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Heterogeneity and Boundary Conditions of the Growth Mindset Effect

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Date: 2023-12-11T00:00:00+00:00

Abstract

Growth mindset is a belief that individuals' attributes are malleable. This belief is often regarded as a panacea for various educational problems, to the extent that educational authorities in different countries actively promote growth mindset intervention programs, sparking a "mindset model revolution" on a global scale. Against this backdrop, researchers in the fields of personality, social, and developmental psychology, drawing upon large-scale survey data and double-blind randomized controlled experiments worldwide, have sparked a new wave of growth mindset research in academia, propelling the field into an era of interdisciplinary, international, and scalable intervention research. However, as research evidence continues to accumulate, researchers have found that the effects of growth mindset exhibit substantial heterogeneity. Mindset-situation interaction theory, based on substantial empirical evidence, posits that growth mindset interventions can only exert their maximal effects when individuals possess vulnerability and the environment offers psychological affordances. These findings provide new directions for optimizing intervention measures. Future research needs to design customized intervention protocols for different populations based on exploring the mechanisms through which psychological affordances and vulnerability operate, thereby effectively promoting individual development and addressing educational problems.

Full Text

The Heterogeneity and Boundary Conditions of Growth Mindset Effects

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Abstract

Growth mindset—the belief that individual attributes can be developed through effort and learning—has been widely promoted as a remedy for various educational challenges. This perspective has inspired educational departments worldwide to implement growth mindset intervention programs, sparking a global "mindset revolution." Against this backdrop, researchers in personality, social, and developmental psychology have launched a new wave of growth mindset research using large-scale international surveys and double-blind randomized controlled field experiments, ushering the field into an era of interdisciplinary, international, and scalable intervention research. However, as evidence accumulates, researchers have discovered that growth mindset effects exhibit substantial heterogeneity. Grounded in extensive empirical evidence, the Mindsets × Context theory proposes that growth mindset interventions are most effective only when individuals experience vulnerability and when environments provide psychological affordances. These findings offer new directions for optimizing interventions. Future research should explore the mechanisms through which psychological affordances and vulnerability operate, design customized intervention programs for different populations, and ensure these interventions effectively promote individual development and address educational challenges.

Keywords: growth mindset, heterogeneity of effects, psychological affordance, vulnerability

Mindsets are beliefs about how to approach situations, challenges, and opportunities that influence behavioral patterns and achievement levels [**?**, **?**]. The publication and popular success of Carol Dweck's *Mindset: The New Psychology of Success* [**?**, **?**] led popular media to portray growth mindset as a panacea for educational problems [**?**, **?**, **?**, **?**]. Consequently, many countries have implemented growth mindset programs in schools, hoping to improve student achievement by shifting their mindsets [**?**, **?**]. For example, education departments in the United States [**?**, **?**], United Kingdom [**?**, **?**], Australia [**?**, **?**], Singapore [**?**, **?**], and various educational organizations have actively promoted growth mindset principles through intervention programs designed to cultivate positive learning attitudes and adaptive capacities, enabling students to better face challenges and enhance their learning abilities. These concerted efforts across different nations have sparked a revolutionary global movement to transform mindset patterns.

In this context, researchers in personality, social, and developmental psychology have conducted large-scale international surveys and double-blind randomized controlled field experiments, generating a new wave of growth mindset research and propelling the field into an interdisciplinary, international, and scalable intervention research era [**?**, **?**, **?**]. However, as research has deepened, the scientific evidence for growth mindset's impact on academic achievement [**?**, **?**] and the effectiveness of growth mindset interventions [**?**, **?**] have faced increasing skepticism. Some evidence suggests that growth mindset shows no significant

correlation with academic achievement, and that the "mindset revolution" may not be the optimal path for reshaping education systems [?, ?]. Moreover, much previous mindset research has been criticized for neglecting key contextual factors. This raises critical questions: Does growth mindset genuinely promote academic achievement? And under what conditions does it do so? To address these questions, researchers must examine the replicability and generalizability of growth mindset interventions, analyzing the heterogeneity and boundary conditions of their effects. Only through such analysis can we clarify which claims in growth mindset research remain valid, which require revision, and how future mindset research should evolve.

