Effects of Inquiry–Based Learning in Mathematicson Growth Mindset of First–Year Students in Chinese Higher Vocational School

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Abstract

This study seeks to examine the effect of inquiry–based learning program of a growth mindset. The research aimed: (1) to compare growth mindset scores among participants in the experimental group before and after engaging in inquiry–based learning; and (2) to compare growth mindset scores between the experimental and control groups after experiment. The study involved a total of 358 freshmen enrolled at Jiuquan Polytechnic College. From this cohort, 40 students with baseline growth mindset scores ranging from 30 to 60 were selected and randomly assigned to either the experimental or control group, with 20 students in each. The experimental group underwent structured inquiry–based learning, while the control group joined traditional instruction. Two instruments were employed in this study: (1) an inquiry–based learning program comprising five sequential phases—Engage, Explore, Explain, Elaborate, and Evaluate, which was implemented in higher mathematics teaching involving core contents of functions, limits, continuity, derivatives, and definite integrals; and (2) the growth mindset Scale, which exhibited strong internal consistency reliability (Cronbach's Alpha = 0.921). Data analysis encompassed descriptive statistics, paired–sample t–test and independent t–test.

The research findings revealed the following: 1) the growth mindset of first–year students who participated in inquiry–based learning program were significantly higher than before experiment at level of 0.001.; 2) the growth mindset of first–year students who participating in inquiry–based learning program were significantly higher than students who participated in traditional instruction at level of 0.001.

Keywords: growth mindset; inquiry–based learning; higher vocational freshmen

Introduction

In the context of rapid technological advancement and evolving educational paradigms, cultivating a growth mindset among students has emerged as a crucial goal in modern pedagogy. The growth mindset, a concept popularized by Dweck (2006), refers to the belief that intelligence and abilities are malleable and can be developed through sustained effort, resilience, and strategic

learning. This perspective contrasts sharply with a fixed mindset, which posits that intelligence is innate and static. Research consistently indicates that students with a growth mindset exhibit greater academic perseverance, embrace challenges, and are more resilient in the face of setbacks (Blackwell et al., 2007).

In China, the Ministry of Education has emphasized the development of core competencies in students, including self–regulation, emotional resilience, reflective thinking, and lifelong learning attributes inherently aligned with a growth mindset. National vocational curriculum documents confirm that most–higher vocational entrants possess weak pre–college mathematical foundations and fear abstract logical deduction (Ministry of Education of the People's Republic of China, 2019). This is particularly significant in the context of higher vocational education, where students often face both external social stigma and internalized academic self–doubt. Many vocational college students believe that their learning potential—especially in traditionally challenging subjects like mathematics—is fixed and limited (Boaler, 2009). These beliefs can inhibit motivation, engagement, and long–term academic success.

Cultivating growth mindset for vocational freshmen is urgent under national vocational education policies, industrial talent demands and students' psychological reality (Ministry of Education of the People's Republic of China, 2019). National math curriculum standards take anti–frustration and lifelong learning as core training targets consistent with growth mindset connotations; surveys confirm most freshmen hold innate math talent fixed stereotypes that harm career competitiveness. Abstract mathematical logic easily consolidates rigid ability cognition, making mathematics the optimal intervention carrier.

Among all general compulsory courses for higher vocational freshmen, mathematics is the discipline that most easily triggers and consolidates students' fixed mindset stereotypes. Different from hands–on professional courses with intuitive feedback, vocational mathematics relies on abstract symbolic reasoning. When students repeatedly fail mathematical exercises, they tend to attribute poor performance to inborn talent rather than insufficient practice or flawed learning strategies, forming negative learning avoidance. Recent regional surveys of northwest vocational students show over 66% hold fixed views about mathematical ability. Therefore, mathematics classrooms serve as an optimal intervention carrier to dismantle students' rigid ability cognition.

To address this issue, educators have explored various instructional strategies designed to foster a growth mindset, including project–based learning, transformative design, and inquiry–based learning (Cao, 2024). Among these, inquiry–based learning stands out for its student–centered nature and emphasis on critical thinking, exploration, and real–world problem solving (Supovitz et al., 2000; Harlen, 2013). The inquiry–based learning model, comprising Engage, Explore, Explain, Elaborate, and Evaluate, has been particularly effective in structuring inquiry–

based mathematics instruction that empowers students to take ownership of their learning and fosters metacognitive reflection.

