Pedagogia Jurnal Ilmu Pendidikan

Journal homepage: http://ejournal.upi.edu/index.php/pedagogia

Effects of Constructive Controversy and Self-Efficacy on Students' Attitude to Genetics' Concepts

Ayodeji Temitope Ojo

Department of Science and Technology Education, University of Ibadan, Ibadan, nigeria

Correspondence: E-mail: at.ojo.@ui.edu.ng

ABSTRACT

Genetics concepts (GCs) are fundamental to human development and societal well-being. However, advancements in genetics have ignited public controversies, particularly in areas such as genetic modification of organisms and sex determination. Despite their importance, students often display negative attitudes toward GCs, while prior educational interventions have largely failed to integrate socioscientific issues, limiting their effectiveness. This study aims to improve students' attitudes and understanding of GCs by utilizing the Constructive Controversy Strategy (CCS), a pedagogical approach designed to foster critical thinking and collaborative learning. Grounded in situated learning theory, the study adopted a pretest-posttest control group quasi-experimental design. A total of 240 senior secondary school science students from six public schools were randomly assigned to the CCS group (n=121) and the conventional strategy group (n=119). Data were analyzed using analysis of covariance (ANCOVA) at a significance level of $p < 0.05$. Results revealed a significant main effect of CCS on students' attitudes toward GCs ($F(1, 215) = 4.42$; partial $\eta^2 = 0.02$). Genetics self-efficacy also significantly influenced attitudes ($F(2, 214) = 3.12$; partial $\eta^2 = 0.03$), and an interaction between treatment and genetics self-efficacy was observed ($F(2, 213) = 3.04$; partial $\eta^2 = 0.05$).The findings conclude that CCS is an effective strategy for improving students' attitudes and understanding of GCs by integrating socioscientific issues. This approach supports the development of genetics-literate citizens equipped to engage with contemporary societal challenges.

ARTICLE INFO

Article History:
Submitted/Received 01 Aug 2024
First Revised 26 Aug 2024
Accepted 19 Nov 2024
First Available Online 28 Nov 2024
Publication Date 01 Dec 2024

Keyword:
Constructive Controversy Strategy, Genetics Concepts, Genetics self-efficacy, Situated Learning.

1. INTRODUCTION

Biology, as a branch of biological sciences, encompasses the study of living organisms in various dimensions, including their morphology, physiology, reproduction, anatomy, chemical processes, molecular interactions, heredity, distribution, and evolution over time. Its inclusion in the secondary school biology curriculum and its relevance to biological science-related courses at tertiary institutions underscores the subject's critical role in modern society. This significance transcends individual growth and development to impact national and global scientific advancements. Recognizing its importance, the Federal Ministry of Education of Nigeria identified the primary goals of biology education, including equipping students with essential knowledge for further studies in biology and related fields and fostering a positive attitude toward science. Although biology is offered as an optional subject at the secondary level, its societal relevance necessitates that it be taught effectively to ensure comprehension and participation in issues arising from its application.

Biology interacts with diverse fields, including engineering, technology, industry, culture, and religion (Allen & Baker, 2017). These interdisciplinary connections often give rise to socioscientific issues, real-world dilemmas rooted in the application of biological knowledge (Zeidler, 2014). Such issues frequently invoke moral, ethical, and societal concerns requiring reflection, reasoning, and judgment. Socioscientific issues are contentious, socially relevant problems that provoke diverse beliefs, values, and agendas, making them resistant to resolution through facts or evidence alone (Zeidler et al., 2019; Zeidler & Sadler, 2023). Examples include cloning, genetic modification of crops, sex determination, and selective abortion. In biology, these issues intersect with concepts such as genetics, ecology, reproduction, and nutrition, forming integral components of the senior secondary school biology curriculum.

Among these concepts, genetics has gained significant attention due to its profound implications for human development and societal well-being (Seymour, 2016). Genetics focuses on the study of genes, their inheritance, variations, and functions. Its application spans biotechnology, genetic disease therapy, crop and animal production, paternity testing, and forensic investigations, all of which have substantially improved human life (Ekong et al., 2015). However, students' attitudes toward genetics concepts significantly influence their learning. Positive attitudes are critical for enhancing learning outcomes, while negative attitudes hinder comprehension and retention (Sri et al., 2018).

