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Failure based learning methodologies and their impact on students' self efficacy and frustration tolerance

Metodologías de aprendizaje basado en el fracaso y su impacto en la autoeficacia y la tolerancia a la frustración de los estudiantes

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RESUMEN

Introducción: Las metodologías de aprendizaje basado en el fracaso permiten comprender los errores y los intentos fallidos como oportunidades para fortalecer el aprendizaje, la autoeficacia y la tolerancia a la frustración. El objetivo del estudio fue analizar el impacto de estas metodologías en estudiantes mediante literatura científica publicada entre 2020 y 2026.

Metodología: Se realizó una revisión sistemática cualitativa siguiendo el modelo PRISMA 2020. Se consultaron Scopus, Web of Science, ERIC, SciELO y Google Scholar. De 72 registros identificados, 16 estudios cumplieron los criterios de inclusión y fueron analizados mediante una matriz documental.

Resultados: El 37,5 % de los estudios se relacionó con aprendizaje basado en el fracaso y fracaso productivo; el 31,25 % abordó la autoeficacia y el 31,25 % la tolerancia a la frustración y al fracaso. Los hallazgos evidenciaron que los errores pueden convertirse en experiencias productivas cuando se acompañan de retroalimentación, reflexión, apoyo docente y oportunidades de mejora. **Conclusiones:** Las metodologías de aprendizaje basado en el fracaso pueden favorecer el aprendizaje, la autoeficacia y la tolerancia a la frustración cuando se desarrollan en ambientes estructurados, seguros y no punitivos.

Palabras clave: aprendizaje basado en el fracaso, fracaso productivo, autoeficacia, tolerancia a la frustración, aprendizaje a partir de errores.

ABSTRACT

Methodology: A qualitative systematic literature review was conducted using the PRISMA 2020 framework as a methodological guide. Scopus, Web of Science, ERIC, SciELO, and Google Scholar were consulted. Of the 72 records initially identified, 16 scientific studies published between 2020 and 2026 met the inclusion criteria and were analyzed through a documentary matrix.

Results: A total of 37.5% of the studies were mainly related to Failure-Based Learning and Productive Failure methodologies, while 31.25% addressed self-efficacy and another 31.25% focused on frustration and failure tolerance. The findings showed that errors can become productive learning experiences when accompanied by feedback, reflection, teacher support, and opportunities for improvement.

Conclusions: Failure-Based Learning methodologies can contribute to learning, self-efficacy, and frustration tolerance when implemented in structured, supportive, and non-punitive environments. The educational value of failure does not depend on the error itself, but on how it is supported, analyzed, and transformed into an opportunity for learning.

Keywords: failure-based learning, productive failure, self-efficacy, frustration tolerance, learning from errors.



1. INTRODUCTION

Failure, error, and frustration are inevitable components of the learning process. However, traditional educational practices have frequently treated mistakes as indicators of insufficient ability or poor academic performance rather than as opportunities for cognitive development. This interpretation may lead students to avoid challenging tasks, experience fear of failure, and develop negative beliefs about their own academic abilities. Contemporary educational research has progressively challenged this perspective by emphasizing the pedagogical value of mistakes and unsuccessful problem-solving attempts when they occur within supportive and appropriately structured learning environments. He (2020) argues that constructive classroom error climates can help students perceive mistakes as learning opportunities rather than threats to their self-esteem, thereby contributing to more adaptive learning processes.

Within this perspective, Failure-Based Learning (FBL) can be understood as an instructional approach in which errors, unsuccessful attempts, cognitive conflict, and subsequent reflection are intentionally incorporated into the learning process. One of the most extensively studied approaches related to this framework is Productive Failure, which typically requires students to attempt complex problems before receiving explicit instruction. Rather than immediately preventing mistakes, the methodology allows learners to explore incomplete or incorrect solutions and subsequently compare them with canonical concepts or procedures. Sinha and Kapur (2021), through a meta-analysis involving 53 studies and 166 comparisons, found a significant advantage for problem solving followed by instruction over instruction followed by problem solving, with stronger effects when Productive Failure principles were implemented with high fidelity.

Recent research has also shown that productive failure can promote conceptual understanding, transfer, and deeper cognitive processing in different educational contexts. Ziegler, Trninic, and Kapur (2021) found that micro-level productive failure could be applied to the acquisition of algebraic procedural knowledge, demonstrating that strategically structured unsuccessful attempts may contribute not only to conceptual learning but also to the development of procedural competence. Similarly, productive failure has been successfully explored in collaborative mathematical learning environments, where problem



solving before instruction can create intellectual need, curiosity, and opportunities for collaborative reasoning.

Nevertheless, failure does not automatically produce learning. Nachtigall, Serova, and Rummel (2020) emphasize that productive failure is highly dependent on instructional design, domain characteristics, and the way the initial problem-solving phase is connected to subsequent instruction. Their findings show that unsuccessful attempts may become unproductive when learners are not adequately prepared to recognize the relevance of their prior solutions or when instructional consolidation does not sufficiently build upon students' initial reasoning. Thus, Failure-Based Learning should not be interpreted as merely exposing students to difficult tasks or allowing them to fail, but rather as a carefully designed pedagogical process in which failure becomes meaningful through feedback, reflection, comparison, explanation, and subsequent instruction.

