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Interaction Effects of Design Thinking-Based Learning and Adversity Quotient on Students' Learning Independence and Creative Thinking Skills

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Abstract: This study investigated the effect of Design Thinking-Based Learning (DTBL) on students' learning independence and creative thinking skills based on adversity quotient (AQ). A quasi-experimental pretest–posttest control group design was employed involving 69 tenth-grade students of SMA Negeri 1 Sidrap. The experimental group was taught using DTBL, while the control group received Project-Based Learning (PjBL). Learning independence was measured using a self-regulated learning questionnaire, creative thinking skills were assessed using a Torrance-based creative thinking test, and AQ was measured using an adaptation of Stoltz's Adversity Response Profile (ARP). Data were analyzed using descriptive statistics and factorial Analysis of Covariance (ANCOVA). The results showed that DTBL significantly affected learning independence ($F = 4.602$, $p = 0.036$) and creative thinking skills ($F = 5.052$, $p = 0.028$). The mean posttest score of learning independence in the DTBL class ($M = 109.23$) was higher than that of the PjBL class ($M = 103.00$), while the mean creative thinking score in the DTBL class ($M = 61.74$) also exceeded that of the PjBL class ($M = 59.85$). AQ significantly influenced learning independence ($F = 9.222$, $p = 0.003$), but not creative thinking skills ($p = 0.279$). A significant interaction between learning model and AQ was found on learning independence ($p = 0.020$), whereas no interaction effect was observed on creative thinking skills ($p = 0.813$). Therefore, DTBL was more effective than PjBL in improving students' learning independence and creative thinking skills.

Keywords: Adversity quotient; Creative thinking; Design thinking based learning; Learning independence; Project-based learning

Introduction

Biology learning requires students not only to understand scientific concepts but also to actively construct knowledge, solve problems, and develop creativity (Lombardi et al., 2021). However, despite the growing emphasis on 21st-century skills, many biology learning practices still position students as passive recipients of information, resulting in low learning independence and limited creative thinking skills (Ismaniati et al., 2025). This condition becomes problematic because biology contains many complex and abstract concepts that require students to think critically, explore alternative solutions, and independently manage their learning processes. Therefore, innovative learning approaches are needed to create more meaningful, interactive, and student-centred learning experiences to address these challenges, innovative learning models are needed to create more meaningful and interactive biology learning experiences (Zurmanely et al., 2025).

One promising approach is Design Thinking-Based Learning (DTBL), which integrates student-centred problem solving through the stages of empathise, define, ideate, prototype, and test. Through these iterative stages, students are encouraged to analyse problems, generate ideas, test solutions, and continuously improve

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their work. DTBL also promotes active participation, reflection, collaboration, and experimentation during the learning process, thereby increasing students' engagement and motivation in biology learning (Atchia, 2023; Fajrina et al., 2024).

DTBL has been widely recognised as an effective approach for increasing student engagement and academic achievement (Asrin et al., 2024). Nevertheless, previous studies indicate that its effectiveness in fostering learning independence and creative thinking remains inconsistent. A meta-analysis revealed that although DTBL positively affects learning achievement, its influence on students' independence does not automatically occur without intensive guidance and sufficient learning duration. Limited curriculum integration and constraints during the prototyping and testing stages often hinder students from optimally developing originality and autonomous learning skills (Yu et al., 2024). In addition, students frequently experience anxiety, uncertainty, and frustration during repeated revisions and prototype failures in DTBL activities. These conditions may reduce students' confidence and increase dependence on teacher guidance, particularly among students who have limited ability to cope with difficulties (Dorland, 2024). Therefore, students' personal resilience may become an important factor influencing the effectiveness of DTBL implementation.

Learning independence is an essential competence that influences students' academic success, particularly in biology learning, which requires initiative, persistence, and critical thinking. Independent learning includes students' ability to manage learning activities, plan and evaluate learning processes, and demonstrate responsibility and self-confidence in completing tasks. According to Hasan et al. (2024) independent learning refers to students' ability to organise and regulate their own learning without excessive dependence on teachers or peers. However, students' learning independence remains relatively low, as reflected in their dependence on teachers and peers during learning activities. This condition becomes a serious challenge because low learning independence is associated with weaker learning outcomes and limited problem-solving abilities in biology learning approaches that actively engage students in problem solving and self-regulated learning are urgently needed (Samaniego et al., 2024).