Despite the importance of positive attitudes toward genetics, studies reveal persistent negative perceptions among students. Negative attitudes toward specific topics like human cell cloning, sex determination, and selective abortion have been reported (Chen et al., 2016). Ineffective teaching styles further exacerbate these attitudes (Bernstein, 2021; Liu et al., 2022). Additional factors influencing attitudes include skipping classes, low participation, and prioritizing examination scores over meaningful learning (Al-Said, 2023; Teng et al., 2022). Moreover, variables such as gender, cultural and religious backgrounds, perceived interest, and instructional strategies significantly shape students' attitudes (Hagay et al., 2013).

Efforts to address students' negative attitudes toward genetics concepts have focused on various innovative teaching strategies, including computer simulations, problem-solving, discovery learning, and the 5E instructional model. While these methods have demonstrated success in some contexts, negative attitudes persist, likely due to their failure to incorporate socioscientific issues into genetics instruction. These strategies often overlook the practical application of knowledge, leaving gaps in students' understanding of the societal relevance of genetics.

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

Constructive controversy, introduced by Johnson and Johnson, offers a promising approach to addressing these challenges (Johnson & Johnson, 2015). This structured cooperative learning strategy engages students in debates and discussions, fostering critical thinking, creativity, and empathy. Students are grouped in pairs to present and discuss perspectives, striving for consensus or at least mutual understanding of the best arguments on both sides (Johnson et al., 2020). The teacher's role is to guide students in exploring controversial issues, encouraging reflective thinking and informed decision-making. While the strategy has limitations, such as occasional difficulties in reaching consensus, its benefits in promoting engagement and learning far outweigh these drawbacks (Johnson & Johnson, 2016).

The application of constructive controversy is well-aligned with the situated learning theory, which posits that knowledge is best acquired in authentic, context-rich environments where learners actively engage with content (Zhang & Li, 2023). In genetics education, this means embedding learning within practical, real-world contexts, enabling students to connect theoretical knowledge with its societal implications. Situated learning emphasizes participation, context, and culture, aligning well with the goals of constructive controversy in fostering a deeper understanding of socioscientific issues.

Another critical factor influencing students' attitudes toward genetics is self-efficacy, defined as the belief in one's ability to organize, plan, and execute tasks effectively (Aivelo & Uitto, 2021; Cebesoy & Oztekin, 2018).

High self-efficacy predicts better academic performance, greater persistence in the face of challenges, and more effective learning strategies (Bryant, 2017). Conversely, low self-efficacy leads to reduced confidence, higher anxiety, and disengagement (Wernersbach et al., 2014). Despite its importance, research on self-efficacy in biology education, particularly in genetics, remains limited, with most studies focusing on mathematics and physics.

Given these gaps, this study aims to determine the effects of constructive controversy and self-efficacy on students' attitudes toward genetics concepts. The integration of socioscientific issues into genetics instruction through constructive controversy offers a novel approach to enhancing attitudes, fostering genetics literacy, and equipping students to navigate the complex societal challenges associated with genetics. By grounding the study in situated learning theory, the research emphasizes active participation and contextual learning, providing a robust framework for addressing the multifaceted challenges in genetics education.

2. METHODOLOGY

2.1 Research Design

The study employed a pretest-posttest control group quasi-experimental design to investigate the effects of the Constructive Controversy Strategy (CCS) on students' attitudes toward genetics concepts and their self-efficacy. This design was selected for its suitability in manipulating the independent variable (CCS) while preserving the natural structure of intact class groups. Students in the experimental group were exposed to CCS, whereas those in the control group received conventional teaching methods. Pretests and posttests were administered to both groups to measure changes in attitudes and self-efficacy, with pretest scores serving as covariates to control for baseline differences.