An important psychological variable within this process is self-efficacy, understood as learners' beliefs regarding their ability to successfully perform academic tasks. Failure may negatively affect self-efficacy when students interpret errors as evidence of limited ability. In contrast, environments that normalize errors and provide opportunities to overcome them may strengthen perceptions of competence. Recent evidence has shown a particularly relevant relationship between classroom error management and self-efficacy. Zhao and Jing (2026), in a study involving 777 primary school students, found that a positive classroom error management climate was positively associated with innovation self-efficacy and that this relationship was partially mediated by fear of failure and growth mindset.

This relationship is especially relevant because self-efficacy influences persistence, effort, willingness to engage in challenging activities, and reactions to academic difficulties. Clardy and Tawfik (2026), in the context of healthcare education, directly examined the relationship between perceived learning from failure and self-efficacy, highlighting the importance of failure-based experiences in preparing students to deal with complex and ill-structured professional situations. Their findings reinforce the idea that educational failure can become psychologically constructive when learners receive opportunities to reinterpret unsuccessful attempts as part of skill development rather than as definitive indicators of incompetence.

Research examining Productive Failure in virtual learning environments provides further evidence of the importance of self-efficacy. Cao and Zhang (2024) explored the



use of productive failure to teach difficult ecological concepts in a virtual world and explicitly examined how self-efficacy and learning strategies influenced the learning process. Their work suggests that the effectiveness of Productive Failure depends not only on instructional sequence but also on students' psychological resources and their capacity to regulate learning during demanding tasks.

The relationship between failure and self-efficacy is also connected with students' willingness to take academic risks. Academic risk taking involves voluntarily engaging in challenging learning activities despite the possibility of making mistakes or experiencing failure. Research published in *Contemporary Educational Psychology* indicates that academic risk-taking behaviors represent proactive responses to potential failure and are associated with students' motivational orientations and willingness to engage with difficult academic tasks. In Failure-Based Learning environments, such willingness becomes particularly important because students must tolerate uncertainty and persist even when an immediate correct solution is unavailable.

Closely associated with these processes is frustration tolerance, which refers to the capacity to manage emotional discomfort when goals are delayed, difficulties arise, or expected outcomes are not immediately achieved. From an educational perspective, low frustration tolerance may lead students to abandon tasks, avoid challenges, react negatively to mistakes, or experience excessive emotional distress. Tobar Viera and Mejía Rubio (2023), studying adolescents between 13 and 17 years of age, found significant relationships between frustration tolerance and emotional regulation, suggesting that students' capacity to deal with stressful situations is closely connected with the way they regulate emotional responses.

Frustration tolerance is particularly relevant in Failure-Based Learning because students are deliberately exposed to uncertainty, incomplete knowledge, temporary impasses, and unsuccessful attempts. However, these experiences do not necessarily result in harmful frustration. Savelson and Muldner (2024), examining students engaged in programming activities within a Productive Failure paradigm, found that uncertainty occurred more frequently than frustration and that constructive contributions during problem solving were positively associated with later performance. The findings suggest that carefully designed failure experiences can generate productive cognitive uncertainty without necessarily producing excessive negative affect.



At the same time, the ability to tolerate frustration may contribute to persistence and adaptation in academic environments. Park and Ju (2022), examining university students, identified relationships among failure tolerance, self-efficacy, and adjustment to college life. Their results indicated that failure tolerance contributed significantly to students' adaptation and, in some groups, self-efficacy was also an important predictor. These results support the hypothesis that self-efficacy and frustration tolerance should not be examined as completely independent outcomes, but rather as interconnected psychological resources that influence how learners interpret and respond to academic difficulty.

Recent Ecuadorian research has also contributed to the study of frustration tolerance. Aviles Fuentala et al. (2026) examined frustration tolerance among high-school students and emphasized its relevance to adolescent psychological and educational functioning. Similarly, Delgado Tuarez and Pilco Guadalupe (2024) investigated frustration tolerance in adolescents within the context of family functioning, reinforcing the importance of social and emotional environments in adolescents' ability to deal with frustrating experiences. These studies are particularly relevant for Latin American educational contexts, where research linking emotional regulation and innovative instructional methodologies remains comparatively limited.

Another essential element of Failure-Based Learning is the development of a positive error climate. Error climate refers to students' shared perceptions regarding whether mistakes are accepted, discussed constructively, corrected through reflection, and treated as legitimate parts of learning. Soncini, Matteucci, and Butera (2021) experimentally examined teachers' error-handling strategies and demonstrated that classroom practices can influence students' achievement emotions and beliefs about errors. Steuer et al. (2022) likewise showed that error climates can be observed across different school subjects and that supportive classroom environments may create more opportunities for students to use mistakes productively.

Longitudinal evidence further supports the importance of such environments. Dresel, Daumiller, Spear, and Janke (2025) examined the development of students' reactions to errors over two years and found that perceived error climate was associated with the way students adapt affectively, motivationally, and behaviorally after making mistakes. This finding is particularly important because Failure-Based Learning requires more than occasional exposure to errors; it requires a sustained classroom culture in which



students feel psychologically safe enough to explore, revise, and learn from unsuccessful strategies.

Feedback also plays a fundamental role in converting failure into learning. Simply identifying an incorrect answer may be insufficient if students do not understand why their reasoning failed. Research on self-explaining feedback has shown that encouraging students to explain their own problem-solving errors can improve error correction and transfer. A 2024 study published in *Contemporary Educational Psychology* demonstrated that explicit prompts requiring learners to explain their mistakes supported correction and near-transfer performance, particularly when scaffolding was provided. These results reinforce the need for Failure-Based Learning methodologies to include metacognitive reflection rather than relying on failure alone.