Design thinking-based learning supports the development of learning independence because students transform from passive recipients of information into active problem-solvers who are responsible for their own learning process (Dwi et al., 2024; Wulandari, 2022). The iterative stages of DTBL require students to manage learning strategies, evaluate progress, revise solutions, and maintain confidence when facing uncertainty. Through this process, DTBL not only facilitates knowledge construction but also strengthens students' autonomy and responsibility in learning (Hasbiyati et al., 2023; Tsai et al., 2023).

In biology learning, Project-Based Learning (PjBL) has also been widely implemented because it encourages collaboration, contextual learning, and active student participation (Al-Qoyyim & Kurniawan, 2025). However, PjBL frequently emphasises project completion and final products rather than iterative redesign and reflective problem solving. Consequently, students may complete projects successfully without deeply engaging in repeated evaluation, revision, and creative exploration processes. In contrast, DTBL explicitly incorporates empathy, prototyping, testing, and iterative refinement, which provide broader opportunities for students to develop learning independence and creative thinking through continuous experimentation and solution improvement. Therefore, DTBL is considered potentially more effective than PjBL in fostering students' learning independence and creative thinking in biology learning contexts (Fatimah et al., 2023).

Creative thinking is another essential competence in biology education because students are required to generate original ideas and solve problems flexibly (Fatmawati et al., 2022; Heryadi et al., 2021; Tengku, 2022). Creative thinking includes originality, fluency, flexibility, and elaboration in producing ideas and solutions. DTBL is considered capable of developing these skills because its iterative learning stages encourage students to explore various alternatives, analyse problems critically, and continuously improve solutions. Supported by Guilford's divergent thinking theory and Duncker's productive thinking theory, DTBL facilitates students in constructing creative solutions through experimentation and collaborative problem solving (Muneer et al., 2025). Nevertheless, not all students are equally capable of adapting to uncertainty, repeated revisions, and failures during the DTBL process.

One factor that may influence students' success in participating in DTBL activities is adversity quotient (AQ) (Unaida et al., 2023). AQ refers to an individual's ability to survive and persist when facing difficulties, uncertainty, and challenges. According to Saxena et al. (2025), AQ consists of four dimensions: control, ownership, reach, and endurance. Individuals with high AQ are more capable of managing setbacks, maintaining optimism, and persisting in difficult situations. This construct becomes highly relevant in DTBL because students are repeatedly confronted with prototype failures, revisions, and problem-solving deadlocks throughout the learning process.

DTBL can therefore be regarded as a high-risk learning model because students must continuously deal with uncertainty, criticism, and repeated revisions. In this situation, AQ becomes an important factor determining whether students are able to maintain learning independence and creative thinking during DTBL implementation. Students with high AQ tend to persist when prototypes fail and remain responsible for their learning despite encountering obstacles. Conversely, students with low AQ are more likely to become frustrated, lose confidence, and depend excessively on teacher assistance. Thus, AQ may strengthen or weaken the effectiveness of DTBL in fostering students' learning independence and creative thinking (Zubaedi, 2025).

Previous studies on DTBL have mainly focused on creativity and cognitive achievement, while studies on AQ have predominantly been conducted in workplace and healthcare contexts. Research integrating AQ into innovative learning models in biology education remains limited. In addition, studies examining learning independence and creative thinking are generally conducted separately, and few studies have simultaneously compared DTBL and PjBL in biology learning contexts (Safitri et al., 2024; Zulyusri et al., 2023). Therefore, the novelty of this study lies not only in integrating DTBL and adversity quotient (AQ), but also in positioning AQ as a factor that may explain why DTBL does not produce equal outcomes across students. In addition, this study simultaneously examines students' learning independence and creative thinking through a comparison between DTBL and PjBL in biology learning. Therefore, this study aims to analyse the effects of DTBL and AQ on students' learning independence and creative thinking in biology learning.