The participants were Senior Secondary School II (SS 2) biology students from Oyo State, Nigeria. A multistage sampling technique was adopted to ensure representative participation across the state. First, one Local Government Area (LGA) was randomly selected from each of

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

the three senatorial districts, resulting in three LGAs. From these LGAs, three secondary schools were randomly chosen, yielding a total of nine schools. The selected schools met specific criteria, including their willingness to participate and geographical separation to minimize interaction among participants. Intact biology classes from each school were randomly assigned to either the experimental or control group, ensuring balanced representation in both treatment conditions.

2.3 Data Collection Technique

Data were collected using two validated instruments: the Students' Attitude to Genetics Concepts Questionnaire (SAGCQ) and the Self-Efficacy in Genetics Concepts Scale (SeGCS). The SAGCQ consisted of 30 items designed to assess students' attitudes toward genetics concepts, including their feelings, beliefs, values, and perceived usefulness of genetics. It utilized a four-point Likert scale, with positive items scored from 4 (Strongly Agree) to 1 (Strongly Disagree), and negative items reverse-scored. The instrument was reviewed by experts in measurement and evaluation for clarity, precision, and relevance. A pilot test conducted with non-sample SS 2 students established its reliability, yielding a Cronbach's alpha coefficient of 0.83.

The SeGCS was adapted from existing validated scales, including the General Self-Efficacy Scale by Schwarzer & Jerusalem (1995) and the Biology Self-Efficacy Scale by Baldwin et al. (1999). It was modified to align with the genetics-specific context and the study's objectives, resulting in 28 items scored on a four-point Likert scale. The instrument was validated by experts in education and piloted with a non-sample group, producing a Cronbach's alpha reliability coefficient of 0.88. Both instruments demonstrated high validity and reliability, making them suitable for use with the study's target population.

The treatment procedure for the experimental group followed an adapted seven-step CCS process based on Johnson & Johnson's (2007) model. These steps included grouping students into teams of four, assigning pairs of students opposing sides of a debate, and providing background information on controversial genetics topics. Students prepared and presented arguments, engaged in open discussions to critique and defend viewpoints, and reversed perspectives to understand opposing arguments. Finally, students synthesized their arguments into a consensus report and completed individual assessments to evaluate their understanding. In contrast, the control group followed traditional teacher-centered instructional methods, without incorporating socioscientific issues or active engagement strategies.

2.4 Data Collection Technique

The collected data were analyzed using both descriptive and inferential statistical methods. Analysis of covariance (ANCOVA) was conducted to evaluate the effects of the Constructive Controversy Strategy (CCS) on students' attitudes and self-efficacy, with pretest scores included as covariates to control for baseline differences. The significance level was set at $p < 0.05$ to assess the statistical impact of the intervention. Estimated Marginal Means (EMM) were calculated to compare the mean scores of the experimental and control groups, identifying which group achieved superior performance. Descriptive statistics, including means, standard deviations, and percentages, provided a detailed summary of the students' performance.

In addition, qualitative data from group reports were analyzed using content analysis to assess the depth of students' understanding and the integration of socioscientific issues.

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

These complementary analytical methods ensured a comprehensive evaluation of the study's objectives and facilitated robust conclusions regarding the effectiveness of CCS in improving students' attitudes and self-efficacy in genetics concepts.

3. RESULT AND DISCUSSION

3.1 Result

The results of this study examined the main and interaction effects of treatment and self-efficacy on students' attitudes toward genetics concepts. A quantitative analysis was performed using analysis of covariance (ANCOVA) to evaluate the influence of these variables while controlling for pre-attitude scores. This statistical method ensured that observed differences in post-attitude scores were attributable to the experimental treatment or interaction effects, rather than pre-existing variations among participants. The significance of the findings was evaluated at $p < 0.05$, and effect sizes were assessed using partial eta squared (η^2) to determine the magnitude of the observed effects.

