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TRANSFORMING SUMMATIVE ASSESSMENT TO REDUCE MATH ANXIETY AND BUILD STUDENT RESILIENCE

Abstract. In the current educational paradigm, summative assessment is often perceived as a "pedagogical verdict" that reinforces math anxiety and blocks students' cognitive progress. This article proposes a rethinking of the role of summative assessment, demonstrating how traditional summative assessments can become powerful tools for building mathematical resilience and metacognition.

Based on the results of a year-long pedagogical experiment involving 72 students aged 10-12, the authors demonstrate that delaying grade assignment in favor of qualitative feedback allows students to exit the "red zone" of panic and remain in the "growth zone" even during summative testing. The use of proprietary tools (the feedback table and the corrective sheet) facilitated a qualitative leap in self-regulation development: 80% of respondents learned to systematically analyze their own errors.

The article reveals the deep psychological mechanism of an assessment's impact on motivation: it was established that immediate knowledge of a grade becomes a "terminal point" for 40% of students, whereas qualitative comments without a numerical equivalent stimulate internal responsibility and cognitive endurance. It is empirically confirmed that 60% of students became emotionally more

stable, and 71% formed a "growth mindset," prioritizing understanding the material over formal grade improvement. This work is critical for educators and researchers seeking to humanize the assessment system.

Keywords: mathematics anxiety; formative assessment; summative assessment; feedback; growth mindset; mathematical resilience; metacognition; self-analysis.

Problem Statement. In contemporary pedagogical science, there is an acute contradiction between the necessity of implementing formative assessment as a supportive instructional tool and the dominance of summative modes of control, which traditionally serve as the primary basis for semester grading. Formative assessment (assessment for learning) is recognized as a powerful strategy for enhancing student outcomes; however, its potential remains under-realized in educational contexts dominated by high-pressure testing.

In many educational systems, including in Ukraine, summative assessment has long been perceived as a definitive endpoint that carries little to no instructional value. Nevertheless, evidence from leading global systems suggests that summative tests can acquire a formative character when utilized through specific "test follow-up" strategies (Xiao, 2017). This approach facilitates the systematic identification of learning gaps, the delivery of constructive feedback focused on task processing, and the cultivation of students' capacity for metacognition and reflection on their own errors.

Consequently, the development of theoretical frameworks and practical guidelines for imbuing summative assessment with formative functions is vital for bridging the artificial dichotomy between assessment and instruction. This transformation is essential for mitigating mathematics anxiety, building mathematical resilience, and fostering conscious educational growth.

Analysis of Recent Research and Publications. The issue of the relationship between formative and summative assessment remains one of the most widely debated topics in contemporary pedagogical science. Traditionally, these two modes of assessment have been viewed as dichotomous: summative assessment as "assessment of learning" (measuring learning), and formative assessment as "assessment for learning" (feedback that improves learning). However, contemporary researchers increasingly emphasize the necessity of building a synergy between them, whereby summative instruments (written assignments, tests, examinations) acquire a formative function.

In research Xiao (2017) points out that the "formative use of summative tests" is a strategy that enables the identification of students' learning difficulties, supports them in learning from their own errors, and develops their capacity for further autonomous learning. A key mechanism for such transformation is the "test follow-up" strategy. This strategy encompasses three primary components: systematic analysis of errors by the teacher, the provision of individualized qualitative feedback, and the stimulation of active student actions aimed at autonomous correction of identified gaps.

The quality and form of feedback constitute a crucial aspect of this process. Hattie and Timperley (2007) emphasize that the most effective feedback is oriented toward task processing and self-regulation. Such an approach informs students about the mechanisms of successful task completion, enabling them to transfer this experience to new assignments (Hattie & Timperley, 2007). It is essential that test results do not merely state the level of achievement but serve as a foundation for recommending specific corrective instructional actions, which effectively facilitates the construction of an individual learning trajectory (Carless, 2011; Kennedy et al., 2008; Onopriienko, 2020).

Research by Carless (2011) demonstrates that the use of summative test as formative tools becomes more productive when students are actively engaged in metacognition – the analysis of their own thinking processes and the strategies that led to an error. This resonates with the ideas of Harlen and James (1997), who argue that summative conclusions should not be a simple arithmetic aggregation of scores but should be based on "summing up the evidence" gathered during the learning process. Such an approach allows for student achievement to be reviewed against external criteria while simultaneously maintaining a focus on individual progress (Keith et al., 2011).