Method

This study employed a quantitative approach using a quasi-experimental method with a pretest–posttest control group design. This design was used to examine the effects of different instructional models on students' learning independence and creative thinking skills while controlling for initial differences between groups. A quasi-experimental design was selected because the participants were existing intact classes, making individual random assignment impractical (Yaghoobzadeh et al., 2023). The study was conducted at SMA Negeri 1 Sidrap during the 2025/2026 academic year. The population consisted of all Grade X students, while the sample was selected using a cluster random sampling technique, resulting in two classes consisting of 35 students in the experimental class and 34 students in the control class. The experimental class received instruction using the Design Thinking-Based Learning (DTBL) model, whereas the control class was taught using the Project-Based Learning (PjBL) model.

The intervention was conducted over six meetings consisting of one pretest session, four treatment sessions, and one posttest session. The learning activities focused on environmental change material for Grade X biology students. In the experimental class, students learned through the DTBL stages of empathise, define, ideate, prototype, and test, which encouraged students to analyse problems, generate ideas, test alternative solutions, and continuously revise their work. Meanwhile, students in the control class learned through project planning, implementation, and presentation activities based on the PjBL model. Before the treatment was implemented, both groups completed pretests measuring learning independence and creative thinking skills. At the end of the intervention, posttests were administered to identify changes in students' performance after the implementation of the instructional models (Novitri et al., 2022).

The research instruments consisted of a learning independence questionnaire, a creative thinking skills test, and an adversity quotient (AQ) questionnaire. The learning independence questionnaire consisted of 40 Likert-scale items covering indicators of learning initiative, learning needs diagnosis, goal setting, monitoring, and evaluation. The instrument included both positive and negative statements with four response alternatives: strongly agree, agree, disagree, and strongly disagree. Creative thinking skills were measured using an essay test administered during the pretest and posttest sessions. The test assessed four indicators, namely fluency, flexibility, originality, and elaboration, to identify changes in students' creative thinking skills after the implementation of the instructional models. The AQ questionnaire was adapted from Stoltz's Adversity Response Profile (ARP) and measured the dimensions of control, origin and ownership, reach, and endurance. The instrument consisted of 40 Likert-scale items and was used to classify students into high and low AQ categories based on the obtained scores. All instruments were validated by experts prior to implementation and pilot-tested to determine their reliability. Reliability analysis using Cronbach's alpha indicated that all instruments met acceptable reliability standards.

Data were collected through pretests and posttests administered to both groups. Descriptive statistics were used to present mean scores, percentages, standard deviations, and category classifications of students' learning independence, creative thinking skills, and AQ. Inferential statistical analysis was conducted using two-way Analysis of Covariance (ANCOVA), with pretest scores treated as covariates and posttest scores as dependent variables. ANCOVA was employed to

examine the effects of instructional models, AQ categories, and their interaction while controlling for initial differences between groups. Prior to hypothesis testing, the assumptions of normality and homogeneity of variance were examined using the Kolmogorov–Smirnov test and Levene's Test at a significance level of 0.05. Estimated Marginal Means (EMM) were further analyzed to examine adjusted mean differences between instructional models and AQ categories after controlling for covariates. Pairwise comparisons were also conducted as a post hoc analysis to identify specific differences between groups. All statistical analyses were performed using SPSS software with a significance level of 0.05 (Wan, 2020).

Result and Discussion

Results

The research results are presented based on descriptive and inferential statistical analysis. Inferential analysis using Two-Way ANCOVA was conducted to test the effect of the learning model and adversity quotient (AQ) on students' learning independence and creative thinking skills.

Table 1. Estimated Marginal Means of Learning Independence

Learning Model	AQ Level	Mean	Std. Error	95% CI Lower	95% CI Upper
DTBL	Low	106.81	3.15	100.50	113.11
DTBL	High	109.42	3.44	102.53	116.31
PjBL	Low	102.32	3.02	96.27	108.38
PjBL	High	106.43	3.46	99.51	113.34

The marginal averages show that students who learned using the DTBL model achieved higher learning independence scores than students who learned using the PjBL model in all adversity quotient categories. Students with high AQ also showed higher learning independence scores than students with low AQ in both learning models.