Table 1. Main and Interaction Effects of Treatment and Self-Efficacy in Genetics Concepts on Post-Attitude to Genetics Concepts

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	7162.547	6	1193.758	3.627	0.002	0.095
Intercept	60871.071	1	60871.071	184.937	0.000	0.471
Pre-Attitude	890.280	1	890.280	2.705	0.102	0.013
Treatment	1453.667	1	1453.667	4.416	0.037*	0.021
Self-efficacy	2055.530	2	1027.765	3.123	0.046*	0.029
Treatment x Self-efficacy	2003.822	2	1001.911	3.044	0.050*	0.028
Error	68462.262	208	329.145			
Total	805745.000	215				
Corrected Total	75624.809	214				

R Squared = 0.10 (Adjusted R Squared = 0.07) * denotes significant p<0.05

Table 1 depicted that the main effect of treatment on students' post-attitude scores to genetics concepts in biology ($F_{(2;\ 214)} = 4.42$; $p<0.05(0.04)$; partial $\eta^2 = 0.02$) was significant. Hence the null hypothesis 1a was rejected at the 0.05 level of significance. Table 1 also revealed an effect size of 2.0%, which indicated that the treatment group accounted for 2.0% (0.02) of the variance in student's adjusted post-attitude scores to genetics concepts in biology responsible. The differences in the post-attitude mean scores of the students exposed to different treatment and control conditions are established by the estimated marginal mean analysis and the result presented in Table 2.

Table 2. Adjusted Post-Attitude to Genetics Concepts Mean Performance by Treatment and Control Groups

Treatment	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Constructive Controversy Strategy (CCS)	60.85	2.01	56.89	64.80
Conventional Strategy (CS)	55.15	1.74	51.72	58.58

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

Table 2 revealed that students taught with the constructive controversy strategy recorded the higher adjusted post-attitude mean score of 60.85 with confidence interval ranging from 56.89 to 64.80, while students exposed to the conventional strategy had the lowest adjusted post-attitude mean score of 55.15 with confidence interval ranging from 51.72 to 58.58. This order is presented as CCS > CS.

Table 1 depicted that self-efficacy in genetics concepts main effect on students' attitude to genetics concepts in biology ($F_{(2, 213)}$ = 3.12 $p<0.05$, partial η^2 = 0.03) was significant after controlling for pre-attitude at $p<0.05$. This means that the null hypothesis 2a was rejected. This depicts that there was a significant difference in the post-attitude mean scores of students to genetics concepts in biology in respect to their self-efficacy. Table 1 revealed an effect size of 3.0%, which means that the moderator effect of self-efficacy in genetics concepts alone accounted for 3.0% of the variation observed in student's adjusted post-attitude scores to genetics concepts. In order to determine the differences among the post-attitude mean scores of the students across self-efficacy in n genetics concepts levels, the estimated marginal means analysis was carried out and the result is presented in Table 3.

Table 3. Adjusted Post-Attitude to Genetics Concepts Mean Performance by Self-Efficacy in Genetics Concepts

Self-Efficacy in genetics concepts	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Low	61.54	2.08	57.44	65.64
Medium	59.22	2.01	55.26	63.19
High	53.22	2.62	48.06	58.39

Table 3 indicated that low self-efficacy students in genetics concepts had the highest adjusted post-attitude mean score of 61.54, followed by moderate genetics concepts self-efficacious students with adjusted post-attitude mean score of 59.22, while high genetics concepts self-efficacious students had the lowest adjusted post-attitude mean score of 53.22. This order is showed as Low > Medium > High.

Table 4. Multiple Comparisons of Self-Efficacy in Genetics Concepts Groups Mean by Post-Attitude to Genetics Concepts

(I) elf-Efficacy in genetics concepts	(J) Self-Efficacy in genetics concepts	Mean Difference (I-J)	Sig.
Low	Medium	2.315	1.000
	High	8.315*	0.042
Medium	Low	-2.315	1.000
	High	6.000	0.213
High	Low	-8.315*	0.042
	Medium	-6.000	0.213

* denotes significant $p<0.05$

Table 4 showed that the difference in the adjusted post-attitude mean score of low and high self-efficacy students in genetics concepts in biology was statistically significant. But there

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

was no statistically significant difference between medium and low self-efficacy students' post-attitude mean score to secondary school biology genetics concepts. Table 4 further revealed that the difference in the adjusted post-attitude mean score to genetics concepts in biology between medium and high self-efficacy students in genetics concepts was not statistically significant. This means that low self-efficacy in genetics concepts was the main source of the significant differences observed across self-efficacy in genetics concepts levels to attitude.

