 2012). The most effective way to measure, understand, and evaluate teachers' assessment methods is to evaluate their perceptions of classroom assessment methods. The use of informal formative assessment as a form of conversation in the classroom to provide teachers with recommendations on the use of informal assessment was studied by Park, Flores, and Nguyen (2020). The authors remark that teachers' attention must be paid to the development of their practice in the application of formative assessment methods. The importance of teachers' reflection is in identifying difficulties and working on them, thereby increasing the teacher's professional competence (Biktagirova, Valeeva, Nagovitsyn, 2021).

A differentiated approach to teaching has also been a topical issue in modern education. Kazakhstani educators studied the use of computer resources for the study of geometry, the activation of independent and creative work of students in the classroom, and the development of practical geometric competencies of students (Ashirbayev, Torebek, Madiyarov, & Abdualiyeva, 2018). The development of students' scientific literacy through differentiated learning. The authors have shown that students develop an interest in natural science subjects and conduct various studies. This as well as their level of scientific literacy has increased in the process of differentiated teaching, considering

interests, the level of readiness of students, and the use of various types of assessment (Şentürk & Sari 2018).

The organization of the learning process in mathematics lessons and the use of various methods and tools of formative assessment that provide constant interactive communication between the student and the teacher was examined. To differentiate the learning process and support students through formative assessment, the cognitive capabilities of the student are determined, and difficult topics are identified (Nurgabyly & Shaken, 2020).

The application of open-ended questions through lessons was studied through observation not only to develop students' communication skills but also to develop their mathematical thinking. The author's research results have shown that by asking open-ended questions in the classroom, the teacher contributes to the development of high-order skills of students. At the same time, the author notes that it was important to provide students with the opportunity to give more than one answer and ask clarifying questions or provide feedback if the student found it difficult to answer (Aziza, 2021).

The issues of supporting students' learning through assessments, the acceptability of the differentiation of assessment in the classroom and during homework and providing students with the opportunity to choose tasks independently or only by the teacher were considered (Tomlinson & Moon, 2013). Thus, the literature review reveals the link between the differentiated approach in the educational process and assessment: learners' motivation, activation of cognitive activity and development of their abilities, considering the individual characteristics of learners, and support for learners in need. Besides, the results of student assessment based on criteria contribute to the implementation of a differentiated approach in the educational process and differentiation will ensure that all students achieve learning objectives. Therefore, a teacher should be competent not only in determining the current level of knowledge of students, but also be ready to assess and develop skills of a higher order.

1.2. Purpose of study

To ensure the high-quality implementation of the updated educational content and the system for assessing the students' academic achievements, an important aspect is the teachers' understanding of the need for the introduced changes. Therefore, it is necessary to identify the teachers' needs, to provide them with the necessary methodological support. This study's goal was an investigation of math teachers' understanding of the differentiated approach and its use in assessing the academic achievements of students. First, a survey was applied to determine teachers' knowledge and perception of differentiation methods, as well as their need for help. Then, associations between various answers to both questions were identified.

2. Methods

2.1. Data collection

Literature review, research papers, and the conceptual frameworks of assessment systems show the importance of the analysis of the assessment of students' academic achievement to arrange the educational process in a way that will meet the students' needs and at the same time develop their abilities. As a student assessment system is important, assessment results will assist teachers in identifying the level of assimilation of the material by a student and choosing the correct learning path for him. To determine the possibility of applying a differentiated approach in the conditions of the modern educational process and the current system for assessing the students' academic achievement, the authors studied the content of curricula in mathematics and the current system of criteria-based student assessment. The literature review will provide a theoretical basis for the development of guidelines for mathematics teachers. The study collected data through a survey. The respondents answered 9 multiple-choice questions related to the use of a differentiated approach in the learning process.

2.2. Participants

At the initial stage of the study, the online survey of 198 mathematics teachers was conducted through the Microsoft Forms platform in the Kazakh and Russian languages by sharing a link with respondents. The respondents are mathematics teachers of secondary and Intellectual schools from the regions of the Republic of Kazakhstan, who have higher education. The average work experience of 198 respondents is 17.9 years, more than half of teachers (108) have below-average work experience. The minimum work experience is 1 month; the maximum experience is 47 years.