Onopriienko emphasizes that the synergy between formative and summative assessment enables the effective monitoring of student's personal development and the progression of their learning experience. This framework establishes conditions under which the student begins to perceive themselves as an active subject of learning, assuming personal responsibility for the quality of their own labor (Onopriienko, 2016).

Researchers dedicate significant attention to the impact of assessment on students' emotional states, specifically the phenomenon of mathematics anxiety. Mackrell and Johnston-Wilder (2020) define mathematical resilience as the capacity to maintain self-efficacy in the face of personal or social threats to mathematical well-being. They argue that traditional high-stakes summative testing frequently serves as a source of stress and "psychological trauma," reinforcing the belief among students that mathematical ability is a fixed trait. Simultaneously, the application of the Growth Zone Model within the assessment process empowers students to differentiate between a state of challenge and a state of threat. The latter can be managed by learning the relaxation response (Benson, 2000). When summative assessment is structured as a formative process emphasizing support and self-improvement, it facilitates a transition from "controlled regulation" (learning driven by fear of punishment or low grades) to "integrated regulation," where the student recognizes the intrinsic value of mathematics for their individual growth.

Evidence suggests that mitigating mathematics anxiety is a prerequisite for increasing student competence; attempts to enhance performance without addressing emotional barriers only serve to intensify anxiety (Johnston-Wilder & Lee, 2019). Consequently, transforming summative assessment into a supportive tool that grants the right to error and provides clear pathways for correction directly fosters the strengthening of self-efficacy according to Bandura (1997) and the cultivation of a "growth mindset" as defined by Dweck (2000).

Despite a substantial theoretical foundation, the practical implementation of such models in school settings remains under-researched, which underscores the relevance of our study.

Research Aim. To substantiate and experimentally verify the effectiveness of a methodology for the formative use of summative assessments, aimed at mitigating mathematics anxiety, developing meta-analysis skills, and enhancing the learning motivation of secondary school students.

Research Methods. To achieve the research aim, a comprehensive set of methods was employed, including a pedagogical experiment, systematic observation, analysis of students' products of activity (specifically summative tests and corrective assignments), and the method of statistical analysis of learning outcomes. The research context and sample involved experimental work conducted at a general secondary education school throughout the academic year. Four classes (representing two parallel year groups) participated in the study.

Control Group (CG): 16 students of 6-B and 21 students of 7-B.

Experimental Group (EG): 18 students of 6-A and 17 students of 7-A.

The total number of active participants comprised 72 students. The classes were comparable in terms of academic achievement levels, as the difference in the mean score on diagnostic assignments did not exceed 1 point. Furthermore, all groups were identical regarding material and technical support and the absence of students with special educational needs.

The research was conducted in strict adherence to high ethical standards for pedagogical experimentation. At the preparatory stage, official authorization was secured from the administration of the Lyceum "Prestige" to conduct the experimental work throughout the academic year. Given that the study involved 72 students from the 6th and 7th grades, aged 11–12, it was mandatory to obtain written informed parental consent for their children's participation in educational monitoring and anonymous surveying. The data collection process was fundamentally based on the principles of voluntariness, anonymity and avoidance of harm.

Research Instrumentation

1. Summative work (provided in two equivalent versions).
2. Feedback table (developed and completed by the teacher and distributed to the students).

The first two columns specified the type and format of the task, while the subsequent columns indicated whether the student managed to complete the assignment and identified the specific nature of any errors made. The teacher's role included both placing checkmarks corresponding to task criteria and providing concise qualitative remarks to guide the student's reflection.

An example of such a table is presented below.

Task No. & Description	Format	Completed Correctly	Minor Errors Made	Errors Made	Not Attempted
No. 1. Writing a polynomial in standard form	Test				
No. 2. Evaluating an algebraic expression for a given variable value					
No. 3. Finding the sum of polynomials					
No. 4. Matching identically equal expressions	Matching				
No. 5. Proving an identity					
No. 6. Simplifying an algebraic expression					

2. Corrective work (the third variant, analogous in structure and task types to the summative work, with the task order specifically preserved).