Table 3 indicated that the interaction effect of treatment and self-efficacy on students' post-attitude to genetics concepts in biology whilst adjusting for pre-attitude ($F_{(2; 213)} = 3.04$; $p<0.05$, partial $\eta^2 = 0.05$) was significant. This indicates that students' post-attitude score to genetics concepts in biology vary significantly among low, medium and high self-efficacy students after they were exposed to the treatment and control conditions. Therefore, null hypothesis 2a was rejected. Table 3 also revealed an effect size of 3.0%, which implies that the interaction effect of treatment and self-efficacy alone accounted for 5.0% of the variance in student's adjusted post-attitude scores to genetics concepts. In order to explore the nature of the interaction effect, the line graph is presented in figure 1.

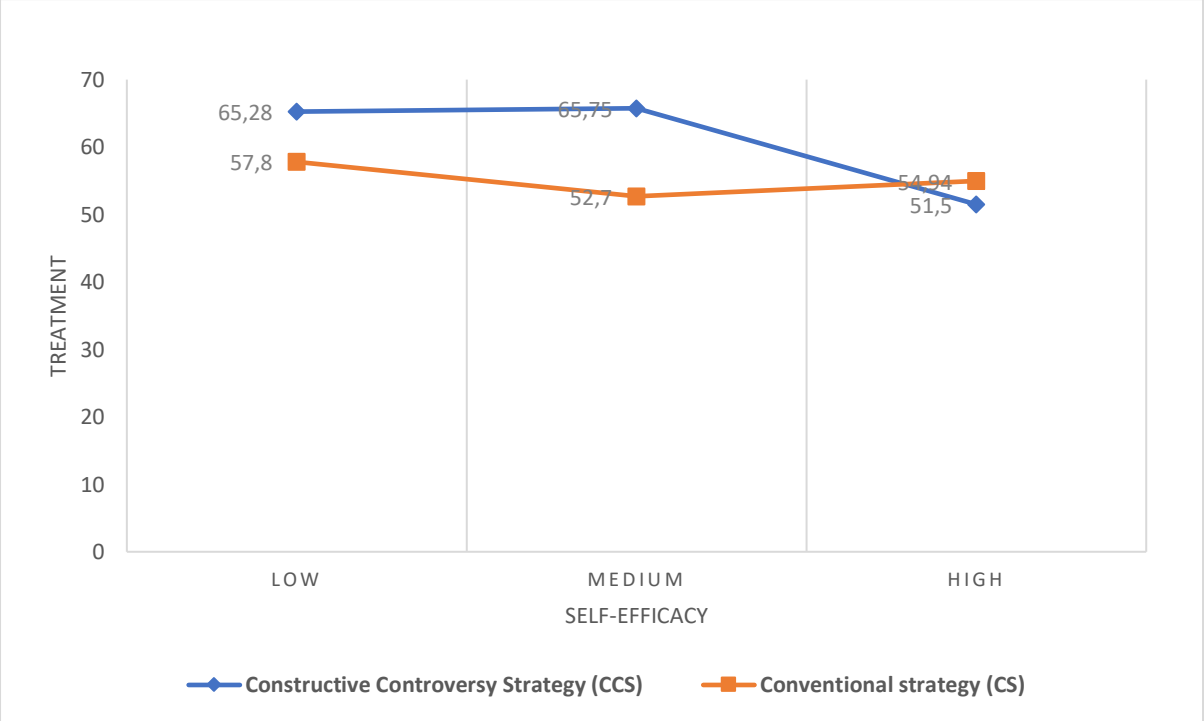

Figure 1. Treatment and Self-Efficacy in Genetics Concepts on Students' Attitude to Genetics Concepts

Figure 1 indicated that medium self-efficacy students in constructive controversy strategy recorded the highest adjusted post-attitude mean score to genetics concepts in biology (65.75) as compared with other combinations of students. Figure 1 also indicated that the nature of the interaction is disordinal since the lines crossed each other. This means that based self-efficacy of students in genetics concepts, it was not the same group of students across treatment group that have better performance in post-attitude mean score to genetics concepts in biology.