Similar evidence has been reported in medical education. A randomized controlled study of erroneous examples in medical statistics showed that engaging learners with incorrect examples may trigger confusion and metacognitive processing, thereby encouraging deeper elaboration of learning materials when adequate instructional support is provided. In nursing education, a quasi-experimental study found that Productive Failure within simulation-based learning could support declarative knowledge, explanatory knowledge, and knowledge transfer when students were allowed to make errors in a non-threatening simulated environment before receiving instruction.

The pedagogical value of sharing and analyzing mistakes has also been documented in university mathematics. Savic, Gunter, Curtis, and Pirela (2021) reported that explicitly valuing mistakes through productive-failure activities could generate psychological and social benefits, as students observed that errors were common experiences rather than individual deficiencies. Such practices may reduce the shame associated with failure and reinforce the perception that academic competence can develop through reflection, correction, and persistence.

Current theoretical discussions therefore emphasize that learning from errors is a multidimensional process involving cognitive, motivational, affective, metacognitive, and contextual mechanisms. Narciss and Alemdag (2025) argue that errors and failures are indispensable components of educational processes but that effective learning from them depends on interactions among learners, instructional environments, support



mechanisms, and adaptive responses. Consequently, the impact of Failure-Based Learning should not be evaluated exclusively through academic achievement. Psychological outcomes such as self-efficacy, fear of failure, emotional regulation, persistence, and frustration tolerance must also be considered.

Based on the reviewed evidence, Failure-Based Learning may contribute to a significant transformation in educational practice. Instead of designing learning environments primarily around the prevention of errors, educators can construct learning sequences in which mistakes become sources of information, reflection, conceptual conflict, and personal growth. Nevertheless, the positive effects of such approaches depend on instructional conditions. Excessive difficulty, punitive feedback, public humiliation, or insufficient guidance may transform productive struggle into discouragement. In contrast, psychologically safe classrooms, constructive feedback, scaffolding, opportunities for reflection, and explicit normalization of mistakes may allow failure to strengthen rather than weaken learners' confidence.

In this context, the general objective of the present study is to analyze scientific research published between 2020 and 2026 regarding Failure-Based Learning methodologies and their impact on students' self-efficacy and frustration tolerance, identifying the pedagogical, emotional, and motivational mechanisms that enable errors and unsuccessful attempts to become productive learning experiences.

The main analytical categories considered in the study are Failure-Based Learning, understood as instructional practices that intentionally incorporate mistakes, unsuccessful attempts, productive struggle, and reflection into the learning process; self-efficacy, understood as students' beliefs regarding their ability to successfully perform learning tasks; and frustration tolerance, defined as the capacity to persist and regulate emotional responses when facing obstacles, errors, uncertainty, or delayed achievement.

This study was developed through a qualitative systematic literature review following the PRISMA 2020 guidelines. The review process included the identification, screening, eligibility assessment, and inclusion of scientific studies related to Failure-Based Learning, self-efficacy, and frustration tolerance.

2. METHODOLOGY



a) Study Approach

The present research was developed under a qualitative approach through a systematic literature review, aimed at analyzing Failure-Based Learning methodologies and their impact on students' self-efficacy and frustration tolerance. The systematic review made it possible to identify, organize, compare, and synthesize recent scientific evidence related to productive failure, learning from errors, classroom error climate, self-efficacy, emotional regulation, fear of failure, and frustration tolerance.

Sauer and Seuring (2023) emphasize that systematic literature reviews require a structured process involving the formulation of the research question, definition of study characteristics, retrieval of relevant literature, selection of studies, synthesis of evidence, and transparent reporting of results. Such organization improves the replicability and methodological consistency of the review process.

b) Method

A systematic literature review method was applied using the PRISMA 2020 guidelines as the methodological framework for documenting the identification, screening, eligibility assessment, and final inclusion of scientific publications.

Page et al. (2021) indicate that PRISMA 2020 provides an updated reporting framework that helps researchers clearly communicate why a systematic review was conducted, how the studies were identified and selected, and what evidence was ultimately included. The framework incorporates a 27-item checklist and standardized flow diagrams that promote transparency in systematic reviews.

The selection procedure was therefore represented through a PRISMA flow diagram showing the number of records initially identified, duplicate records removed, documents screened through titles and abstracts, full-text articles assessed for eligibility, studies excluded with reasons, and the 16 articles finally incorporated into the systematic review.

Kolaski, Logan, and Ioannidis (2023) emphasize that systematic reviews should incorporate explicit methodological procedures, appropriate appraisal practices, and transparent documentation of study-selection decisions in order to reduce bias and improve the reliability of evidence synthesis.

c) Search Strategy

The bibliographic search was conducted in Scopus, Web of Science, SciELO, ERIC, and Google Scholar. Scientific publications published between 2020 and 2026 were considered. The search was conducted between January 2026 and March 2026, with the final search update completed on March 15, 2026.

Articles written in English or Spanish were included when they presented a direct relationship with Failure-Based Learning, Productive Failure, learning from errors, self-efficacy, frustration tolerance, failure tolerance, fear of failure, or classroom error climate.

Boolean operators AND and OR were used to combine the main search descriptors.