This study investigates the effect of inquiry–based learning in mathematics on the growth mindset of first–year students in Chinese higher vocational institutions. By focusing on students at Jiuquan Polytechnic College, the research aims to address critical challenges in vocational education and provide empirical evidence on the effectiveness of inquiry–based pedagogy in enhancing students' psychological and academic development. The findings are expected to inform both classroom practices and broader educational strategies aimed at nurturing resilient, self–directed learners who are better equipped to thrive in a rapidly changing world.

Objectives

1. To compare the difference in growth mindset scores before and after participating in inquiry–based learning in Mathematics in the experimental group.

2. To compare the difference in the growth mindset scores between the control and experimental groups after participating in inquiry–based learning program in Mathematics.

Literature Review

Growth mindset, established significantly by Dweck (2006), refers to the core belief that an individual's talents, intelligence, and basic abilities can be developed over time through practice, persistent effort, and hard work. Individuals possess either a growth mindset or a fixed mindset. Those with a fixed mindset perceive intelligence as innate and unchangeable, leading to maladaptive behaviors such as avoiding challenging work, experiencing helplessness, and easily giving up in the face of academic setbacks. Conversely, individuals with a growth mindset view intelligence as maleable and developable, embrace challenges, enjoy the learning process, and recover quickly from failures. Research has consistently indicated that students who possess a growth mindset exhibit greater academic motivation, deal more effectively with real–world mathematics problem–solving tasks, and demonstrate higher academic achievement.

Inquiry learning refers to a student–centred pedagogy that uses purposeful, extended investigation in real–life problems to improve student competence and as a feedback loop that increases teacher insight into student thought processes. Inquiry–based learning allows students to engage in courses by connecting with the real world. This type of learning will also help teachers better understand students' thought processes and their understanding (Marshall et al., 2017). There are five stages of learning in guided inquiry to help provide guidance and modelling. The first stage is an introduction, where students start and open. This is followed by the exploration phase, in which students explore ideas and background information. Next is the Explain stage, where students share the methods and skills used in the exploration process in an all–round way. Then, there is Elaboration when the student understands the application. Finally, there is

assessment, in which students assess their understanding and abilities. Inquiry-based learning usually involves students working in small groups. Students' mathematical thinking and teaching strategies will contribute to students' success in mathematics (Bostwick et al., 2020). Open math tasks allow students to become interrogators. Students not only find answers but also think critically. This helps students take ownership of their learning, which will help foster a growth mindset (Dweck, 2015). Students' ability to learn from their mistakes is rooted in their growth mindset.

Research Conceptual Framework

This study adopted a quasi-experimental research design to investigate the effect of inquiry-based learning program in mathematicson the development of a growth mindset. The specific research framework is outlined as follows:

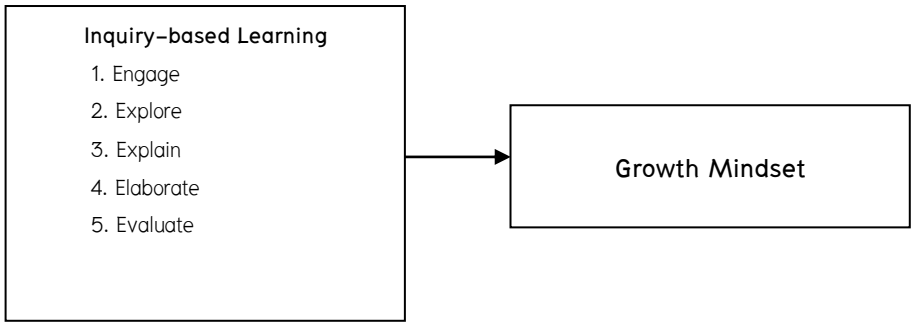


Figure 1 Conceptual Framework

Research Methodology

This study adopted a quasi-experimental design, with inquiry learning as the independent variable and growth mindset as the dependent variable. The research design divided the samples into experimental and control groups. After the pre-test, the experimental group adopted inquiry-based learning, while the control group adopted traditional imparted learning. The two groups compared the post-test results to investigate the impact of inquiry-based learning on growth mindset of first-year students in higher vocational schools.