Table 2. ANCOVA Results for Learning Independence

Source	df	F	Sig.	Partial Eta Squared	Decision
Pre-learning independence	1	24.77	0.00	0.27	Significant
Learning model (DTBL)	1	4.60	0.03	0.06	Significant
Adversity quotient	1	9.22	0.00	0.12	Significant
Interaction (Model × AQ)	1	5.68	0.02	0.07	Significant

The results show that DTBL significantly affects learning independence ($p < 0.05$), with a moderate effect size. Adversity quotient also significantly contributes to learning independence, and a significant interaction indicates that students with higher resilience benefit more from DTBL-based instruction.

The ANCOVA results showed that the learning model significantly influenced student learning independence ($p < 0.05$). Students learning using DTBL had higher levels of learning independence than those learning using PjBL. Adversity quotient also significantly influenced learning independence, indicating that students with high AQ tended to be better able to regulate, maintain, and evaluate their learning process independently.

Table 3. Results of Pairwise Comparisons Test of Learning Independence Based on Adversity Intelligence Category

Learning Model	AQ Comparison	Mean Difference (I–J)	Std. Error	Sig.	95% CI Lower Boud	95% CI Upper Bound	Decision
DTBL	1–2	-8.21	3.93	0.04	-16.07	-0.34	Sig.
PjBL	1–2	-6.84	3.98	0.09	-14.81	1.11	Not Sig.

The interaction between the learning model and adversity quotient also showed significant results. These findings indicate that the effectiveness of DTBL in enhancing learning independence is influenced by students' AQ levels. Students with high AQ benefited more from DTBL implementation because they were able to maintain perseverance, responsibility, and initiative throughout the learning process. DTBL's characteristics, which involve repeated prototyping, testing, and revision, require resilience in the face of failure and uncertainty during the problem-solving process. Conversely, students with low AQ tended to have difficulty maintaining learning independence when faced with complex and iterative learning processes. These findings indicate that DTBL is a learning model that demands resilience so that students can maintain their learning independently.

Table 4. Estimated Marginal Means of Creative Thinking Skills

Learning Model	AQ Level	Mean	Std. Error	95% CI Lower	95% CI Upper
DTBL	Low	62.93	1.01	60.90	64.96
DTBL	High	59.70	1.16	57.36	62.03
PjBL	Low	60.76	1.03	58.69	62.83
PjBL	High	59.45	1.09	57.27	61.63

The marginal average shows that students who learned using DTBL obtained higher creative thinking skill scores than students who learned using PjBL. Interestingly, students with low AQ in the DTBL class obtained slightly higher scores than students with high AQ, although the difference was relatively small and statistically non-significant. This finding indicates that DTBL may provide a flexible and supportive learning environment that enables students across different AQ levels to explore ideas and develop creativity relatively equally.

Table 5. ANCOVA Results for Creative Thinking Skills

Source	df	F	Sig.	Partial Eta Squared	Decision
Pre-creative thinking	1	3.83	0.05	0.05	Not Significant
Learning model (DTBL)	1	5.05	0.02	0.07	Significant
Adversity quotient	1	1.19	0.27	0.01	Not Significant
Interaction (Model × AQ)	1	0.05	0.81	0.00	Not Significant

ANCOVA results showed that only the learning model had a significant effect on students' creative thinking skills. Students learning using DTBL demonstrated higher creative thinking skills than those learning using PjBL. Conversely, adversity quotient did not significantly influence creative thinking skills, and no significant interaction was found between the learning model and AQ.

These findings indicate that the DTBL learning structure has a more dominant influence on developing creative thinking skills than students' internal character. The stages of empathize, define, ideate, prototype, and test in DTBL provide relatively equal opportunities for all students to explore ideas, generate alternative solutions, and make creative revisions without being significantly influenced by their AQ levels. Thus, DTBL can facilitate the development of creativity in both high and low AQ students.