1. Growth Mindset

Growth mindset refers to the belief that individual attributes can develop over time, whereas fixed mindset refers to the belief that attributes are static and unchangeable [?, ?]. Individuals can hold different mindsets across various abilities and attributes; for example, one person might simultaneously hold a fixed mindset about personality and a growth mindset about intelligence [?, ?]. Furthermore, mindsets are not dichotomous but conceptualized as a continuum from fixed to growth, with individuals positioned at different points along this spectrum [?, ?]. Mindset research originated in education, focusing primarily on intelligence [?, ?], but has since expanded to health [?, ?, ?], prejudice [?, ?, ?], organizational behavior [?, ?], morality [?, ?], interest [?, ?], and other domains. Nevertheless, the mainstream of growth mindset research remains focused on academic achievement, particularly how to improve student performance [?, ?]. Therefore, this paper concentrates on growth mindset research in educational contexts. In this domain, mindset is typically measured by assessing agreement with statements such as "You have a certain amount of intelligence, and you can't really change it" [?, ?, ?, ?, ?]. Higher agreement indicates a more fixed mindset, while greater disagreement suggests a more growth-oriented mindset.

Although research confirms that mindsets remain relatively stable over time [?, ?], they differ from personality traits in that they can be changed through experimental manipulation or long-term intervention [?, ?, ?, ?, ?]. Researchers believe that mindsets can be altered through simple exercises in precise ways, leading to lasting personal and social positive change [?, ?]. Notably, growth mindset interventions do not change individuals' objective attributes; rather, they aim to shift students' beliefs about their personal attributes, moving them from a fixed to a growth mindset [?, ?]. The core content of these interventions involves shaping the belief that intelligence and abilities can be developed through actions such as effort, strategy change, and help-seeking [?, ?, ?]. Growth mindset interventions also convey a memorable metaphor: the brain is like a muscle that grows stronger when persistently tackling challenges and completing difficult tasks [?, ?].

The standardized face-to-face intervention procedure [?, ?] proceeds as follows: First, participants read a scientific article titled "You Can Grow Your Intelli-

gence," which conveys the idea that the brain functions like a muscle and can become smarter through challenge. The article explains what neurons are and how they form networks in the brain, noting that animals or people with more experience or learning develop denser neural networks. Next, participants complete a writing task describing an experience of ability growth after struggle and how they might apply growth mindset to future goals. Finally, participants write a letter encouraging a student with a fixed mindset (e.g., "I'm already smart, so I don't have to study hard" or "I'm stupid and there's nothing I can do about it"). This "saying is believing" exercise helps students internalize growth mindset through cognitive dissonance processes within a short timeframe [**?**, **?**]. Recently, online interventions have been developed, with researchers using computer and internet technologies to deliver interventions directly to students, convey core growth mindset principles, and invite students to deepen their understanding of applying these principles in daily life, thereby increasing the potential for scalable implementation [**?**, **?**, **?**].

2. The Heterogeneity of Growth Mindset Effects

Based on achievement goal theory and attribution theory, mindset theory [**?**, **?**, **?**, **?**] posits that mindsets determine how individuals understand themselves and their environments—what goals they should pursue, why they fail, and whether effort is good or bad. In other words, mindsets guide individuals toward different "meaning systems" when facing challenges and setbacks, leading to different achievement outcomes. Individuals with growth mindsets are more likely than those with fixed mindsets to pursue learning goals (rather than avoid looking incompetent), attribute failure to controllable factors like effort and strategy (rather than fixed low ability), and believe they can improve through effortful learning. Consequently, growth mindsets should lead to higher academic achievement [**?**, **?**, **?**]. While numerous studies confirm that growth mindsets are beneficial and can significantly enhance student achievement [**?**, **?**], an increasing body of research shows that growth mindset effects on academic achievement are small and complex [**?**, **?**, **?**]. Meta-analyses further indicate substantial heterogeneity in the overall relationship between growth mindset and academic achievement, meaning that growth mindsets are effective in some contexts but ineffective or even harmful in others [**?**, **?**].

With growing emphasis on replicability and generalizability, researchers have increasingly focused on when, why, and under what conditions positive growth mindset effects emerge. Examining the heterogeneity and boundary conditions of growth mindset effects is therefore crucial for predicting intervention outcomes and advancing mindset theory and application [**?**, **?**]. In the long term, extracting useful lessons from these controversies can further promote theoretical progress and methodological reform.