Search equation in English

("failure-based learning" OR "productive failure" OR "learning from errors" OR "error-based learning" OR "error climate") AND ("self-efficacy" OR "academic self-efficacy") AND ("frustration tolerance" OR "failure tolerance" OR "fear of failure" OR "emotional regulation")

Complementary search equation

("productive failure" OR "learning from failure") AND ("students" OR "learners") AND ("self-efficacy" OR "frustration" OR "failure tolerance" OR "error climate")

Search equation in Spanish

("aprendizaje basado en el fracaso" OR "fracaso productivo" OR "aprendizaje a partir del error") AND ("autoeficacia" OR "autoeficacia académica") AND ("tolerancia a la frustración" OR "tolerancia al fracaso" OR "miedo al fracaso" OR "regulación emocional")

The equations were adapted according to the syntax available in each database. In Scopus, searches were carried out within title, abstract, and keyword fields; in Web of Science, the Topic search field was used; in SciELO and ERIC, thematic descriptors were applied; while Google Scholar was used as a complementary search engine.

Publications were limited to the period 2020–2026, peer-reviewed scientific articles, publications in English or Spanish, and studies directly related to the research variables.

d) Identification of Records

The literature search initially identified 72 records from the five selected information sources:

Table 1

Records identified according to database source



Database	Records identified
Scopus	16
Web of Science	13
ERIC	11
SciELO	8
Google Scholar	24
Total	72

Note. Google Scholar was used as a complementary search source. Due to the large number of results generated by this platform, the first 100 results ordered by relevance were examined through titles, abstracts, and bibliographic information.

From this initial assessment, 24 records were considered potentially relevant and incorporated into the identification stage.

The 72 retrieved records were organized in a bibliographic control matrix. Subsequently, duplicate publications were identified by comparing title, author, publication year, journal, and DOI.

e) Selection and Evaluation of Studies

The study-selection process was carried out in consecutive stages.

Initially, 72 records were identified. After removing 11 duplicate records, 61 documents remained for title and abstract screening.

During the screening stage, 27 studies were excluded because they did not directly address Failure-Based Learning, Productive Failure, learning from errors, self-efficacy, or frustration tolerance, or because their population and objectives were unrelated to educational contexts. Consequently, 34 full-text articles were assessed for eligibility.

During the full-text evaluation, 18 studies were excluded for the following reasons:

- 7 articles addressed failure only as an academic outcome and did not analyze learning from failure.
- 5 articles did not examine self-efficacy, frustration tolerance, or closely related psychological variables.
- 3 articles presented insufficient methodological information.



- 3 articles did not provide results directly applicable to educational contexts.

Finally, 16 scientific studies met all established eligibility criteria and were incorporated into the systematic review.

f) Phases of the Study

The research process was organized into four phases.

Search phase. Scientific literature was identified in Scopus, Web of Science, ERIC, SciELO, and Google Scholar using combinations of descriptors related to Failure-Based Learning, Productive Failure, learning from errors, self-efficacy, frustration tolerance, fear of failure, and error climate. A total of 72 records were initially identified.

Screening phase. Eleven duplicate records were removed, leaving 61 documents for title and abstract review. During this stage, 27 records were excluded, resulting in 34 articles eligible for full-text assessment.

Eligibility and analysis phase. The 34 full-text documents were evaluated according to the established inclusion and exclusion criteria. Eighteen articles were excluded because they did not sufficiently address the study variables or failed to provide relevant evidence. Therefore, 16 studies constituted the final documentary sample.

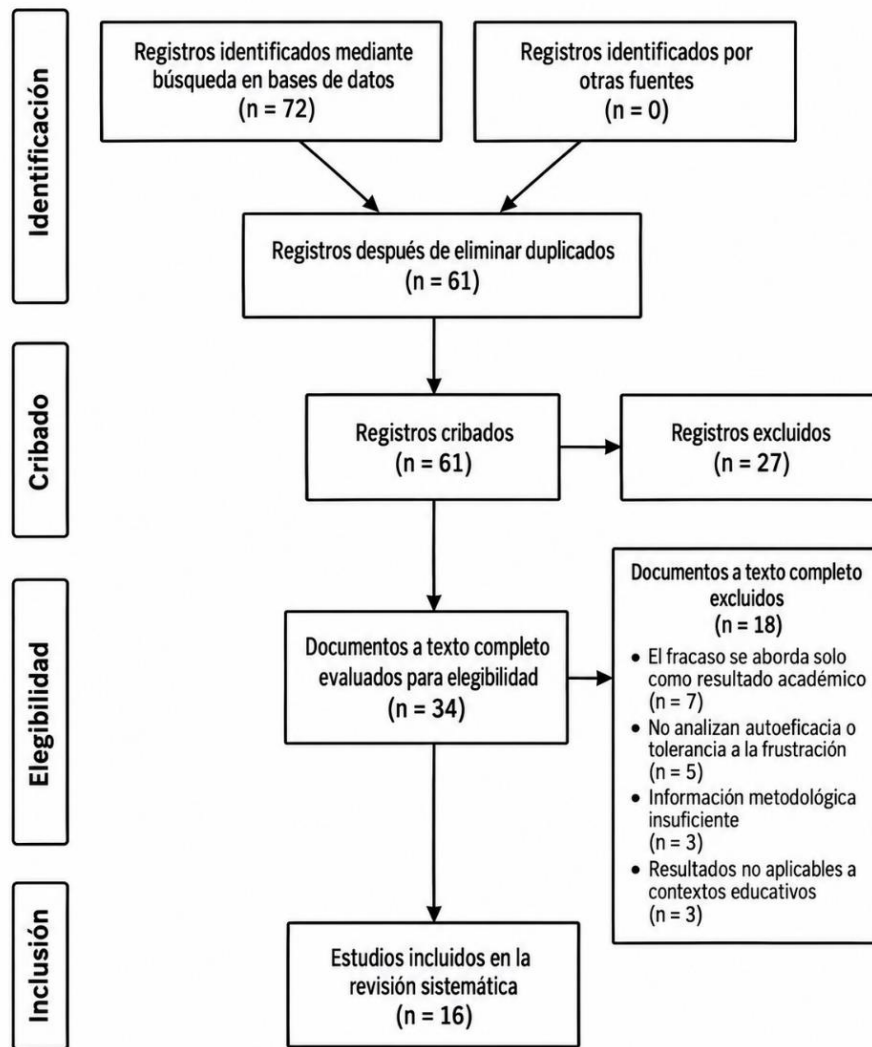
Synthesis phase. The 16 selected articles were organized in an analytical matrix including author, publication year, country, educational level, study objective, methodology, variables analyzed, main findings, and contribution to the research topic. The evidence was subsequently synthesized according to three main analytical categories: Failure-Based Learning methodologies, student self-efficacy, and frustration tolerance.