Based on the results of pairwise comparisons of the creative thinking skills variable, it was found that in the DTBL learning group there was no significant difference between students in the low adversity intelligence category and those in the high adversity intelligence category. This is indicated by a significance value of 0.639 ($p > 0.05$). The mean difference of 0.563 indicates that the average creative thinking skills of students in the low adversity intelligence category were slightly higher than those in the high adversity intelligence category; however, this difference was not statistically significant. The 95% confidence interval also crosses the zero line (-1.821 to 2.946), thereby reinforcing that there is no significant difference between the two categories of adversity intelligence in the DTBL model.

Table 6. Results of Pairwise Comparisons Test of Creative Thinking Skills

Learning Model	Level AQ	Mean Difference (I–J)	Std. Error	Sig.	95% CI Lower Bound	95% CI Upper Boud	Decision
DTBL	1–2	0.56	1.19	0.63	-1.82	2.94	Not Sig.
PjBL	1–2	-1.10	1.20	0.36	-3.51	1.30	Not Sig.

In the PjBL learning group, the same results were also found. A significance value of 0.364 ($p > 0.05$) indicates that there is no significant difference in creative thinking skills between students in the low adversity intelligence category and those in the high adversity intelligence category. The mean difference of -1.104 indicates that the average creative thinking skills of the high adversity intelligence category were slightly higher than those of the low adversity intelligence category, but this difference was not statistically significant. This is also supported by the 95% confidence interval, which includes zero (-3.517 to 1.309). It can therefore be concluded that, in both learning models—DTBL and PjBL—there was no significant difference in the learners' resilience intelligence scores in relation to their creative thinking skills following the intervention

Discussion

Overall, the findings indicate that DTBL is more effective than PjBL in improving students' learning independence and creative thinking skills. The structured stages of DTBL promote active engagement, problem-solving, and reflective learning, which are essential for developing learner autonomy. This

supports constructivist learning theory, which emphasizes knowledge construction through experience.

Figure 1. Learning activities during DTBL implementation

The significant role of adversity quotient in learning independence suggests that students with higher resilience are better able to manage learning challenges and benefit from student-centered instructional models. However, its non-significant effect on creative thinking implies that creativity is more strongly influenced by instructional design rather than personal resilience alone. The ANCOVA results indicate that the DTBL model has a significant effect on learning independence and creative thinking. These findings support (Jia et al., 2023) that DTBL has an impact on increasing student creativity. The interaction of the model with AQ on learning independence was also significant, meaning that students with high AQ benefited more. Emphasise that students need resilience in the face of uncertainty and that teachers must foster a culture of experimentation. Conversely, the interaction between the model and AQ on creative thinking was not significant, meaning that DTBL regardless of students' AQ levels. This is consistent with Jia who found that DTBL classes outperformed others in creativity, risk-taking, curiosity, imagination, and challenge.

The findings of this study are consistent with the results of (Jha, 2025) study, which showed that the application of design thinking as a pedagogical framework significantly enhances students' higher-order thinking skills, particularly in terms of creativity and problem-solving. In her study, the group that received the design thinking intervention experienced a 22% increase in creativity and an 18% increase in problem-solving ability, far higher than the group receiving conventional instruction. This reinforces the notion that the DTBL approach—which is iterative, learner-centred, and emphasises empathy and solution exploration—is capable of fostering active engagement and learner autonomy. Furthermore, the characteristics of design thinking that demand adaptation to uncertainty and continuous reflection are also relevant to the finding that learners with a high adversity quotient derive greater benefits from DTBL. Thus, the results of this study underscore that DTBL is an innovative learning model that is not only effective in enhancing independent learning but also makes a tangible contribution to the development of creative thinking skills within the context of 21st-century education.

The results of the study indicate that the DTBL model has a significant effect on students' learning independence. This finding is supported by Kristiantari et al. (2025), who reported a significant increase in students' learning independence following the implementation of Design Thinking, with a very large effect size (Cohen's d = 2.01). Furthermore, a significant interaction was found between the DTBL model and AQ on learning independence. This implies that students with a high AQ benefit more from the DTBL model compared to those with a low AQ. Kristiantari explain that Design Thinking cultivates students' mental resilience through an iterative learning process, enabling students to learn from failure and become more independent. Consequently, DTBL is effective in enhancing learning independence, particularly for students with high mental resilience.