2.3. Analysis

Data grouped by years of teachers' experience. The statistical program SPSS was used to process the estimation results. After the analysis of the data for a normal distribution, nonparametric tests were used to process the results. The calculation of associations between the independent variables was carried out by using Spearman's Rank Correlation Test, estimating Spearman's rank correlation coefficient by using the difference between the two ranks of each answer type and the number of answers. As the number of answers ($n > 10$) is moderately large, the T statistic is calculated to determine the probability that the relationship between the two variables exists and is not random.

3. Results

The teacher plays a significant role in innovation implementation in education. To develop teachers' understanding of the updated educational content the country's teachers are trained in further training courses. These courses are oriented on the use of criteria-based assessment, the development of assessment tools, the use of active teaching methods, and differentiation in the classroom. However, the use of a differentiated approach during the lesson leads to the emerging question. A survey was conducted to determine the understanding and to identify the difficulties. Key questions number 7 "What do you mean by differentiation in the lesson?" and number 9 "What kind of support would be most effective for you?" were analyzed in the context of work experience.

To the question 7 "What do you mean by differentiation in the lesson?" respondents had to choose no more than 3 of the proposed options:

- A) formation of classes with in-depth study of the subject (6.7%);
- B) the formation of classes by gender (0.3%);
- C) curriculum adaptation (3.4%);
- D) conducting extracurricular activities / consultations (1.6%);
- E) use of student diagnostic results (9.3%);
- F) adapting the teaching material to a learner's need (19.2%);
- G) organization of individual work in the lesson (11.2%);
- H) organization of pair, and group work in the lesson (9.6%);
- I) providing individual homework (7.7%);
- J) using tasks of different levels of difficulty (24.9%);
- K) use of criteria/descriptors in assessment (6.1%).

The most popular answers were options F (19.2%) and J (24.9%), while options B (0.3%) and D (1.6%) were chosen by the smallest number of teachers.

Table 1

Spearman's Rank Correlation analysis of answers to question 7 by work experience

Ro Spearman, N=48	7A	7B	7C	7D	7E	7F	7G	7H	7I	7J	7K	
7A	Cor. coefficient	1	0,195	,315*	,367*	,461**	,568**	0,252	,388**	0,276	,564**	,360*
	Sig. (2-tailed)	.	0,184	0,029	0,01	0,001	0	0,084	0,006	0,058	0	0,012
7B	Cor. coefficient	0,195	1	0,254	-0,1	0,082	0,245	,329*	-0,16	,313*	0,24	0,097
	Sig. (2-tailed)	0,184	.	0,081	0,499	0,579	0,094	0,022	0,281	0,031	0,101	0,51
7C	Cor. coefficient	,315*	0,254	1	0,277	,329*	,415**	0,273	,337*	,286*	,344*	0,136
	Sig. (2-tailed)	0,029	0,081	.	0,057	0,022	0,003	0,061	0,019	0,049	0,017	0,358
7D	Cor. coefficient	,367*	-0,1	0,277	1	0,131	0,214	,350*	,506**	0,244	,388**	0,208
	Sig. (2-tailed)	0,01	0,499	0,057	.	0,375	0,144	0,015	0	0,094	0,007	0,156
7E	Cor. coefficient	,461**	0,082	,329*	0,131	1	,571**	0,151	,383**	,293*	,675**	,339*
	Sig. (2-tailed)	0,001	0,579	0,022	0,375	.	0	0,307	0,007	0,043	0	0,018
7F	Cor. coefficient	,568**	0,245	,415**	0,214	,571**	1	,433**	,442**	,525**	,808**	,503**
	Sig. (2-tailed)	0	0,094	0,003	0,144	0	.	0,002	0,002	0	0	0
7G	Cor. coefficient	0,252	,329*	0,273	,350*	0,151	,433**	1	,393**	,544**	,523**	,395**
	Sig. (2-tailed)	0,084	0,022	0,061	0,015	0,307	0,002	.	0,006	0	0	0,005
7H	Cor. coefficient	,388**	-0,16	,337*	,506**	,383**	,442**	,393**	1	,346*	,466**	,296*
	Sig. (2-tailed)	0,006	0,281	0,019	0	0,007	0,002	0,006	.	0,016	0,001	0,041
7I	Cor. coefficient	0,276	,313*	,286*	0,244	,293*	,525**	,544**	,346*	1	,615**	,610**
	Sig. (2-tailed)	0,058	0,031	0,049	0,094	0,043	0	0	0,016	.	0	0
7J	Cor. coefficient	,564**	0,24	,344*	,388**	,675**	,808**	,523**	,466**	,615**	1	,502**
	Sig. (2-tailed)	0	0,101	0,017	0,007	0	0	0	0,001	0	.	0
7K	Cor. coefficient	,360*	0,097	0,136	0,208	,339*	,503**	,395**	,296*	,610**	,502**	1
	Sig. (2-tailed)	0,012	0,51	0,358	0,156	0,018	0	0,005	0,041	0	0	.