g) PRISMA 2020 Flow Diagram

Figure 1

PRISMA 2020 Flow Diagram





Note. The diagram represents the identification, screening, eligibility, and inclusion stages followed during the systematic literature review. A total of 72 records were initially identified across five academic information sources. After removing 11 duplicate records, 61 documents were screened through titles and abstracts. Twenty-seven records were excluded during screening, leaving 34 full-text articles for eligibility assessment. Eighteen articles were subsequently excluded because they did not sufficiently address the study variables or failed to meet the methodological criteria. Finally, 16 studies were included in the systematic review. Adapted from PRISMA 2020 (Page et al., 2021).

h) Inclusion and Exclusion Criteria

The inclusion criteria were: scientific articles published between 2020 and 2026; peer-reviewed studies; publications written in English or Spanish; full-text availability;



studies involving students or educational environments; research addressing Failure-Based Learning, Productive Failure, learning from errors, or classroom error climate; and studies examining self-efficacy, frustration tolerance, failure tolerance, emotional regulation, fear of failure, or closely related variables.

The exclusion criteria included duplicate publications; theses, dissertations, conference abstracts, opinion articles, and non-peer-reviewed documents; publications prior to 2020; studies without full-text access; research unrelated to educational environments; articles in which failure was analyzed exclusively as poor academic achievement without a learning-from-errors perspective; and publications that did not provide sufficient methodological or empirical information.

i) Sources and Sample

The information sources used were Scopus, Web of Science, ERIC, SciELO, and Google Scholar. The search period comprised publications from 2020 to 2026.

The identification stage yielded 72 records. Following duplicate removal, screening, and full-text eligibility assessment according to PRISMA 2020, the final documentary sample consisted of 16 scientific articles directly related to Failure-Based Learning, self-efficacy, frustration tolerance, and associated educational variables.

j) General Procedure

The procedure began with the definition of the research variables and search descriptors. Subsequently, bibliographic searches were conducted using Boolean combinations in the selected databases. All retrieved publications were entered into a bibliographic matrix and duplicate records were removed.

Titles and abstracts were then examined according to the predefined inclusion and exclusion criteria. Potentially relevant publications underwent full-text evaluation. The 16 studies finally selected were incorporated into a documentary analysis matrix and classified according to author, year, purpose, educational context, methodological design, variables, findings, and contribution to the review.

The qualitative synthesis focused on identifying relationships among Failure-Based Learning methodologies, self-efficacy, and frustration tolerance, as well as contextual variables such as classroom error climate, fear of failure, emotional regulation, persistence, academic risk taking, and feedback.



k) Quality Assessment of Included Studies

The methodological quality of the included studies was assessed to determine the reliability and relevance of the evidence incorporated into the systematic review. A structured appraisal matrix was applied considering five criteria: clarity of research objectives, coherence between methodology and research design, description of participants or study context, adequacy of data analysis procedures, and consistency between results and conclusions. Each criterion was evaluated as fulfilled, partially fulfilled, or not fulfilled. The assessment results were considered during the qualitative synthesis to identify methodological strengths and limitations of the included studies.

Table 2

Quality assessment of included studies

Criterion	High compliance	Partial compliance	Low compliance
Research objectives clarity	14	2	0
Methodological coherence	13	3	0
Participant/context description	12	4	0
Data analysis procedures	11	5	0
Results-conclusions consistency	15	1	0

Note. The quality assessment showed that most included studies presented high methodological compliance across the evaluated criteria. The main limitations were related to incomplete descriptions of data analysis procedures and contextual information. These aspects were considered during the interpretation and synthesis of findings.

3. RESULTS

The results were obtained through a qualitative systematic literature review focused on Failure-Based Learning methodologies and their impact on students’ self-efficacy and frustration tolerance. After applying the identification, screening, eligibility, and inclusion stages established through the PRISMA 2020 framework, 16 scientific studies published between 2020 and 2026 were finally included in the analysis.

The selected studies were organized in a documentary analysis matrix considering author, year of publication, predominant analytical category, study focus, and main contribution. For



interpretative purposes, each publication was assigned to one predominant category according to its central research purpose. The included studies were classified according to their main research focus. Six studies addressed Failure-Based Learning and Productive Failure, five studies focused on self-efficacy, and five studies analyzed frustration tolerance and failure tolerance.

