



Supplementary file 1. Teacher instructional strategies for empowering creative thinking skills based on review findings

No.	Author	Instructional Strategies	Implication
1.	Anggraeni <i>et al.</i> (2022)	TPACK-based problem-based learning (PBL); TPACK-based reading-questioning-answering (RQA); TPACK-based PBL-RQA combination.	Student creativity on the topic of genetics was enhanced through the implementation of these three TPACK- based strategies.
2.	Wahyudi <i>et al.</i> (2022)	Guided inquiry model	The implementation of a guided inquiry model assisted by the Phyphox application significantly enhanced students' creative thinking skills. The highest indicators were observed in Fluency, followed by Flexibility, Originality, and Elaboration.
3.	Supratman <i>et al.</i> (2020)	Problem-oriented project- based learning (POPjBL); Student Team Achievement Division (STAD); Integrated POPjBL-STAD	These three strategies (POPBL, STAD, POPBL-STAD) significantly enhanced students' creative thinking skills compared to conventional learning. POPBL excelled in project-based problem-solving, STAD proved effective for collaborative discussions, and the integrated POPBL-STAD combined the strengths of both, resulting in the most substantial improvements across all indicators of creativity.
4.	Amalia <i>et al.</i> (2022)	Project-based learning (PjBL)	Project-based learning (PjBL) provides active and collaborative learning activities, and it can enhance students' creativity.
5.	Liline <i>et al.</i> (2024)	HOTs-integrated Project-based Learning (PjBL)	PjBL-HOTS is capable of fostering students' creative thinking skills.
6.	Yoade <i>et al.</i> (2022)	Station Rotation Blended Learning (SRBLS); Flipped blended learning (FBLS)	SRBLS and FBLS strategies are more effective in enhancing students' creative thinking skills in Biology classes.
7.	Eliaumra <i>et al.</i> (2024)	Digital literacy-based project-based learning (PjBL)	Digitally literate project-based learning can effectively enhance students' creative thinking and digital literacy skills in Biology education.

8.	Nurmi <i>et al.</i> (2024)	Exploring, Analyzing, Questioning, Defining-Peer Coaching integrated with Learning Journal (EAQD-PC-LJ)	
9.	Baytiyeh (2017)	Flipped classroom	Learning with the flipped classroom model can enhance student creativity. Furthermore, it also positively impacts self-regulation, problem-solving skills, collaboration, and communication.
10.	Rosyidi <i>et al.</i> (2023)	Project-based biopreneurship	The implementation of a project-based biopreneurship module can effectively enhance students' creativity and biopreneurial literacy.
11.	Xu <i>et al.</i> (2024)	Digital game-based AI chatbot	The integration of AI Chatbot in Digital Game-Based Learning (DGBL) enhances academic performance, higher-order thinking skills, and creativity. Students in the experimental group showed significant improvement in their ability to ask creative questions and propose innovative solutions. Log data revealed more varied and in-depth idea exploration patterns compared to the control group.
12.	Uwitonze & Nizeyimana (2022)	The use of virtual laboratory media	The use of virtual laboratories can enhance students' creative thinking skills and learning outcomes.
13.	Muliadi <i>et al.</i> (2025)	Ethnoscience-integrated Project-based Learning (PjBL)	The implementation of ethnoscience-based PjBL can empower students' creative thinking skills through culturally contextualized, collaborative, and problem-solving-oriented learning.
14.	Fatmawati (2016)	The Use of Mind Map Media	Mind maps assist students in expressing creative ideas on Biotechnology material. The highest indicators observed were Flexibility and Fluency, while Originality was relatively lower.
15.	Suprpto <i>et al.</i> (2018)	Visuospatial 3DsMax-based Wimba Learning Model	The application of the visuospatial 3DsMax-based Wimba Learning Model with deductive and inductive approaches can enhance creative thinking skills.
16.	Yustina <i>et al.</i> (2020)	Blended learning (BL); Project-based learning (PjBL)	The implementation of Blended Learning (BL) and Project-based Learning (PjBL) is more effective in enhancing students' creative thinking skills in Biology education compared to traditional learning models.
17.	Herak <i>et al.</i> (2025)	PENTI local wisdom-based learning model	The PENTI local wisdom-based learning model provides contextual and meaningful experiences, thereby effectively enhancing creative thinking skills compared to conventional models

18.	Xiong & Ren (2024)	Science Fiction Film-based Creative Problem Solving (CPS) Model	The integration of science fiction films in the CPS learning model can empower students' creative thinking skills in Biology education.
19.	Hidayati <i>et al.</i> (2019)	Digital Mind Map-based Project-based Learning (PBLDMM)	The integration of the PBLDMM model in human anatomy and physiology courses can simultaneously enhance students' creative and critical thinking skills.
20.	Safitri <i>et al.</i> (2020)	Reading-Concept Mapping (Recamp) integrated with Group Investigation (GI)	The integration of Recamp-GI, when implemented in Biology courses, has the potential to enhance students' creative thinking skills compared to separate implementations.
21.	Zainuddin <i>et al.</i> (2020)	Creative responsibility based learning (CRBL)	The implementation of CRBL in Biology courses positively impacts creative thinking abilities. Furthermore, creative thinking ability correlates with an increase in scientific knowledge and science process skills.
22.	Muskita <i>et al.</i> (2020)	The use of Inquiry-Level Based Worksheets	The application of inquiry-level based worksheets (structured, guided, open) is effective in enhancing the critical and creative thinking skills of Biology students.
23.	Rahardjanto <i>et al.</i> (2019)	Hybrid-Project-based learning (Hybrid-PjBL)	The implementation of Hybrid-PjBL makes learning more meaningful and enhances students' creative thinking skills and learning outcomes.
24.	Husamah <i>et al.</i> (2017)	Orientation, Identify, Discussion, Decision, and Engage (OIDDE) learning model	The application of the OIDDE model can stimulate students' creative thinking abilities as an aspect of higher-order thinking skills.
25.	Hidayati & Idris (2020)	Habits of Minds (HoM) Profile-based Learning	The implementation of HoM in Biology courses can enhance students' self- efficacy, creative thinking skills, and critical thinking skills.