3. Corrective sheet (a specially designed table consisting of two columns: 1) re-solving the task where an error was made during the initial summative work; 2) a detailed explanation of the nature and causes of the student's own mistake).

Procedural Algorithm of the Experiment. The study was implemented according to a step-by-step algorithm shared by both groups. The only difference between the control and experimental groups was the mode of result representation.

Stage 1 (Initial Summative Control). Students performed the summative work for 45 minutes. The teacher checked the work and completed the feedback table; if deemed necessary, detailed comments regarding the correctness or logic of task execution were provided as the separate note in the margins.

Stage 2 (Differentiated Assessment and Feedback). In the control group, students received their checked papers with comments and the feedback table. A specific score (assigned grade) was clearly indicated in the paper for each task and as a total.

In the experimental group, students received their checked papers with comments and the feedback table, but no grade or score was assigned. For this group, the score for this stage was recorded by the teacher only in a private monitoring table for subsequent analysis. Students remained unaware of the specific grade they received but could identify which tasks were performed successfully and which required correction.

Stage 3. (Corrective work) conducted during the lesson following the summative work, typically within a 1-2 day interval. During a dedicated lesson, students from both groups engaged in corrective activity. They were required to re-solve only those specific task types from the corrective sheet in which they had previously committed errors. A mandatory requirement was the completion of the second column of the grid (error self-analysis). Brief or formalistic responses, such as "forgot" or "inattentive," were strictly prohibited. Instead, students were expected to provide substantive explanations, for example, "incorrectly applied the substitution method". Upon the successful completion of the task and a clear explanation of the error's cause, students were awarded half of the potential points originally assigned to that task.

Stage 4. (Final Assessment). The teacher evaluated the corrective sheet and assigned a final grade that integrated the outcomes of both assessment stages. In both groups, the overall grade accounted for the performance on both the initial summative work and the subsequent corrective work. However, a key experimental variable was initial grade awareness: students in the control group were immediately informed of their summative work grade, whereas students in the experimental group remained unaware of their preliminary score until the conclusion of the corrective process.

Data Collection and Analysis Methods. To evaluate the effectiveness of this approach, an analysis of the 'progress delta' (the difference between the initial and final grade) - was employed - specifically, the difference between the initial summative work grade (which was withheld from the experimental group) and the final integrated grade. The students' psychological state and levels of learning anxiety were assessed through systematic observation of their reactions upon receiving their checked work and via student questionnaires administered at both the beginning and the end of the academic year. The assessment of student engagement in error self-analysis was conducted by the teacher (Nataliia Minina) and was based on the quality and depth of the entries in the second column of the corrective feedback grid.

Results and Discussion. An analysis of the results of the pedagogical experiment, conducted with 6th and 7th-grade students (aged 11-12), revealed several patterns regarding the impact of the "feedback without grades" methodology on both students' academic activity and their psychological well-being, which we will describe in detail below.

Acquired Skills. The use of the Feedback table, Corrective work, and Corrective sheet was a common feature for all groups of students.

An analysis of the students' exit survey reveals that, in students' view, the following skills were developed through this approach to summative assessment:

- learned to analyze their written assignments (80% of students);
- learned to self-organize (35% of students);
- learned to explain their actions (48% of students);
- learned not to give up (41% of students);
- learned not to worry unnecessarily (37% of students);
- other (1% of students).

The finding that 80% of students learned to analyze their own work resonates with the study by Szeibert et al. (2022) on test-enhanced learning, which emphasizes that self-efficacy is more significant than the raw result of a test

Dynamics of Academic Achievement. An analysis of the 'progress delta' revealed no fundamental difference in the actual grade increase between the Experimental Group (EG) and the Control Group (CG). Overall, the delta for students in the CG averaged 0.7 points, and for the EG 1.1 points. As we can see, overall, the students in the experimental group were able to improve their grades slightly more. However, the difference is not significant.

The absence of a significant difference in the 'progress delta' between the EG and the CG aligns with the findings of Grosas et al. (2016), who noted that active engagement in the formative process does not always immediately translate into higher scores on summative tests.