1) Populations and Sampling

The research population consisted of 358 first-year students enrolled in the School of Civil Engineering at Jiuquan Polytechnic. All participants uniformly completed the growth mindset Scale pre-test to measure their baseline psychological level. Based on pre-test results, 40 students with scores ranging from 30 to 60 and moderate fixed mindset tendencies were screened as subsamples, and matched grouping was adopted to set the experimental group and control group with 20 participants each. The experimental group underwent instruction through inquiry-based learning, while the control group received standard didactic instruction.

2) Variables

The independent variable of this study is inquiry–based learning, and the dependent variable is a student growth mindset.

3) Research Tools/Instruments

3.1) Inquiry–based learning program

Inquiry–based learning is an instructional approach in which students, guided by teachers, engage in identifying problems, gathering relevant materials, solving problems, and presenting and explaining findings within the context of teaching activities. Throughout this process, students actively construct, acquire, and apply knowledge. Inquiry–based learning enhances students' critical thinking, practical skills, and scientific literacy. The inquiry–based teaching plan comprises 11 activities, each structured around five sequential phases: Engage, Explore, Explain), Elaborate, and Evaluate. Based on expert feedback from three specialists, the teaching plan was refined and subsequently piloted.

3.2 Growth Mindset Scale

The growth mindset Scale employed in this research was originally developed by Dweck (2015) and has been appropriately adapted to reflect the pedagogical characteristics of mathematics instruction in higher vocational colleges. The revised version of the scale consists of 24 items, each with four response options. The scoring system is structured as follows: Strongly Agree corresponds to 4 points, Agree to 3 points, Disagree to 2 points, and Strongly Disagree to 1 point.

To ensure content validity, input from three subject matter experts was solicited. The Item Objective Consistency (IOC) index was utilized as a quantitative measure of validity, and only items with IOC values between 0.67 –1.00 were retained. The revised version of the scale demonstrated high internal consistency, with a Cronbach's alpha coefficient of 0.921. These results suggest that the adapted growth mindset Scale possesses adequate psychometric properties and is suitable for use within the context of this study.

4) Data Collection

Step1: Pretest

All participating students were assessed prior to the commencement of the experiment to determine their baseline levels of growth mindset. Each student completed a standardized questionnaire, evaluating each item on a 4–point Likert scale based on their personal circumstances. A higher cumulative score reflects a more pronounced growth mindset orientation. Subsequently, forty participants whose scores ranged from 30 to 60 were randomly and evenly assigned to two experimental groups, each consisting of twenty individuals, to proceed with the subsequent phase of learning and evaluation.

Step 2: Experiment

At this stage, the experimental group received inquiry–based learning, whereas the control group did not, in order to investigate the impact of inquiry–based learning on the development of a

growth mindset. This study utilizes the teaching content of higher vocational mathematics as the experiment tool for implementing inquiry-based learning. The specific implementation process is structured into five stages: engage, explore, explain, elaborate, and evaluate, with the aim of guiding participants to actively engage in the learning process and enhance their growth mindset. The inquiry-based learning experiment spans four weeks, conducted three times per week, with each session lasting two hours.

Step 3: Post-test

Following the completion of the inquiry-based learning program, a post-test was administered to all participating students to evaluate potential shifts in their growth mindset. The same validated growth mindset scale used in the pre-test was employed for the post-test assessment.

5) Data analysis

Data analysis was conducted using SPSS statistical software. Descriptive statistical analysis and t-test were utilized to examine and compare the growth mindset scores of the experimental and control groups. Prior to the experiment, an independent samples t-test was performed on the pre-test data to assess baseline equivalence, yielding mean values and corresponding t-values. Following the experiment, both groups completed a posttest, and a subsequent t-test was conducted to evaluate post-experiment performance. A comparative analysis of pre-test and posttest scores indicated that the experimental group not only outperformed the control group in the posttest but also demonstrated a notable improvement from its own pre-test scores.