Spearman's Rank Correlation shows a strong positive correlation (0.8) between responses F and J. Therefore, by differentiation teachers think of "adapting the teaching material to learner needs" who responded F also think as "using tasks of different levels of difficulty" who chose answer J. There is a strong positive correlation (0.7) between answers J "using tasks of different levels of difficulty" and E "use of student diagnostic results." In addition, there is a moderate positive correlation (0.6) between answers A and F, A and J, E and F, I and J, I and K. A significance test was used to determine if there was a linear correlation in the collected data. Therefore, the null hypothesis is tested below.

Null hypothesis: there is no monotonic correlation in the population

Alternative hypothesis: monotonic correlation is present

T-statistics test was performed to determine the relationship between the following pairs of values F&A, F&E, J&A, J&E, J&F, J&I, and K&I to question 7, which were estimated in the context of work experience. At p (0,0), the table shows very strong evidence that the F&A, F&E, J&A, J&E, J&F, J&I, and K&I values have a monotonic correlation. Answers to question 7 at n = 48, p <0.001 are strongly positively monotonically correlated between the values of F and A (= 0.6), F and E (= 0.6), J and A (= 0.6), J and E (= 0.7), J and F (= 0.8), J and I (= 0.6), K and I (= 0.6), thus, the more teachers chose the first option (for example F), the more teachers chose the second option, respectively (for example A).

To the question 9 "What kind of support would be most effective for you?" respondents had to choose no more than two answer options from the proposed ones:

A) development of an individual educational route for a learner (11.9%);

- B) the choice of methods and techniques, considering the cognitive needs, and learners' abilities (26.4%);
- C) selection and development of resources and tasks (18.8%);
- D) monitoring progress and providing feedback to learners (19%);
- E) developing formative assessment tools to support learners (16.4%);
- F) developing summative assessment tools to support learners (7.6%).

The most popular answers were B (26.4%), C (18.8%), and D (19%). To determine the relationship between the questions "What do you mean by differentiation during the lesson?" and "What kind of support would be the most effective for you?" the correlation analysis of the results was carried out. Spearman's correlation coefficient test was calculated for answers between questions 7 and 9 in terms of experience. There is a strong positive correlation between the answer "using tasks of different levels of difficulty" to question 7 and the answers to question 9 "the choice of methods and techniques, considering the cognitive needs, learners' abilities" (0.80); "developing formative assessment tools to support learners" (0.75); "selection and development of resources and tasks" (0.72); "monitoring progress and providing feedback to students" (0.64). Therefore, there is a link between answers J to question 7 and answers B, C, D, and E to question 9.

There is also a strong positive correlation between the answer to the 7th question "adaptation of educational material to the learners' needs" and the answers "the choice of methods and techniques, considering the cognitive needs, learners' abilities" (0.77); "selection and development of resources and tasks" (0.72); "monitoring progress and providing feedback to students" (0.75) in question 9. Therefore, there is a correlation between F to question 7 and answers B, C, and D to question 9. A significance test is performed to determine if there is a linear relationship and to determine how likely it is that a correlation exists and, if so, how strong it is in the collected data.

Significance test results showed that at $p < 0.01$ there is very strong evidence that the revealed dependence has a monotonic correlation. With α equal to 0.05, the probability that the detected relationship is a random event is approximately 5 out of 100 cases. We are looking for a t-value that falls in the extreme 5% of the normal distribution, that is, one of the two extreme ends ("tails").

To check if the same group has different mean scores for different variables, T Statistic was calculated (Table 2).

Null hypothesis: there is no relationship between the answers to questions 7 and 9;

Alternative: there is a connection between the answers to questions 7 and 9.

The calculated t-score indicates that there is a statistically significant probability that the relationship between the two variables exists and is not random.