Table 3

Classification of included studies according to research focus

Research focus	Number of studies
Failure-Based Learning and Productive Failure	6
Self-efficacy	5
Frustration tolerance and failure tolerance	5

Note. Percentage distribution of the 16 scientific studies included in the systematic review according to their predominant analytical category. Own elaboration.

The findings showed a slightly greater presence of studies focused on Failure-Based Learning and Productive Failure, representing 37.5% of the selected literature. These studies emphasized the educational value of unsuccessful attempts, problem solving before instruction, error analysis, reflection, and subsequent instructional support. Research on self-efficacy and frustration or failure tolerance represented 31.25% each, indicating that recent literature increasingly considers not only cognitive learning outcomes but also students’ motivational and emotional responses to error and failure.

Table 4.

Classification Matrix of the Studies According to the Analytical Categories

No.	Author(s) and year	Predominant category	Study focus	Main contribution
1	Nachtigall, Serova, and Rummel (2020)	Failure-Based Learning	Conditions of Productive Failure	Demonstrates that failure is not automatically productive and that instructional design strongly influences whether unsuccessful attempts lead to learning.



No.	Author(s) and year	Predominant category	Study focus	Main contribution
2	Sinha and Kapur (2021)	Failure-Based Learning	Productive Failure meta-analysis	Shows that problem solving before instruction can produce stronger learning outcomes when Productive Failure principles are properly implemented.
3	Ziegler, Trninic, and Kapur (2021)	Failure-Based Learning	Micro Productive Failure in algebra	Shows that carefully structured failure experiences can contribute to procedural as well as conceptual learning.
4	Savic et al. (2021)	Failure-Based Learning	Productive failure in university mathematics	Highlights the educational and social value of making mistakes visible and treating them as legitimate components of learning.
5	Kapur, Saba, and Roll (2023)	Failure-Based Learning	Prior knowledge and learning from productive failure	Shows that prior achievement and the quality of students' initial solutions influence learning from productive failure.
6	Narciss and Alemdag (2025)	Failure-Based Learning	Learning from errors and failure	Synthesizes recent evidence showing that error-based learning depends on contextual, motivational, affective, and instructional factors.
7	Soncini, Matteucci, and Butera (2021)	Self-efficacy	Teachers' error-handling strategies	Demonstrates that teachers' responses to mistakes influence students' beliefs, emotions, and classroom error climate.



No.	Author(s) and year	Predominant category	Study focus	Main contribution
8	Steuer, Tulis, and Dresel (2022)	Self-efficacy	Error climate across school subjects	Shows that supportive error climates vary across subjects and can facilitate more constructive responses to mistakes.
9	Cao and Zhang (2024)	Self-efficacy	Productive Failure in a virtual learning environment	Examines how students' self-efficacy and learning strategies interact with Productive Failure during complex learning tasks.
10	Dresel et al. (2025)	Self-efficacy	Development of reactions to errors	Shows that perceived classroom error climate is associated with students' affective, motivational, and behavioral adaptation after mistakes.
11	Zhao and Jing (2026)	Self-efficacy	Error-management climate and innovation self-efficacy	Finds that a positive classroom error-management climate is positively associated with innovation self-efficacy, with fear of failure and growth mindset acting as mediators.
12	Park and Ju (2022)	Frustration / failure tolerance	Failure tolerance and adaptation	Identifies relationships among failure tolerance, self-efficacy, and adjustment to academic life.
13	Tobar Viera and Mejía Rubio (2023)	Frustration / failure tolerance	Frustration tolerance and emotional regulation	Shows that adolescents' ability to tolerate frustration is related to their capacity to regulate emotional responses.



No.	Author(s) and year	Predominant category	Study focus	Main contribution
14	Savelson and Muldner (2024)	Frustration / failure tolerance	Emotional responses during Productive Failure	Indicates that uncertainty and frustration emerge during challenging learning activities, but constructive interaction can support subsequent performance.
15	Delgado Tuares and Pilco Guadalupe (2024)	Frustration / failure tolerance	Frustration tolerance in adolescents	Highlights the relationship between students' emotional context and their ability to cope with frustrating experiences.
16	Aviles Fuentala et al. (2026)	Frustration / failure tolerance	Frustration tolerance in secondary students	Emphasizes frustration tolerance as an important psychological and educational variable in adolescence.

Note. The table presents the 16 studies included in the systematic review after applying the PRISMA identification, screening, eligibility, and inclusion criteria. Each study was classified according to the predominant analytical category: Failure-Based Learning, self-efficacy, or frustration/failure tolerance. Own elaboration.

In relation to Failure-Based Learning, the studies revealed that failure becomes educationally productive when it is intentionally incorporated into a structured instructional process. Productive Failure does not consist simply of exposing learners to difficult tasks; rather, students first attempt solutions, generate incomplete or incorrect representations, and subsequently receive instruction that helps them compare, reorganize, and refine their previous reasoning. Sinha and Kapur (2021) found that problem solving before instruction can produce significant learning benefits, while Ziegler et al. (2021) showed that micro-level productive failure can also support procedural knowledge acquisition.

However, the findings also showed that failure does not necessarily generate positive outcomes under all conditions. Nachtigall et al. (2020) emphasized that productive effects



depend on instructional design and the relationship between the initial problem-solving stage and subsequent teaching. Similarly, Narciss and Alemdag (2025) concluded that learning from errors is influenced by contextual factors, individual motivational beliefs, emotions, learning processes, feedback, and instructional support.