Further analysis using paired samples t-tests revealed statistically significant differences in the experimental group's scores before and after the experiment. Moreover, a statistically significant difference was observed between the posttest scores of the experimental and control groups, suggesting the experiment had a measurable effect on fostering a growth mindset.

Result

Research Objectives1: The result indicates that the pre-experiment average scores for growth mindset were 1.831 in the experimental group and 1.958 in the control group. A statistical significance test comparing these scores yielded a p-value of 0.484, which exceeds the conventional alpha level of 0.05. This outcome demonstrates that there was no statistically significant difference in growth mindset between the two groups prior to the implementation of the inquiry-based learning experiment. Consequently, it is methodologically sound to proceed with administering the inquiry-based learning program to the experimental group. As shown in table 1.

Table 1 Analysis of differences of growth mindset between the experimental group and the control group before the experiment

Variable	Group	N	Mean	S.D.	T	P
Growth Mindset	control	20	1.958	0.702	-0.707	0.484
	experiment	20	1.831	0.393		

The results showed that, following the implementation of inquiry-based learning in the experimental group, there was a notable increase in the average growth mindset score, rising from 1.831 to 3.185, which reflects a meaningful improvement compared to pretest. Statistical analysis revealed a significant difference in growth mindset scores before and after the experiment, with a p-value of less than 0.001. These findings provide strong evidence that inquiry-based learning had a significant effect on the development of growth mindset among students in the experimental group. As shown in table 2.

Table 2 Analysis of the Differences in growth mindset of the Experimental Group Before and After the Experiment

Variable	**Group**	**N**	**Mean**	**S.D.**	**T**	**P**
Growth Mindset	Pretest	20	1.831	0.393	13.948***	0.000
	Posttest	20	3.185	0.499		

*** p < .001

Research objectives2: The results indicated that following the implementation of the inquiry-based learning program, a statistically significant difference emerged in growth mindset development between the experimental group and the control group ($p < 0.001$). These findings reveal that students in the experimental group demonstrated considerably higher post-experiment growth mindset scores compared to those in the control group. As shown in table 3.

Table 3 Analysis of the differences in growth mindset between the experimental group and the control group after the experiment

Variable	**Group**	**N**	**Mean**	**S.D.**	**T**	**P**
Growth Mindset	Control	20	2.423	0.482	4.916***	0.000
	Experimental	20	3.185	0.499		

*** p < .001

Discussion

This study aims to investigate the effects of inquiry-based learning in mathematics on the development of a growth mindset among first-year students in Chinese higher vocational colleges. The research findings provide robust empirical support for both research hypotheses.

First, with respect to the first research objective, this study examines potential differences in growth mindset scores among students in the experimental group before and after their engagement in inquiry-based learning. The hypothesis posits that the average growth mindset

score of the experimental group will demonstrate a statistically significant increase following participation in the experiment. The results indicate that the growth mindset scores of students in the experimental group increased significantly after completing the inquiry–based learning program, with the difference reaching statistical significance ($p < 0.001$). These findings substantiate Hypothesis 1, suggesting that inquiry–based learning effectively contributes to the enhancement of students' growth mindset.

The results are consistent with Dweck's (2006) theory of growth mindset, which suggests that individuals who believe intelligence and abilities are malleable are more likely to embrace challenges, persist through difficulties, and recover from failure. The inquiry–based learning adopted in this study, the 5E learning model (Engage, Explore, Explain, Elaborate, Evaluate), encourages active participation, collaborative learning, and metacognitive reflection (Bybee et al., 2006; Marshall et al., 2017), all of which are conducive to nurturing a growth mindset. Research has shown that inquiry–based learning supports self–regulation, agency, and resilience among students. For instance, Blackwell et al. (2007) found that junior high school students who received growth mindset experiments showed improved academic motivation and achievement over time.

Compared with prior studies focusing on adolescents or undergraduates (Blackwell et al., 2007), this research innovatively targets higher vocational freshmen with fixed mathematical cognition, and adopts a complete four–week standardized 5E cycle rather than scattered inquiry activities to realize sustained psychological intervention (Sahagun et al., 2021). In the specific context of vocational education, this finding holds added significance. Students in vocational colleges often struggle with self–perception issues, believing their academic abilities, especially in subjects like mathematics, are fixed and limited (Boaler, 2009). Inquiry–based learning, by emphasizing effort, process, and collaborative problem–solving, helps dismantle these limiting beliefs. The learning process becomes a positive feedback loop where effort leads to success, which in turn reinforces a growth–oriented belief system (Paunesku et al., 2015; Yeager et al., 2016).