2.1 Positive Effects of Growth Mindset

Many large-scale surveys conducted by governments and international organizations have found positive correlations between growth mindset and academic achievement. At the national level, large-sample surveys have documented these positive effects. First, a survey of 300,629 students in grades 4 through 7 in California's "CORE" districts found that growth mindset positively correlated with English/Language Arts scores (r=0.28) and math scores (r=0.27) [**?**, **?**]. Additionally, all 10th-grade students in Chile's public schools (N=168,533) completed growth mindset measures alongside national standardized exams, revealing a significant positive correlation between growth mindset and total standardized test scores (r=0.34). Students' mindset patterns predicted their academic achievement as strongly as family income or other standard economic indices [**?**, **?**]. More compelling evidence comes from large-scale international surveys. The OECD's Programme for International Student Assessment (PISA) conducted random sampling across 74 countries (N=555,458) and found that, after controlling for student and school socioeconomic status, students with growth mindsets outperformed their fixed-mindset peers in reading, math, and science. The performance gaps were largest in New Zealand, Australia, and the United States, where growth-minded students scored approximately 60 points higher in reading than their peers after socioeconomic controls [**?**, **?**]. Research conducted in China also demonstrates that growth mindset significantly and positively predicts middle school students' math achievement [**?**, **?**].

Numerous intervention studies have shown that growth mindset interventions can significantly improve academic achievement. Early face-to-face interventions demonstrated positive effects. For example, a study with seventh-grade students in authentic middle school classroom settings, conducted by specially trained counselors, found that while control group students' grades continued to decline, growth mindset intervention reversed this downward trend in the experimental group [**?**, **?**]. Although effective, such face-to-face interventions suffer from poor scalability due to extensive training requirements and classroom time demands. More recently, standardized online interventions have been developed and implemented at scale. Researchers using online delivery and double-blind randomized controlled designs found that brief online growth mindset interventions significantly improved low-achieving students' academic performance [**?**, **?**]. Subsequent validation studies have shown that online growth mindset interventions significantly increased full-time college enrollment rates among students from disadvantaged backgrounds [**?**, **?**], improved academic performance among first-generation college students from underrepresented minority groups [**?**, **?**], boosted Latino students' GPA [**?**, **?**], and enhanced middle school students' math achievement [**?**, **?**]. Particularly compelling is a pre-registered randomized controlled experiment with a nationally representative sample [**?**, **?**]. This study used standardized growth mindset intervention materials and procedures with a nationally representative sample of 65 public high schools across the United States (N=12,486). A large research team reviewed intervention

materials and procedures to ensure reliability and quality. An independent company specializing in national surveys constructed the sample, trained staff, guided school teachers, and collected and merged all data. Another independent company specializing in impact evaluation constructed the analysis dataset and wrote its own independent evaluation report based on their analysis. Both the research team's analysis and the independent report [**?**, **?**] found that, compared to the control group, growth mindset intervention reduced the prevalence of fixed mindset beliefs. When assigned to the growth mindset intervention, lower-achieving adolescents earned higher GPAs in core courses by the end of ninth grade relative to control condition students.

2.2 Null and Negative Effects of Growth Mindset

Although growth mindset is generally considered beneficial, its effects on academic achievement have been widely questioned. Correlational studies from different countries show no significant relationship between students' reported mindsets and academic performance. Small-sample longitudinal studies have found no significant association between growth mindset and academic achievement. For example, a four-year longitudinal study with British university students found that growth mindset was unrelated to initial enrollment grades and showed no significant association with academic performance during the challenging transition from high school to university or in any subsequent years [**?**, **?**]. Large-scale national survey data have also revealed null effects. A questionnaire study with a large sample (N=5,653) of university applicants in the Czech Republic found no significant correlation between growth mindset and academic achievement [**?**, **?**]. Even PISA data [**?**, **?**] show no significant relationship between growth mindset and academic achievement among students in mainland China.

Growth mindset intervention outcomes are similarly controversial, with some studies finding interventions ineffective. Early face-to-face interventions revealed null effects. For instance, a face-to-face growth mindset intervention with fifth-grade students (N=286) found no significant improvement in academic performance compared to the control group [**?**, **?**]. Another face-to-face intervention examining whether growth mindset could promote interest and performance in computer science found that while the manipulation increased interest in the field, it had no significant impact on academic performance [**?**, **?**]. Additionally, despite their standardized and scalable nature, some online intervention studies have also found null effects. For example, an online growth mindset intervention with a sample of rural adolescent girls found that, compared to the control group, students receiving the intervention showed stronger growth mindset beliefs at post-test and four-month follow-up, but the intervention had no impact on academic performance [**?**, **?**].