Table 2

Significance test results for the performed correlation analysis between answers to questions 7 and 9 in the context of work experience

		N=48, DF=46	question №9					
		&	A)	B)	C)	D)	E)	F)
question №7	between F	coefficient	0.47	0.77	0.72	0.75	0.58	0.53
		T Statistic	3.61	8.06	7.1	7.8	4.78	4.24
		p value	0	0	0	0	0	0
	between G	coefficient	0.32	0.42	0.54	0.37	0.41	0.37
		T Statistic	2.29	3.17	4.37	2.69	3.09	2.73
		p value	0.03	0	0	0.01	0	0.01
	between I	coefficient	0.34	0.54	0.44	0.44	0.63	0.46
		T Statistic	2.42	4.34	3.33	3.35	5.57	3.53
		p-value	0.02	0	0	0	0	0
	between J	coefficient	0.58	0.8	0.72	0.64	0.75	0.5
		T Statistic	4.88	9.01	7.05	5.64	7.73	3.94

p value	0	0	0	0	0	0
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In calculating, the probability of making an error, the measured α is chosen to be 0.05. Thus, where the correlation coefficient of answers to questions 7 and 9 is calculated with a p-value less than α , it means that the probability of making a mistake is less than every 20th when calculating the correlation between answers to question 7 and answers to question 9 in the table. Therefore, the null hypothesis was reliably rejected for the absence of dependence. To conclude: for $n = 48$, p-value < 0.05 is at the level of statistical significance when calculating the correlation coefficient for the values of answers to question 7 and answers to question 9, which can be seen in Table №2. Therefore, the above values are indeed positively monotonically correlated. Thus, the more teachers chose the first answer option (for example, answer F to question 7), the more teachers chose the second option, respectively (for example, answer B to question 9).

4. Discussion

The analysis of the results of the questionnaire revealed the link between the teachers' understanding of a differentiated approach and their needs for methodological support. The following conclusions can be drawn based on the findings:

1. The most popular answers to the question "What do you mean by differentiation in the lesson?" were F) "adaptation of educational material to the needs of students" (19.2%) and J) "using tasks of different levels of difficulty" (24.9%). At the same time, there is a positive correlation between these answers in the context of work experience. The analysis showed that the adaptation of the educational material depends (F) on the use of multilevel tasks (J); with an increase in J, F increases in response to the question of understanding differentiation in the lesson, which confirms the hypothesis of the study.

2. The survey showed that teachers require support in choosing methods and techniques, considering the students' cognitive needs and abilities (26.4%), choosing and developing resources and assignments (18.8%), monitoring progress, and providing feedback to students (19%). At the same time, there is a correlation between the most popular answers to the question of understanding differentiation (F and J) and these options for supporting teachers.

The findings answer the research question and reveal a relationship between the teachers' understanding and their needs (Ahad et al., 2021). The results of the survey of teachers are predictable since for many years teachers have used tasks of different levels of difficulty as differentiation, giving stronger students difficult tasks, sometimes even of an Olympiad nature, and easier tasks for students who have difficulty in learning mathematics.

During professional development courses, attention is paid to considering the students' needs and adapting the educational material, which also affected the results of the survey. The interrelation of answers suggests that teachers understand the importance of selecting tasks based on students' educational needs (Sánchez-Matamoros, Fernández & Llinares, 2019). However, not all teachers understand the significance of assessment criteria and task descriptors. The learning objectives will be achieved by all students in case of being provided with tasks of equal difficulty and descriptors to the students, who require them.

Assessment of students' academic achievement and a differentiated approach to teaching are significant components of the educational process and they are correlated (Dunn & Kennedy, 2019). The assessment results will ensure teachers effectively implement a differentiated approach in the process of teaching mathematics. It is possible to apply a differentiated approach in assessment. This issue is relevant in the development of the education system and methods of teaching mathematics.

5. Conclusion

Teachers, who are applying tasks of different levels of difficulty, require support in considering the cognitive abilities of students, selecting resources, and developing tools for formative monitoring. Teachers who consider differentiation as material adaptation equally require support in terms of considering learners' cognitive abilities, resource selection, and monitoring.

The findings made it possible to determine the areas of support for teachers in the application of a differentiated approach to assessment. Further work will be aimed at developing guidelines for teachers. These recommendations should show the possibilities of applying assessment criteria and descriptors for differentiation in the assessment process and providing feedback to assist teachers in choosing relevant resources for the lesson, considering the students' cognitive abilities, and conducting monitoring of learning objectives achievement.

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