This significance arises because DTBL is designed as hands-on learning, in which students are actively involved in problem-solving and building understanding independently. Fayanto et al. (2024) explain that design-based learning fosters student engagement and motivation through direct learning experiences that provide a sense of achievement, whilst enhancing imagination, creativity and thinking skills. In this study, cognitive engagement emerged as the most dominant factor (M = 3.87) as it is directly linked to learning independence and deep learning strategies. In other words, students learning through the DTBL model do not merely receive information passively, but actively construct their own knowledge through iterative processes such as designing, testing, and revising their work. It is this process that makes students more responsible, disciplined, and confident in managing their own learning, thereby significantly enhancing their learning independence.

The results of the study indicate a significant interaction between the DTBL model and AQ on learning independence. This implies that students with a high AQ derive greater benefit from the DTBL model than those with a low AQ. This is consistent with the findings of Akbar et al. (2023), who reported that AQ has a significant relationship with learning independence ($p = 0.006$), whereby individuals with high AQ tend to have high learning independence as well. Akbar also explained that the majority of respondents (92.7%) fell

into the 'climbers' category, i.e. individuals who are persistent in the face of difficulties. In the context of this study, students with high AQ were better able to self-regulate during the DTBL learning process, resulting in a more significant increase in their learning independence.

This significance arises because individuals with high AQ possess characteristics that directly support the development of learning independence. Nokaew et al. (2025) explain that AQ encompasses four key dimensions: control (self-regulation), ownership (taking responsibility for problems encountered), reach (the ability to limit the impact of problems), and endurance (resilience in the face of long-term challenges). Participants with high AQ in their study demonstrated greater resilience, perseverance, and adaptability, as well as the ability to manage setbacks more effectively. Furthermore, it is emphasised that AQ plays a crucial role in fostering learning independence, as students with high AQ tend to take control of their learning process, take responsibility for their learning progress, and demonstrate high perseverance when facing difficulties. Consequently, students with high AQ are better able to self-regulate their learning, are less likely to give up when faced with difficult tasks, and ultimately possess greater learning independence.

The research findings demonstrate a significant interaction between the DTBL model and AQ on learning independence. These findings indicate that students with a high AQ (climbers) benefit more from the DTBL model than students with a low AQ (campers or quitters). Juwita et al. (2020) explain in their literature review that climbers are characterised by their ability to manage difficult situations, take full responsibility, not give up easily, and maintain hope and optimism when facing problems. Conversely, campers tend to be easily satisfied and give up quickly when facing severe difficulties, whilst quitters lack resilience in solving problems and always rely on others. In the context of DTBL learning, which requires students to go through an iterative process (designing, testing, and revising their work independently), students with high AQ are better able to persevere through these challenges, thereby developing their learning independence more effectively. Consequently, the effectiveness of DTBL in enhancing learning independence is significantly influenced by students' AQ levels.

This significance arises because students with the AQ 'climber' type possess characteristics that are highly aligned with the demands of the DTBL model. Fauziah et al. (2020) explain that 'climber' type students demonstrate self-control in difficult situations, take full responsibility for the problems they face, do not give up easily, and are able to maintain hope and optimism. In the DTBL model, which requires students to undergo an iterative process (designing, testing, and revising their work independently), climber students are better able to persevere in the face of challenges, learn from failure, and keep trying until the task is completed. Conversely, camper-type students tend to be easily satisfied and give up quickly when faced with significant difficulties, whilst quitter-type students lack resilience in solving problems and always rely on others. The findings of Fauziah also demonstrate that there is a significant interaction between the learning model and AQ on students' thinking abilities, with climber students performing better than camper and quitter students across all learning models (Rohmah & Lataruva, 2023). Consequently, the effectiveness of DTBL in enhancing independent learning is largely determined by students' AQ levels, with those possessing high AQ (climbers) deriving significantly greater benefits.