Meta-analytic results indicate substantial heterogeneity in the overall relationship between growth mindset and academic achievement [**?**, **?**]. One study conducted two meta-analyses: one focusing on correlations between students'

growth mindset beliefs and achievement, encompassing 273 studies with 365,915 participants, found a significant average correlation (d=0.10); another focusing on growth mindset intervention effectiveness, involving 43 studies with 57,155 participants, found a significant difference in academic achievement between intervention and control groups (d=0.08) [**?**, **?**]. Another meta-analysis including 53 studies published between 2002 (the first growth mindset intervention) and the end of 2020 found that growth mindset interventions predicted student academic achievement (d=0.09) [**?**, **?**]. Although these meta-analyses yield statistically significant results, researchers argue that the average effects are small, with numerous studies showing non-significant effect sizes and very high heterogeneity. Indeed, another meta-analysis involving 63 studies and 97,672 participants found that the overall effect of growth mindset interventions was significant but small (d=0.05), and this effect became non-significant after correcting for potential publication bias [**?**, **?**]. These meta-analytic findings indicate that growth mindset can effectively enhance student achievement in some contexts but not in others, underscoring the importance of heterogeneity in growth mindset research [**?**, **?**].

Beyond positive and null effects, a few studies have found negative effects of growth mindset. For example, a study of 1,549 Belgian minority students examining the relationship between growth mindset and academic achievement found, contrary to researchers' expectations, a significant negative correlation [**?**, **?**]. Another online growth mindset intervention with urban high school students found that while the intervention significantly shifted participants' mindset beliefs—making intervention group students more growth-minded than control group students—it failed to improve GPA. In fact, intervention group students showed slight negative GPA changes over time, while control group students showed positive changes, with no significant differences in course attendance between groups [**?**, **?**]. Meta-analyses indicate that negative effects appear in approximately 6% of correlational studies and 2% of intervention studies [**?**, **?**].

3. Boundary Conditions of Growth Mindset Effects

To address the substantial heterogeneity in growth mindset effects, researchers have proposed the Mindsets × Context theory [**?**, **?**], which argues that contextual factors systematically explain inconsistencies in growth mindset outcomes. This theory emphasizes that growth mindset alone is insufficient for positive results; its effects depend heavily on context. Specifically, effective interventions require both an adaptive belief system (planting high-quality seeds) and supportive contextual features (fertile soil). In other words, interventions plant a "seed," but it will not germinate unless the "soil" is fertile [**?**, **?**, **?**, **?**]. Researchers [**?**, **?**, **?**] have termed contextual features that facilitate growth mindset, making it more legitimate and adaptive, as psychological affordances. According to this view, growth mindset interventions produce positive effects only in environments with psychological affordance. This perspective fundamen-

tally differs from the "mindsets alone" hypothesis, which posits that forming a growth mindset about abilities and intelligence can compensate for prior risk factors and benefit individuals regardless of context [?, ?].

Furthermore, Mindsets × Context theory [?, ?, ?] suggests that individuals' mindsets develop from their experiences, which may be limited or one-sided, leading to misalignment between mindsets and actual circumstances that affects learning performance [?, ?]. For example, a student beginning advanced mathematics who scores high on an exam may feel confident and become more engaged in learning, creating a self-reinforcing positive feedback loop. In such cases, growth mindset intervention may yield minimal benefits because the student is already performing well with limited room for improvement [?, ?]. However, disadvantaged groups may be more susceptible to negative feedback loops [?, ?, ?]. For instance, a student beginning advanced mathematics who scores low may feel they lack mathematical talent and develop resistance or avoidance toward the subject. This negative feedback creates a self-undermining cycle leading to maladaptive outcomes [?, ?]. Growth mindset interventions combined with contextual resource support can effectively help these vulnerable students break negative feedback cycles and overcome difficulties [?, ?, ?]. Thus, growth mindset interventions are more effective for such vulnerable students. In summary, growth mindset interventions are most likely to produce meaningful effects when individuals face vulnerability (e.g., low achievement or challenging courses or school transitions) and when environments provide psychological affordances (e.g., classroom policies that offer opportunities to act on growth mindset).