Impact on Motivation and Engagement. The most striking result of the study was the distinct differentiation in motivational orientations between the CG and the EG. In the EG, where students received exclusively qualitative comments without an initial grade, a mindset focused on maximal revision predominated: "I do not know my grade yet, but I will do my best to ensure it is higher than it might have been". Consequently, situations involving the refusal of corrective work were virtually non-existent in this group. In contrast, within the CG, awareness of the initial score often acted as a destabilizing factor: 40% students satisfied with a mid-range result frequently declined to engage in correction ("This grade satisfies me"), which effectively halted their academic progress.

These findings corroborate the research of Xiao (2017), which indicates that students perceive feedback as beneficial only when they are actively engaged in thinking and reflection rather than

merely receiving ready-made answers or scores. This also correlates with the conclusions of Ismail et al. (2022), suggesting that the absence of a grade at the formative stage mitigates anxiety and detaches the thinking process from the perceived necessity to simply "get everything right" or guess the correct result.

At the end of the study, only 14% of students in the EG remained proponents of traditional grades as the sole incentive. The remainder favored alternatives: exclusively qualitative feedback or comments accompanied by grades. In contrast, students in the CG maintained a strong dependency on numerical scores; 86% of these students were convinced that grades should always be assigned, claiming that they 'motivate'.

Across all groups, 100% of students supported the inclusion of corrective assignments, confirming a broad student demand for a more humane assessment system. However, the motivation for engaging in correction differed significantly: for students in the experimental groups, it was more frequently associated with a desire 'to resolve misunderstandings' (60%), whereas for students in the control groups, the dominant motive was simply 'to raise the grade' (56%).

Psychological Aspect: Anxiety and Resilience. Students in both groups had the opportunity to improve their grades through corrective work; consequently, they began to perceive a mistake not as a final result, but as a necessary stage requiring analysis. However, in the EG, where students received only qualitative comments without scores in the first stage, the attitude towards errors took on a more constructive character. In the EG, 71% of students developed the mindset that one learns from mistakes, while in the control group, this figure was only 59%. Furthermore, only 23% of students in the EG believe that they constantly make mistakes that are always reflected in their grades, compared to 30% of students in the CG who hold this conviction.

An analysis of the entry and exit surveys for both the experimental and control groups leads to the conclusion that 60% of all surveyed students indicated they had become calmer and less nervous because they had the opportunity to correct errors. In the interviews, the children from the experimental group talked more about not being so afraid of the final tests and this should be followed up with further research.

This result aligns with the theory of mathematical resilience. The established "right to make mistakes" and the teacher's support through comments help students move out of the "red zone" of panic and remain within the "growth zone" according to the Growth Zone Model (Johnston-Wilder et al., 2020).

The uniqueness of our study lies in the practical application of the Growth Zone Model during summative assessment. While most researchers focus on using this model during ongoing instruction, we have demonstrated that creating a 'safety net' through the right to correction allows more students to remain in the 'growth zone' even during summative testing.

Despite the positive effects, the experiment revealed a significant increase in teacher workload. The necessity of developing three versions of assignments (two variants for the summative work, to prevent cheating among students in the class, and one for the corrective work) and the preparation of personalized corrective sheets required substantial time investment. This corroborates the concerns of many researchers (Glazova & Pakhomova, 2024; Guthrie et al., 2022; Vasylieva & Bukalov, 2024) that a lack of time within the school schedule and large class sizes are primary obstacles to the widespread implementation of summative assessment with a formative function. These challenges may be somewhat mitigated through the use of ready-made control and corrective papers or by using digital technologies for creating summative and corrective works, as well as for the subsequent automated grading of student performance.

Limitations of the Study. Despite the positive results obtained, this study has a number of limitations that should be considered when interpreting and extrapolating its findings. First and foremost, the sample size consisted of 72 students from two parallel age groups (11-12 years) within a single general secondary education school, which limits the possibility of broadly generalizing the results to students at all levels of basic and senior high school. An important factor is also that

all groups were similar in composition and did not include inclusive learners (students with special educational needs); therefore, the effectiveness of the "feedback without grades" methodology in an inclusive educational environment requires separate study.