Moreover, the model used in this study provided multiple opportunities for students to explore problems independently and in groups, make mistakes safely, and receive scaffolded support from teachers. These conditions have been identified as critical in fostering intellectual risk–taking and long–term academic resilience (Kuhlthau, 2021).

In summary, the growth mindset scores in the experimental group confirms that inquiry–based learning program serves not only as a pedagogical tool but also as a psychological experiment. It enables students to shift their beliefs from fixed to growth–oriented, promoting greater motivation, persistence, and self–directed learning in vocational education.

Second, regarding the second research objective, this study compares the growth mindset scores between the experimental group and the control group after the implementation of inquiry–

based learning. The hypothesis assumes that the experimental group will exhibit significantly higher average growth mindset scores than the control group post-experiment. The findings confirm this assumption, as the data reveal that the experimental group's scores on the growth mindset scale were markedly higher than those of the control group ($p < 0.001$). This outcome provides evidence that inquiry-based learning is more effective than traditional teaching methods in promoting the development of a growth mindset among vocational college students.

Inquiry-based learning promotes an active, student-centered classroom environment where learners are encouraged to explore problems, engage in collaboration, and reflect on their learning processes. This contrasts sharply with conventional instruction, which tends to emphasize passive knowledge acquisition and memorization (Hmelo-Silver et al., 2007). The student-centered design of inquiry-based pedagogy supports the psychological development of learners by encouraging intellectual risk-taking, learning from failure, and persistence in solving complex problems (Zimmerman, 2002; Kuhlthau, 2021).

The superiority of inquiry-based learning observed in this study is also supported by prior research. For example, Boaler (2016) argue that engaging students in challenging, open-ended tasks within a supportive environment enhances their belief in their own potential and fosters cognitive flexibility. In addition, students in the experimental group were more likely to experience a sense of autonomy and competence.

The findings are particularly meaningful in the vocational education context, where many students internalize negative beliefs about their academic abilities, especially in subjects such as mathematics (Boaler, 2009). Traditional instruction may reinforce fixed mindset beliefs by focusing heavily on correct answers and penalizing mistakes, whereas inquiry-based learning allows students to engage in authentic learning experiences that emphasize the value of effort, revision, and resilience (Yeager & Dweck, 2012).

Moreover, the structure of the inquiry-based experiment in this study, based on the 5E model, provided repeated opportunities for students to take initiative, confront uncertainty, and receive formative feedback. These learning experiences served not only to build content knowledge, but also to reshape students' beliefs about learning, failure, and self-efficacy (Bandura, 1997; Harlen, 2013).

As a frontline vocational mathematics teacher, the author puts forward targeted, operable classroom suggestions derived from the present research findings: instructors ought to deliver process-focused feedback and design tiered mathematical tasks across all five phases of the 5E cycle, so as to gradually dismantle students' ingrained stereotypes that mathematical talent is innate (Rashid & Johnston-Wilder, 2025).

In conclusion, the comparative analysis between the experimental and control groups further reinforces the argument that inquiry-based learning program is a powerful tool for

cultivating growth mindset among vocational students. Beyond improving academic outcomes, it contributes to the development of essential psychological competencies, including persistence, optimism, and adaptive learning behavior.

New Knowledge from Research

This study clarifies the unique academic contribution of the standardized full–cycle 5E inquiry mathematics intervention developed herein, revealing its exclusive advantages in reshaping higher vocational freshmen's Growth Mindset and reconstructing their cognition of academic failure compared with fragmented inquiry activities and conventional lecture–based instruction.