Figure 2. Students' prototype or creative product developed through DTBL

The research findings demonstrate that the DTBL model has a significant effect on students' creative thinking skills ($F = 5.05$; $p = 0.02$; $\eta^2 = 0.07$). This finding is supported by Cengiz (2023), who reported that the implementation of the Design Thinking model over nine weeks resulted in a significant increase in creative thinking scores ($t(28) = -12.68$; $p = 0.000$) with a very large effect size ($\eta^2 = 0.85$). This significance arises because each stage of Design Thinking—empathise, define, ideate, prototype, and test—serves to eliminate cognitive barriers such as functional fixedness and premature judgement, whilst systematically providing space for both divergent and convergent thinking. The ideate stage facilitates fluency and flexibility in generating ideas, whilst the prototype and test stages foster elaboration and originality through feedback-based iteration. The N-Gain analysis in the study by Cengiz shows a pre-test to post-test increase of 15.72 points (from 33.55 to 49.27), whilst your study produced a smaller yet still significant effect ($\eta^2 = 0.07$), which may be attributed to differences in intervention duration, subject characteristics, or the instruments used. Thus,

the effectiveness of DTBL in enhancing students' creative thinking skills has been empirically demonstrated.

Design Thinking has a significant impact on creative thinking skills through three key mechanisms. Firstly, the empathy process fosters creative confidence in students, enabling them to feel certain that the solutions they design are genuinely beneficial to users, thereby encouraging them to dare to put forward new ideas without fear of making mistakes (Kurniawati et al., 2025). Secondly, Design Thinking fosters strong team collaboration, where each group member contributes diverse ideas and inspires one another, thereby sparking richer collective creativity. Thirdly, the stages of Design Thinking, particularly the ideation stage, provide students with the freedom to generate ideas without constraints, whilst still integrating critical thinking during the feedback and final solution stages to refine and perfect those ideas. Balakrishnan (2022) reports that all participants in his study gave positive feedback that Design Thinking had facilitated their creative thinking, as this model combines the freedom of divergent thinking with a systematic process of refining ideas. Thus, Design Thinking has proven to be significant in enhancing students' creative thinking skills.

The results of the study indicate that AQ does not have a significant effect on students' creative thinking abilities. This finding differs from the results of the study by Hariyani et al. (2025), who reported a very strong positive relationship between AQ and creative thinking ($\rho = 1.000$; $p < 0.01$). This difference can be rationally explained by the differing contexts and variables tested. Hariyani examined the direct relationship between AQ and creative thinking without the intervention of a specific learning model, so the influence of AQ appeared dominant. Meanwhile, in your study, students learnt using the DTBL model, which has systematic stages—empathise, define, ideate, prototype, test—that directly train each indicator of creative thinking (fluency, flexibility, originality). In other words, when the learning model actively facilitates the development of creativity, the role of AQ as an internal factor becomes insignificant because the effect of the learning model is more dominant. Thus, this discrepancy in findings actually enriches our understanding that the influence of AQ on creativity is contextual: AQ acts as a strong predictor when learning is conventional (Hariyani et al., 2025), but its role weakens when the learning model used is specifically designed to explicitly foster creativity, such as DTBL.

The results of the study indicate that AQ does not have a significant effect on students' creative thinking abilities. This finding can be rationally explained by three factors. Firstly, differences in the learning context. Habsyi et al. (2025) reported that in conventional learning, students of the Climbers type (high AQ) were able to progress through all stages of creative thinking, whilst Quitters (low AQ) only reached the preparation and incubation stages. However, in your study, the DTBL model intervention with its five systematic stages (empathise, define, ideate, prototype, test) explicitly trains each indicator of creative thinking (fluency, flexibility, originality). Secondly, the learning model dominance effect. When a structured learning model facilitates the development of creativity, the influence of internal factors such as AQ is reduced because the model provides equivalent cognitive scaffolding for all students. Thirdly, the characteristics of the construct of creativity are more influenced by external factors (learning environment, learning strategies, and feedback) than by internal factors such as mental resilience. Thus, the non-significance of AQ in this study indicates that the DTBL model acts as an effective equaliser in facilitating the development of creativity evenly across AQ levels.