Regarding self-efficacy, the reviewed studies indicated that students' beliefs about their own capabilities can be strengthened when classroom environments normalize mistakes and frame them as opportunities for learning. Teacher responses, error climate, constructive feedback, and opportunities for correction emerged as important factors affecting students' confidence and willingness to persist after unsuccessful attempts.

A particularly relevant finding was reported by Zhao and Jing (2026), who studied 777 primary school students and found a positive association between classroom error-management climate and innovation self-efficacy. Their analysis also identified fear of failure and growth mindset as mediating mechanisms, suggesting that supportive responses to mistakes may influence confidence both directly and through changes in how students interpret failure.

The category of frustration and failure tolerance showed that emotional reactions are central to understanding whether failure becomes constructive or discouraging. The analyzed studies indicated that students with greater capacity to regulate frustration tend to persist longer, adapt more effectively to academic challenges, and respond more constructively to mistakes. In contrast, low frustration tolerance can increase task abandonment, avoidance, and negative emotional responses.

The evidence also suggested that Productive Failure does not necessarily produce excessive frustration. Rather, uncertainty appears to be a common emotional and cognitive condition during challenging learning tasks. When adequate instructional support is available, students can use uncertainty and temporary failure as signals to revise strategies, seek explanations, and continue problem solving.

Table 5.

Main Transformations Identified in Failure-Based Learning



Analytical category	Traditional educational conception	Contemporary tendency identified
Failure-Based Learning	Errors are viewed mainly as incorrect responses that should be avoided or penalized.	Errors and unsuccessful attempts are deliberately incorporated as opportunities for exploration, reflection, feedback, and conceptual reconstruction.
Self-efficacy	Success is often used as the principal indicator of ability and competence.	Students' confidence can also develop through overcoming mistakes, revising strategies, and receiving constructive support after failure.
Frustration tolerance	Frustration is viewed mainly as a negative emotional response that interferes with performance.	Moderate frustration and uncertainty can become part of productive struggle when students receive emotional and instructional support.

Note. Comparative synthesis based on the findings identified in the 16 studies selected for the systematic review. Own elaboration.

Overall, the results showed that contemporary research has moved from considering failure exclusively as evidence of poor performance toward understanding it as a potentially valuable pedagogical, motivational, and emotional experience. The reviewed studies indicate that mistakes can promote learning when they are followed by reflection, feedback, instructional guidance, and opportunities to revise previous reasoning.

The evidence also showed that the effect of Failure-Based Learning extends beyond academic achievement. Its effectiveness is related to psychological variables such as self-efficacy, fear of failure, emotional regulation, persistence, growth mindset, and frustration tolerance. This broader perspective suggests that students do not simply learn academic content from failure; they may also develop greater confidence and more adaptive responses to challenging situations.

Consequently, the principal finding of the review was that Failure-Based Learning can positively contribute to students' learning and psychological adaptation when failure occurs within a supportive, structured, and non-punitive educational environment. The evidence



particularly highlights the importance of constructive error climates, appropriate feedback, reflection, and instructional scaffolding.

4. DISCUSSION

The findings of the systematic review show that contemporary research increasingly recognizes failure, error, and frustration as potentially valuable components of the learning process rather than as exclusively negative academic outcomes. Across the studies analyzed, Failure-Based Learning and related approaches such as Productive Failure, error-based learning, and constructive error climates were associated with opportunities for deeper understanding, reflection, persistence, and emotional adaptation. However, the evidence also indicates that failure does not automatically produce learning; its educational value depends on how the experience is structured, interpreted, and supported by teachers.

Regarding Failure-Based Learning, the reviewed studies reveal an important shift from educational models focused primarily on avoiding mistakes toward approaches that deliberately incorporate unsuccessful attempts into instruction. Sinha and Kapur (2021) showed that problem solving before explicit instruction can generate significant learning advantages when Productive Failure principles are appropriately implemented. Similarly, Ziegler, Trninic, and Kapur (2021) demonstrated that carefully designed productive failure experiences can support the acquisition of procedural knowledge, suggesting that the benefits of failure are not limited to conceptual understanding.

Nevertheless, the findings also reveal important conditions that determine whether failure becomes productive. Nachtigall, Serova, and Rummel (2020) reported that Productive Failure may lose its effectiveness when the initial problem-solving stage is not adequately connected with subsequent instruction. This result is particularly relevant because it shows that failure itself should not be interpreted as an instructional strategy. Instead, learning emerges from the combination of challenge, unsuccessful attempts, reflection, feedback, comparison of strategies, and explicit instructional consolidation.

This interpretation is consistent with the broader perspective proposed by Narciss and Alemdag (2025), who emphasize that learning from errors depends on interactions among cognitive, affective, motivational, and contextual factors. From this perspective, students' responses to failure cannot be understood solely by examining whether an answer is correct



or incorrect. Their beliefs about ability, emotional responses, previous knowledge, classroom environment, and the type of feedback received all influence whether an error becomes an opportunity for learning or a source of discouragement.

In relation to self-efficacy, the findings suggest that classroom environments play a central role in shaping the way students interpret their own mistakes. Soncini, Matteucci, and Butera (2021) showed that teachers' error-handling strategies can influence students' beliefs and emotions related to mistakes. Similarly, Steuer et al. (2022) demonstrated that the error climate perceived by students differs across educational contexts and subjects, indicating that classroom culture influences whether mistakes are experienced as threats or as legitimate elements of learning.