3.1 Vulnerability

Mindset theory, as a theory about responding to challenges or setbacks, predicts stronger associations between mindset and academic achievement among individuals facing academic difficulties or setbacks [?, ?]. Therefore, assessing vulnerability is crucial in mindset research. In this context, vulnerability refers to individual-level risk factors that may negatively affect academic achievement, such as poverty, low grades, difficult courses, or school transitions [?, ?].

Correlational research shows that growth mindset effects are moderated by vulnerability. For example, a study surveying all tenth-grade students in Chile's public schools (N=168,203) found that higher growth mindset scores predicted better performance on standardized language and math tests, particularly among students from impoverished backgrounds. Specifically, growth-minded students from poor families (lowest 10th percentile of family income) performed as well as students from wealthy families (80th percentile of family income) [?, ?]. Another study of 195 fourth-grade students in the United States found that, after controlling for word reading skills, growth mindset positively predicted reading comprehension. This positive association was stronger for students with lower reading comprehension levels and weaker among higher-achieving students [?, ?].

Intervention studies confirm that growth mindset intervention effects are also moderated by vulnerability. For example, a study in which participants read a scientific article about "building your brain," describing how the brain grows like a muscle through repeated practice when facing challenges, found that Latino students receiving the growth mindset intervention achieved significantly higher first-semester GPAs than control group peers, reducing the average achievement gap between Latino and White students by 72% [**?**, **?**]. Similarly, a growth mindset intervention with first-year college students significantly improved grades, with a significant interaction between ethnicity and intervention—the intervention had a larger impact on academic performance among minority students [**?**, **?**]. Another study conducted an online growth mindset intervention with a nationally representative sample of 65 U.S. high schools (N=12,486), randomly assigning participants to intervention or control groups. The intervention emphasized effort as a means to develop intelligence, while the control condition explained brain function without providing information about neuroplasticity. Results showed that lower-achieving students benefited more from the online growth mindset intervention, earning higher GPAs in core courses by the end of ninth grade [**?**, **?**].

3.2 Psychological Affordance

Affordances are contextual features that elicit specific interpretations and responses [**?**, **?**, **?**, **?**]. Initially, psychologists understood affordances from the perspective of physical objects, viewing them as physical possibilities in a situation [**?**, **?**]. For example, a sidewalk affords walking along a specific path. Later, researchers recognized that affordances could also involve possibilities in social situations—psychological affordances. Specifically, psychological affordances refer to social environmental features that make individuals' pre-existing beliefs easier to activate, more legitimate, and more adaptive [**?**, **?**, **?**]. These features may include cultural values, social norms, and authority endorsements in the social environment, which enhance individuals' acceptance and endorsement of specific beliefs, thereby guiding their behavior. Psychological affordances explain why growth mindset interventions are highly effective in some situations but not others, depending on the environment. Researchers argue that psychological affordances are key to growth mindset's positive impact; growth mindsets are more effective in environments that provide psychological affordance—contexts that allow and encourage students to view abilities as developable and to act accordingly [**?**, **?**, **?**].

Correlational research shows that the effect of self-reported growth mindset on academic achievement is moderated by psychological affordance. For example, researchers [**?**, **?**] used representative large-sample data from PISA (2018) to examine how psychological affordance (operationalized as upward mobility in academic environments) moderated growth mindset effects. Results showed that low psychological affordance (low upward mobility) reduced the academic benefits of growth mindset, with growth mindset having smaller effects in low-