First, unlike traditional mathematics teaching that judges learning outcomes solely by final scores and regards errors as proof of insufficient talent, the five sequential phases of the customized 5E model systematically restructure students' perception of failure. The Engage stage creates cognitive conflict to break ingrained fixed beliefs about innate mathematical ability; the Explore and Explain stages normalize trial–and–error group discussion and public sharing of flawed reasoning, guiding students to redefine failure as valuable exploratory feedback rather than a marker of limited talent; the Elaborate stage designs progressive vocational–oriented transfer tasks to let students experience capability improvement through repeated attempts; the multi–dimensional process evaluation adopted in the Evaluate stage eliminates single score assessment, decoupling personal worth and talent judgment from imperfect problem–solving results (Rashid & Johnston–Wilder, 2025). This complete psychological guidance chain cannot be realized by scattered, discontinuous inquiry designs adopted in most previous vocational education studies (Sahagun et al., 2021).

Second, the self–designed four–week, 11–lesson 5E inquiry scheme possesses prominent intervention strengths for vocational freshmen with low baseline Growth Mindset scores ranging from 30 to 60. Targeted at students with severe fixed mathematical stereotypes ignored by prior research, the sustained cyclic inquiry activities provide repeated opportunities for students to engage in independent exploration, accept constructive feedback and persist in tackling mathematical challenges. Long–term iterative stimulation effectively lifts their recognition of effort's developmental value and enhances internal learning motivation, producing far more stable Growth Mindset promotion effects than one–off fragmented inquiry tasks or independent mindset lecture interventions.

Third, the integrated dual–value attribute constitutes the core novelty of this research. The structured 5E inquiry program simultaneously serves as a subject teaching carrier and a targeted psychological intervention tool. Instead of separating mathematics knowledge teaching and Growth Mindset cultivation into two independent sessions, this design embeds mindset transformation guidance into daily compulsory mathematics classes, greatly improving operability and popularization value for frontline vocational mathematics teachers. Empirical data verify that

implementing the full 5E model in mathematics significantly outperforms conventional didactic instruction in fostering Growth Mindset among Chinese higher vocational first-year students; by shifting classroom logic from passive knowledge memorization to a student-centered atmosphere featuring collaborative problem-solving and tolerance of mistakes, this pedagogy achieves dual gains in mathematical literacy and adaptive psychological development that traditional teaching cannot replicate.

Conclusion

This research demonstrates that implementing a structured 5E inquiry-based learning program in mathematics significantly improves the Growth Mindset of first-year Chinese higher vocational students. The study provides strong empirical evidence that students participating in inquiry-based learning achieve significantly higher Growth Mindset scores compared to both their pre-test baselines and peers exposed to traditional instruction. By replacing passive, didactic teaching methods with a student-centered environment that emphasizes active exploration, collaborative problem-solving, and learning from mistakes, this pedagogical approach effectively doubles as a psychological intervention. Ultimately, these findings reveal that a structured inquiry framework can successfully dismantle deeply ingrained academic self-doubt and fixed-mindset barriers, offering a scalable solution to support the psychological and academic development of students facing external and internalized stigmas in vocational education.

Suggestions

Suggestion for Implementing the Research Findings

Based on the significant effect of inquiry-based learning on students' growth mindset, the following practical recommendations are proposed for educators, curriculum developers, and policymakers:

1) Teachers in vocational colleges are encouraged to integrate the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate) to create interactive, student-centered learning environments. This model effectively balances conceptual understanding with the development of a growth mindset.

2) Educational institutions should implement a structured professional development framework to train vocational teachers to shift from praising innate ability to praising effort, strategy, and process. This includes training teachers to identify and reflect on fixed-mindset language in their daily instructional habits, providing explicit guidelines on framing mistakes as constructive learning steps, and offering actionable feedback focused on effort and problem-solving. Additionally, it involves establishing continuous peer-mentoring loops where teachers observe classroom dynamics and support each other in maintaining growth-oriented communication.

2. Suggestions for Future Research

1) As this study was conducted within a single vocational college with a limited sample size, future research should incorporate multi–institutional samples across diverse geographical regions to enhance the generalizability of the findings.

2) Researchers should adopt longitudinal research designs to evaluate the long–term stability and sustainability of mindset changes over time. Tracking students across multiple academic terms or into their transition into the workforce would clarify whether the benefits of inquiry–based learning endure over time.

3) Future studies could examine the direct and indirect influences of inquiry–based learning on related constructs such as academic motivation, self–efficacy, grit, and learning autonomy.