The longitudinal findings reported by Dresel et al. (2025) reinforce this interpretation by showing that students' affective, motivational, and behavioral reactions to errors develop in relation to the classroom error climate. These results indicate that self-efficacy is not shaped only by academic success but also by the way students are allowed to respond after failure. When learners have opportunities to correct mistakes, reconsider strategies, receive constructive feedback, and experience subsequent improvement, failure may contribute to a stronger perception of competence.

A particularly important contribution was identified in Zhao and Jing (2026), who found that a positive classroom error-management climate was associated with higher innovation self-efficacy and that this relationship was partially explained by reductions in fear of failure and increases in growth mindset. This finding suggests that educational environments that normalize mistakes may strengthen students' beliefs in their capacity to improve, experiment, and persist when facing difficult tasks.

The results concerning frustration tolerance reveal a closely related emotional dimension. Failure-Based Learning intentionally exposes students to uncertainty, difficulty, and unsuccessful attempts, making the ability to tolerate frustration an important condition for productive engagement. Tobar Viera and Mejía Rubio (2023) identified an association between frustration tolerance and emotional regulation in adolescents, suggesting that students who are better able to regulate their emotional responses may also be more capable of persisting in challenging learning situations.



Park and Ju (2022) similarly reported relationships among failure tolerance, self-efficacy, and adaptation to academic life. Their findings support the idea that frustration tolerance and self-efficacy are interconnected rather than completely independent variables. Students who believe they are capable of overcoming challenges may be more willing to persist after failure, while students who tolerate frustration more effectively may have more opportunities to experience mastery and consequently strengthen their self-efficacy.

The findings of Savelson and Muldner (2024) provide an important nuance to this interpretation. Their study showed that uncertainty was more frequent than frustration during programming activities based on Productive Failure. This distinction is relevant because it suggests that challenging learning experiences do not necessarily produce excessive negative emotion. Under appropriate conditions, temporary uncertainty can stimulate exploration, discussion, and strategy revision without becoming psychologically harmful.

Research focused on adolescents also reinforces the importance of social and emotional context. Delgado Tuarez and Pilco Guadalupe (2024) examined frustration tolerance in relation to family functioning, while Aviles Fuentala et al. (2026) highlighted the educational relevance of frustration tolerance among high-school students. Together, these findings indicate that students' responses to failure are influenced not only by instructional design but also by broader emotional and interpersonal resources.

The reviewed literature therefore suggests that the relationship between Failure-Based Learning, self-efficacy, and frustration tolerance is reciprocal. Productive failure experiences may strengthen self-efficacy when students are able to overcome difficulty through reflection and instructional support. At the same time, greater self-efficacy may encourage students to remain engaged when initial attempts fail. Similarly, frustration tolerance can facilitate persistence during challenging tasks, while repeated experiences of successfully overcoming difficulty may contribute to improved emotional regulation.

However, the studies do not support the assumption that all failure should be considered beneficial. Excessive task difficulty, punitive classroom environments, public exposure of mistakes, insufficient scaffolding, or feedback that focuses primarily on deficiency may increase fear of failure and reduce confidence. The evidence therefore points toward the importance of productive struggle rather than uncontrolled failure. The educational objective



is not to make students fail, but to create conditions in which temporary failure can be analyzed, corrected, and transformed into learning.

From a pedagogical perspective, one of the principal implications of this review is the importance of teachers' responses to error. Constructive feedback, psychological safety, opportunities for revision, guided reflection, and explicit normalization of mistakes appear repeatedly as relevant conditions across the reviewed literature. Consequently, Failure-Based Learning should be understood as a structured instructional methodology rather than as simple exposure to difficulty.

The findings also have implications for contemporary educational practices. In educational systems where grades and correct answers often dominate assessment, students may interpret mistakes as evidence of low ability. Failure-Based Learning challenges this interpretation by presenting error as information about the learning process. This approach may contribute to the development of students who are more willing to explore alternatives, persist through difficulty, and revise their understanding.

Overall, the discussion indicates that Failure-Based Learning has potential educational value when cognitive challenge is accompanied by emotional and instructional support. The results extend beyond academic performance and highlight the importance of psychological variables such as self-efficacy, frustration tolerance, fear of failure, growth mindset, emotional regulation, and persistence. Therefore, future instructional designs based on failure should integrate both cognitive and emotional dimensions of learning.

5. CONCLUSIONS

The systematic review of 16 studies published between 2020 and 2026 showed that Failure-Based Learning can become an effective educational strategy when mistakes and unsuccessful attempts are accompanied by reflection, feedback, guidance, and opportunities for improvement. The reviewed evidence suggests that failure itself is not necessarily beneficial; its educational value depends on the way it is managed within the learning environment.

The findings also indicate that these methodologies may contribute to strengthening students' self-efficacy, since overcoming difficulties and correcting mistakes can improve confidence, persistence, and willingness to face challenging tasks. Likewise, frustration tolerance appears



to be an important factor, because students who regulate their emotions and persist after an unsuccessful attempt are better able to continue the learning process.

Overall, the studies suggest that error and failure should not be understood only as negative academic outcomes, but also as opportunities for cognitive, emotional, and motivational development. Therefore, supportive and non-punitive classroom environments, constructive feedback, and appropriate instructional scaffolding are essential for failure to become a productive learning experience.

Future research should continue examining the effects of Failure-Based Learning across different educational levels, subjects, and contexts, especially its long-term relationship with self-efficacy, emotional regulation, and frustration tolerance.

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