affordance environments than in high-affordance environments (high upward mobility). This study demonstrated that growth mindset positively affected academic achievement only in high-affordance environments. Another study with 1,094 participants aged 13 to 19 experimentally assigned participants to growth-mindset or fixed-mindset teacher conditions (psychological affordance). In the growth-mindset teacher condition (high affordance), teachers described instructional methods providing verbal growth-mindset support messages (e.g., "I believe all students can learn and achieve in my class, regardless of where they start") and classroom policies offering opportunities to act on growth mindset (e.g., "If your test scores improve this semester, I will raise your final grade"). In the fixed-mindset teacher condition (low affordance), teachers provided verbal fixed-mindset support messages and policies without opportunities to act on growth mindset. Results showed that participants' growth mindsets translated into learning-oriented choices only when teachers provided supportive messages and opportunities: in the growth-mindset teacher condition, participants reporting more growth mindset were more likely to choose a challenging, learning-promoting assignment over a simple review assignment, whereas in the fixed-mindset teacher condition, growth mindset showed null effects. A subsequent confirmatory study replicated these results [**?**, **?**]. Another study using social beliefs as an indicator of psychological affordance examined its moderating role in growth mindset effects. Multilevel structural equation modeling of data from 273,074 students across 39 countries/regions found that social beliefs weakened the positive association between growth mindset and student achievement. Specifically, in societies with stronger beliefs in social complexity—where people tend to believe that behaviors and outcomes may differ across contexts and that multiple problem-solving approaches typically exist—students may also learn that flexible and varied strategies can lead to success, some of which may not involve using or improving intelligence, thereby weakening growth mindset effects [**?**, **?**]. Another study using societal mindset patterns as a psychological affordance indicator found that growth mindset positively predicted academic achievement across all subjects (math, science, reading), but this association was stronger in societies with growth-mindset norms [**?**, **?**].

In a nationally representative sample of 65 U.S. high schools (N=12,486), an online growth mindset intervention was delivered via the internet. At the intervention's conclusion, peer norms (a psychological affordance indicator) were measured through a behavioral challenge-seeking task ("Create a Math Worksheet"). Results showed that intervention group GPA was significantly higher than control group GPA when students were surrounded by behavioral norms supporting growth mindset beliefs. In learning environments where peers sought academic challenges (high affordance), growth mindset significantly promoted academic achievement; conversely, in environments with weaker challenge-seeking norms (low affordance), students benefited less from the growth mindset intervention [**?**, **?**]. More importantly, a double-blind experiment with 8,775 ninth-grade students and 223 teachers in the United States examined how teachers' mindsets (psychological affordance) and students' baseline mindsets (vulnerability)

influenced intervention effects. The study measured both students' and teachers' mindsets using scales. The intervention group received an online growth mindset intervention conveying the classic metaphor that the brain becomes stronger and smarter when learning from difficult challenges, after which students were asked to provide examples of putting growth mindset into practice. The control group received information about brain function and its relationship to memory and learning without mentioning neuroplasticity. Students' math achievement was measured 7-8 months later. Results showed that although the growth mindset intervention improved math achievement overall, it did not benefit all students equally. Students whose teachers held fixed mindsets in the classroom showed no improvement in ninth-grade math achievement, whereas students in classrooms with growth-mindset teachers showed significant gains. Critically, students who initially reported more fixed mindsets (high vulnerability) and were in growth-mindset teacher classrooms (psychological affordance) showed greater math achievement gains than students who were already more growth-minded at the study's outset [**?**, **?**]. This finding suggests that individuals experiencing vulnerability who also receive greater psychological affordance are most likely to benefit from growth mindset interventions.

4. Summary and Future Directions

Mindset research has proposed effective and scalable intervention methods, generating considerable interest in using growth mindset research to enhance educational achievement. However, as evidence accumulates, researchers have found that growth mindset effects exhibit substantial heterogeneity. Grounded in extensive empirical evidence, the Mindsets × Context theory proposes that growth mindset interventions are most effective only when individuals face vulnerability and environments provide psychological affordances. These findings offer new directions for optimizing interventions. However, deriving meaningful conclusions from psychological heterogeneity is challenging, particularly when examining real-world behaviors and policy-relevant outcomes. Therefore, several issues in this field require further clarification.

First, research on the heterogeneity of growth mindset effects is still in its early stages, and no definitive conclusions have been reached regarding when growth mindset is effective—this question awaits future investigation. As the literature review reveals, growth mindset research has transitioned from a first era characterized by theoretical model establishment to a second era focused on intervention research. The first era originated in the 1960s-1970s with research on learned helplessness [**?**, **?**], attribution theory, and achievement goal theory [**?**, **?**], addressing how beliefs about ability malleability organize learned helplessness, attributions, and goals into a meaning system that influences behavior and achievement [**?**, **?**]. The second era of intervention research began in the 21st century, focusing on how to intervene on beliefs to alter individuals' long-term developmental trajectories [**?**, **?**, **?**]. Current research on effect heterogeneity and boundary conditions represents the main content of this in-