Interestingly, students with low AQ in the DTBL group demonstrated slightly higher creative thinking scores than students with high AQ, although the difference was not statistically significant (Wahyuningtyas et al., 2020). This finding suggests that the DTBL model may create a more open, flexible, and psychologically supportive learning environment that allows students with lower resilience levels to participate more freely in idea exploration and creative experimentation. During the DTBL process, students are encouraged to generate multiple alternative solutions, test prototypes, and revise ideas collaboratively without excessive emphasis on achieving perfect answers in the early stages (Putri et al., 2019). Such learning conditions may reduce fear of failure and performance pressure, which are often experienced by students with lower AQ.

In addition, students with high AQ may tend to approach problem solving in a more structured and goal-oriented manner, focusing more on achieving effective solutions than on exploring diverse and unconventional ideas. Conversely, students with lower AQ may engage more spontaneously and imaginatively during brainstorming and ideation activities because the DTBL environment provides sufficient space for trial-and-error learning and creative risk-taking. Consequently, although AQ contributes to students' persistence in learning, the structure of DTBL itself appears to function as an equalizing learning mechanism that enables students across different AQ levels to develop creative thinking skills relatively equally.

The findings indicate that adversity quotient does not have a significant effect on students' creative thinking skills and does not interact with the learning model, which is consistent with the findings of Putri et

al. (2019) who found that differences in AQ levels only resulted in variations in creativity achievement in the moderate and low categories, without showing a significant increase. This condition is also reflected in Table 4, where the differences in estimated marginal means between AQ levels are relatively small in both DTBL and PjBL, thus reinforcing that AQ is not a dominant factor in determining creative thinking ability. Furthermore, the study's findings, which show the dominance of the novelty indicator over fluency and flexibility, indicate that learners tend to be able to generate unique ideas, but are not yet consistent in producing numerous and diverse solutions, thereby explaining why variations in creativity across AQ levels in this study were not significant. Thus, these data confirm that improvements in creative thinking ability are more influenced by the learning model—namely DTBL—than by differences in adversity quotient levels.

The finding that the adversity quotient does not have a significant effect on creative thinking ability ($p = 0.279$) can be explained by the research of Nurfajrianti et al. (2023) which shows that creativity is not solely determined by AQ, but is also influenced by other factors such as cognitive processes and academic anxiety. The results of the study show that within each AQ category, students' levels of creativity still vary and are not consistently high, suggesting that the relationship between the two is weak. Furthermore, not all students were able to meet all the indicators of creativity (fluency, flexibility, novelty). This finding is consistent with the data in Tables 3 and 4, which show that the differences in creativity scores across AQ levels are relatively small, thereby confirming that creative thinking ability is more influenced by the learning model DTBL than by AQ.

Conclusion

Based on the research results and data analysis, it can be concluded that the implementation of the Design Thinking Based Learning (DTBL) model significantly improves students' learning independence and creative thinking skills compared to the Project Based Learning (PjBL) model. The DTBL model facilitates students to be more active in identifying problems, exploring ideas, and developing solutions systematically, thus supporting a more meaningful learning process. Furthermore, the adversity quotient also influences students' learning independence and creative thinking skills. Students with higher adversity quotient levels tend to demonstrate better abilities in facing learning challenges, maintaining learning motivation, and completing assignments independently. However, the analysis results showed no significant interaction between the learning model and adversity quotient on students' creative thinking skills. This finding indicates that the improvement in creative thinking skills through the implementation of DTBL occurs relatively consistently across students with varying adversity quotient levels. Thus, the effectiveness of DTBL in improving creative thinking skills does not depend on the students' adversity quotient levels. In practice, the application of DTBL can be used as an alternative innovative learning model in Biology learning because it is able to encourage active student involvement, increase learning independence, and develop creative thinking skills through learning stages that are oriented towards problem solving and developing ideas collaboratively and individually.

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Author Contributions

Conceptualization, methodology, formal analysis, investigation, data curation, visualization, and writing original draft preparation, S.D.C.A.; validation, writing review and editing, F.D and F; supervision, H and A.A. and I. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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