References

Bandura, A. (1997). *Self–efficacy: The exercise of control*. W. H. Freeman.

Blackwell, L. S., Trzesniewski, K. H., & Dweck, C. S. (2007). Implicit theories of intelligence predict achievement across an adolescent transition: a longitudinal study and an intervention. *Child development*, *78*(1), 246–263. https://doi.org/10.1111/j.1467–8624.2007.00995.x

Boaler, J. (2009). *The elephant in the classroom: Helping children learn and love mathematics*. Souvenir Press.

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. Jossey–Bass/Wiley.

Bostwick, K. C., Collie, R. J., Martin, A. J., & Durksen, T. L. (2020). Teacher, classroom, and student growth orientation in mathematics: a multilevel examination of growth goals, growth mindset, engagement, and achievement. *Teaching and Teacher Education, 94,* Article ID: 103100. https://doi.org/10.1016/j.tate.2020.103100

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins, effectiveness, and applications.* Colorado Springs BSCS.

Cao, Y. (2024). Project–based learning and growth mindset development in vocational classrooms. *China Vocational Education Review*, *40*(2), 58–66.

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.

Dweck, C. S. (2015, September 22). *Carol Dweck revisits the 'growth mindset'*. Education Week. https://www.edweek.org/leadership/opinion–carol–dweck–revisits–the–growth–mindset/2015/09

Harlen, W. (2013). Inquiry–based learning in science and mathematics. *Review of Science, Mathematics & ICT Education*, *7*(2), 9–33. https://doi.org/10.26220/rev.2042

Hmelo–Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem–based and inquiry learning: A response to Kirschner, Sweller, and Clark. *Educational Psychologist*, *42*(2), 99–107. https://doi.org/10.1080/00461520701263368

Kuhlthau, C. C. (2021). *Guided inquiry: Learning in the 21st century.* In IASL Annual Conference Proceedings. DOI:10.29173/iasl7647

Marshall, J. C., Horton, R. M., & Smart, J. (2017). 4E × 2 Instructional model: Uniting three learning constructs to improve praxis in science and mathematics classrooms. *Journal of Science Teacher Education, 20*(6), 501–516. DOI:10.1007/s10972–008–9114–7

Ministry of Education of the People's Republic of China. (2019). *Guiding opinions on the formulation and implementation of talent training programs for vocational colleges*. http://www.moe.gov.cn/srcsite/A07/moe_953/201906/t20190618_386287.html

Paunesku, D., Walton, G. M., Romero, C., Smith, E. N., Yeager, D. S., & Dweck, C. S. (2015). Mind–set interventions are a scalable treatment for academic underachievement. *Psychological Science*, *26*(6), 784–793. https://doi.org/10.1177/0956797615571017

Rashid, M. S., & Johnston–Wilder, S. (2025). Building bridges, not barriers: A brief study of developing mathematical resilience in FE GCSE mathematics resit students. *Creative Education*, *16*(10), 1637–1650. DOI: 10.4236/ce.2025.1610100

Sahagun, M. A., Moser, R., Shomaker, J., & Fortier, J. (2021). Developing a growth–mindset pedagogy for higher vocational education. *Social Sciences & Humanities Open*, *4*(1), 100168. https://doi.org/10.1016/j.ssaho.2021.100168

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on science teaching practices and classroom culture. *Journal of Research in Science Teaching, 37,* 963–980.

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist*, *47*(4), 302–314. https://doi.org/10.1080/00461520.2012.722805

Yeager, D. S., Romero, C., Paunesku, D., Hulleman, C. S., Schneider, B., Hinojosa, C., Lee, H. Y., O'Brien, J., Flint, K., Roberts, A., Trott, J., Greene, D., Walton, G. M., & Dweck, C. S. (2016). Using design thinking to improve psychological interventions: The case of the growth mindset during the transition to high school. *Journal of Educational Psychology*, *108*(3), 374–391. https://doi.org/10.1037/edu0000098

Zimmerman, B. J. (2002). Becoming a self–regulated learner: An overview. *Theory into Practice, 41,* 64–70. http://dx.doi.org/10.1207/s15430421tip4102_2