tervention era. This paper has focused on two boundary factors influencing growth mindset effect heterogeneity: intervention recipients' vulnerability and intervention contexts' psychological affordances. Additionally, cross-cultural research has found that definitions of intelligence (U.S. students tend to measure intelligence through crystallized intelligence, while Chinese students value fluid intelligence more) and understandings of growth mindset (whether mindsets form a continuum from fixed to growth or represent two independent factors) also significantly moderate growth mindset effects [**?**, **?**, **?**]. So, what are the most core moderating variables? To answer this question, researchers have primarily used meta-analysis. However, meaningful conclusions are difficult to draw from meta-analyses because when different studies involve different populations, interventions, and environments simultaneously, understanding the sources of heterogeneity becomes challenging. Since meta-analyses typically evaluate moderating variables at the overall level across studies rather than analyzing moderation effects within individual studies, and since included studies often simultaneously alter participant groups, environments, and intervention methods, moderating variables become confounded. Therefore, the current primary method for examining growth mindset effect heterogeneity—meta-analysis—is not well-suited for understanding moderating variables. In fact, large-scale, rigorous randomized controlled experiments are highly effective for resolving heterogeneity debates arising from meta-analyses [**?**, **?**]. Only by keeping intervention strategies and target populations constant while conducting randomized controlled experiments across different contexts can we effectively determine whether environmental heterogeneity is meaningful. Thus, to clearly answer when growth mindset is effective, future research must employ large-scale, rigorous randomized controlled experiments.

Second, the Mindsets × Context theory provides an excellent framework for understanding growth mindset effect heterogeneity, helping answer for whom and under what conditions growth mindset is effective, thereby enabling prediction of heterogeneous outcomes and advancing theoretical and methodological development. However, it does not adequately answer *why* growth mindset is effective. According to the theory, growth mindset interventions produce meaningful effects only when individuals actively face challenges or setbacks (e.g., when they have low grades or face difficult courses or school transitions) and when environments provide opportunities for students to act according to their mindsets. To date, most research has focused on the moderating effects of psychological affordance and vulnerability, but few studies have examined the underlying mechanisms. Based on mindset theory and empirical evidence, this paper proposes that psychological affordance moderates the relationship between mindset and meaning-system-related motivational and behavioral patterns, thereby influencing academic achievement. First, psychological affordance moderates the relationship between growth mindset and meaning systems. Mindset theory posits that growth mindset leads students toward positive effort beliefs, mastery goals, and mastery-oriented behaviors, whereas fixed mindset leads to negative effort beliefs, performance goals, and helpless behaviors in achievement

contexts [?, ?, ?]. However, the relationship between mindset and meaning systems may be more complex than assumed; students holding the same mindset may not be a homogeneous group, and their motivational patterns may differ [?, ?]. For example, U.S. research found that students reported mastery goals alongside growth mindset but found no evidence linking fixed mindset with performance goals [?, ?]. A longitudinal study of German elementary students found that children with fixed mindsets were more likely to adopt high-mastery/high-performance goal patterns [?, ?]. Research in Hong Kong showed that growth mindset beliefs could predict both mastery and performance-approach goals [?, ?]. Preliminary empirical research indicates that meaning system effects are moderated by psychological affordance. For example, a correlational study using structural equation modeling found that growth mindset improved academic performance through practice only in high-mobility environments, with non-significant relationships in low-mobility environments [?, ?]. Another experimental growth mindset intervention study showed that participants' growth mindsets translated into learning-oriented choices only when teachers provided supportive growth-mindset messages and opportunities. In growth-mindset teacher conditions, participants reporting more growth mindset were more likely to choose challenging, learning-promoting assignments over simple review assignments, whereas in fixed-mindset teacher conditions, these relationships were non-significant [?, ?]. Second, psychological affordance researchers [?, ?] propose that affordance may operate through two pathways: first, by supporting or contradicting the validity of individuals' held beliefs. For example, if teachers consistently imply that student abilities are fixed—some students are smart, others are not—students are less likely to view the classroom as a context where growth mindset applies, leading to different attributions for setbacks and failure and different achievement goals. Second, affordance can influence whether belief-based behaviors are useful for individuals in that context, thereby affecting their motivation to act according to their beliefs. In summary, this paper argues that psychological affordance (high academic mobility, teacher growth mindset, etc.) makes growth-minded individuals (especially vulnerable individuals with low grades or facing challenging courses or transitions) more likely to pursue learning goals (rather than avoid looking incompetent), attribute failure to controllable factors like effort and strategy (rather than fixed low ability), and believe they can improve through effortful learning, leading to higher academic achievement. In other words, meaning systems can theoretically address the "why" question that Mindsets × Context theory has not answered. Whether this perspective withstands empirical testing awaits future research.