The study had a narrow subject specificity, focusing exclusively on mathematics, where the phenomenon of "mathematics anxiety" has a particular impact on cognitive activity; accordingly, the results of implementing such strategies in humanities or natural sciences may differ. Methodologically, the analysis of anxiety and stress levels was based primarily on systematic observation and student surveys, which have a certain degree of subjectivity compared to standardized psychometric scales. Finally, although the work lasted throughout the academic year, tracking the long-term impact of such a model on student success during high-stakes exams in senior high school remains beyond the scope of this study.

Conclusions and Prospects for Futher Research. The results of the pedagogical research confirmed the hypothesis that integrating formative strategies into summative mathematics assessment, particularly through the "feedback without grades" methodology, significantly transforms students' learning activities and emotional states. The proposed approach, based on creating a "safety net" through a guaranteed right to correction, allowed for overcoming emotional barriers and developing mathematical resilience: the realization that the initial grade is not final enabled students to exit the "red zone" of panic and remain in the "growth zone," resulting in 60% of all surveyed students becoming calmer.

Delaying the assignment of a grade shifted the focus from "punishment" to a "resource for growth," fostering a "growth mindset": 71% of students in the experimental group (EG) developed the belief that one learns from mistakes, while in the control group (CG), this figure was only 59%. Replacing a grade with meaningful comments prompted students to read teacher explanations to understand the essence of their gaps, while personalized recommendations helped them grasp the causes of errors and the algorithms for their correction.

The study revealed changes in motivational settings and agency: knowing the initial grade in the CG served as a "terminal point" for 40% of students who ceased effort after achieving a satisfactory result, whereas in the EG, the absence of an immediate grade transformed the summative task into a continuous learning process, stimulating internal responsibility instead of external compliance. The use of tools such as the feedback table and corrective sheets facilitated the development of self-regulation skills, allowing 80% of students to qualitatively analyze their written work and transition from a fear of grades to an internal need to understand the material.

Summative tests, traditionally perceived solely as control tools, can become a powerful means of developing metacognition and reflection when used formatively through "test follow-up" strategies, where students analyze difficulties, plan improvements, and assume responsibility for their own progress. Although the implementation of such an integrated model creates an additional workload for the teacher, opportunities exist for its optimization through the use of digital technologies. Conducting similar experiments in senior high school (grades 10–11) opens new scientific horizons, as mathematics anxiety often becomes chronic at this stage and the pressure of exams reaches its peak, making the further study of automated assessment and personalized corrective assignments highly promising.

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ТРАНСФОРМАЦІЯ ПІДСУМКОВОГО ОЦІНЮВАННЯ ДЛЯ ЗМЕНШЕННЯ ТРИВОГИ З МАТЕМАТИКИ ТА ФОРМУВАННЯ СТІЙКОСТІ УЧНІВ

Анотація. У сучасній освітній парадигмі підсумкове оцінювання часто сприймається як «педагогічний вердикт», що посилює математичну тривожність і блокує когнітивний прогрес учнів. У цій статті запропоновано переосмислення ролі підсумкового оцінювання, демонструючи, як традиційні підсумкові роботи можуть стати потужними інструментами формування математичної стійкості та метакогніції.

На основі результатів річного педагогічного експерименту за участю 72 учнів 10–12 років автори демонструють, що відтермінування виставлення оцінок на користь якісного зворотного зв'язку дає змогу учням вийти з «червоної зони» паніки і залишатися в «зоні зростання» навіть під час написання підсумкової роботи. Використання авторських інструментів (таблиця зворотного зв'язку та коригувальний лист) сприяло якісному стрибку в розвитку саморегуляції: 80 % респондентів навчилися систематично аналізувати власні помилки.

У статті розкрито глибинний психологічний механізм впливу оцінювання на мотивацію: встановлено, що повідомлення оцінки стає «кінцевою точкою» для 40% учнів, тоді як якісні коментарі без числового еквівалента стимулюють внутрішню реакцію. Емпірично підтверджено, що 60 % учнів стали емоційно стабільнішими, а 71 % сформували «розум, орієнтований на розвиток», надаючи пріоритет розумінню матеріалу над формальним підвищенням оцінок. Ця робота має вирішальне значення для освітян і дослідників, які прагнуть гуманізувати систему оцінювання.

Ключові слова: математична тривога; формувальне оцінювання; підсумкове оцінювання; зворотний зв'язок; мислення, орієнтоване на розвиток; математична стійкість; метакогніція, самоаналіз.