Third, as understanding of growth mindset and psychological affordance deepens, the next major challenge will be helping teachers provide more psychological affordance for students. The core tenet of Mindsets × Context theory is that interventions need further customization before they can be delivered to different populations [?, ?]. In other words, growth mindset interventions may not benefit everyone, and educators can design targeted interventions and provide

additional support for those most likely to benefit from mindset interventions. Previous research on sources of heterogeneous growth mindset effects has focused on intervention quality (e.g., number of sessions, delivery method) [?, ?] and structural opportunities (e.g., learning trajectories, teaching quality) [?, ?]. This provides prerequisites for research on psychological affordance and vulnerability, because mindset change only improves outcomes when other aspects needing improvement in the system are in place [?, ?]. If growth mindset interventions are ineffective in chaotic or under-resourced schools, this may signal the need for structural reforms to increase learning resources and opportunities. If students have adequate learning resources and opportunities, and growth mindset interventions are successfully implemented but still fail to produce expected effects, this may signal the need to examine psychological affordance and vulnerability issues and develop further customized intervention plans to shape contexts and provide more psychological affordance for students [?, ?]. Preliminary research shows that university STEM faculty's growth mindset significantly and positively predicts minority students' academic achievement in their courses [?, ?], and students' perceptions of their instructors' growth mindset predict reduced psychological vulnerability in class (i.e., decreased evaluation concerns and increased sense of belonging), which in turn predicts greater engagement, interest, and course performance [?, ?]. These findings generally point to teachers' influential role in shaping classroom growth mindset.

How, then, can teachers use their classroom influence to create psychological affordance for student growth mindset? According to Mindsets × Context theory, teachers with fixed mindsets may convey that only some students have the talent to achieve good grades [?, ?, ?]. This may lead students to believe they will be negatively evaluated if they must work hard or ask questions about material they don't understand, preventing them from acting on their growth mindset. Teachers with growth mindsets may convey in the classroom that mistakes are learning opportunities rather than signs of low ability, and support this view by rewarding assignments and assessments that show continuous improvement [?, ?, ?], thereby encouraging students to continue acting on their growth mindset. However, compared to physical affordances as tangible environmental features, psychological affordances may be more difficult for individuals to perceive. Evidence shows inconsistencies between teachers' self-reported mindsets and students' perceptions of their teachers' mindsets [?, ?]. Past teacher-centered interventions using belief-focused, practice-light approaches have also proven ineffective [?, ?, ?]. In other words, simply identifying teachers' mindsets as a moderating factor does not reveal what teaching practices encourage students to act according to their growth mindset beliefs. Therefore, to understand how teachers' behaviors provide psychological affordance for growth mindset, we must consider what makes these behaviors visible and meaningful to students. Future research should hypothesize and manipulate teachers' classroom practices to guide students' perceptions of teachers' beliefs, making teachers' growth mindsets clearly visible and students' growth mindsets appear reasonable, rewarding, and actionable—this will have practical

significance and provide a foundation for subsequent applications utilizing teachers' instructional practices. Meanwhile, designing interventions based solely on affordance features may be insufficient; cultural characteristics must also be considered. Some researchers note that when cultural norms already demand hard work, growth mindset may not further increase test scores and may have no significant effect on Chinese mainland students' achievement [**?**, **?**]. Sociocultural values and social norms are important components of psychological affordance. China has significantly different sociocultural values and norms from the West: Chinese culture both emphasizes effort (e.g., "with enough effort, an iron rod can be ground into a needle") and stresses the importance of innate talent (e.g., "rotten wood cannot be carved"). Chinese social norms may also tend to emphasize performance and competition [**?**, **?**]. Therefore, individuals in Chinese culture may emphasize effort regardless of whether they endorse growth mindset [**?**, **?**, **?**]. In summary, how to help teachers provide effective psychological affordance for students based on Chinese culture to promote better student development represents an important direction for future research.

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