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

3.2 Discussion

The main effect of treatment on genetics concepts post-attitude of students in biology was significant. The result further indicated that students in constructive controversy treatment group had better post-attitude than those in the conventional strategy to genetics concepts in biology. This outcome implies that constructive controversy was effective in developing positive attitude in students towards genetics concepts and related social issues.

The constructive controversy strategy is more effective at improving students' post-attitude to genetics concepts in biology than the conventional strategy. This may be attributed to the one of the features of constructive controversy strategy which allow team members to re-evaluate their attitudes about genetics concepts and the related problems as well as incorporating opposing accepted opinions (Fraser et al., 2014; O'Neill et al., 2017; Minson & Chen, 2022). This may also be because this strategy gives team partners the opportunity to interact positively and strengthen cordial relationships among them by encouraging high worth problem-solving tasks, motivation to study the topic under debate, therefore, enhancing their disposition, belief and value of that topic (Adeogun & Olisaemeka, 2011; Ahmeda et al., 2020; Korir & Kipkemboi, 2014).

This result of effectiveness of constructive controversy on students' attitude to genetics concepts over the conventional strategy is in agreement with the study of Nam (2014) in which the results revealed that constructive controversy was significantly effective than conventional strategy in improving different components of students' attitude to online collaborative learning settings. This result is consistent with Tichy et al. (2010), who found that constructive controversy significantly resulted in development of positive attitudes in 3rd, 4th, and 5th-grade students toward social interdependence.

The main effect of students' self-efficacy in genetics concepts in this current study on their attitude to genetics concepts in secondary school biology was found to be significant. The result also revealed that low self-efficacious students had better post-attitude to genetics concepts mean score, as against medium and high self-efficacious students, respectively. The reason for this outcome could be that students were encourages to raise genetics issues, reflect on them and relate them to real life situations. In such conditions, they perceive difficult tasks as something to cater to, reflect on, and evaluate rather than to shun away from. And as a result, low self-efficacy students become more persistent, resilient and self-assured in learning of genetics concept and related issues.

This result is affirmed by the finding of Yau & Leung (2018) that positive correlation existed between self-efficacy and students' attitude to technology usage in Hong Kong higher education. This is also reinforced by the result of Kundu & Ghoshe (2016), that relationship existed between higher secondary students' attitude to mathematics. But this current study is in variance with Kundu & Ghoshe' findings that high self-efficacy students had the highest mean score in mathematics at higher secondary level.Treatment and self-efficacy interaction on students' attitudes to genetics concepts in biology had significant effect. This indicates that being low, medium or high efficacious has different effect on the treatment applied.

This finding is confirmed by the research report of Sadi & Uyar (2013) which indicate that higher level t existed between teacher use of instructional strategies and students' attitude. This finding is corroborated by the finding of Sen & Yilmaz (2016), who found a correlation between strategies used and self-efficacy of students. This present finding is corroborated by the assertion of Berger & Karabenick (2011) that the mode of cooperative learning instructions used can be determine by self-efficacy of students.

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

4. CONCLUSION

The findings of this study demonstrate that the Constructive Controversy Strategy (CCS) is significantly more effective in improving students' attitudes toward genetics concepts and related socioscientific issues in secondary school biology compared to conventional teaching methods. The strategy's effectiveness highlights the importance of incorporating active learning approaches that promote critical thinking, collaboration, and engagement with real-world issues. Additionally, genetics self-efficacy emerged as a critical factor influencing students' attitudes, with medium self-efficacious students in the CCS group displaying the most favorable attitudes. The significant interaction between treatment and self-efficacy suggests that tailoring instructional strategies to align with students' self-efficacy levels can further enhance learning outcomes.

These findings have important implications for educators and curriculum developers. Integrating CCS and socioscientific issues into biology instruction can better prepare students with the skills and attitudes necessary to address complex societal challenges in genetics. Future research should examine the long-term effects of CCS on students' attitudes and learning outcomes in other biology topics, as well as its applicability in diverse cultural and educational contexts. Additionally, further studies could explore the role of digital tools and technologies in enhancing the implementation of CCS to address emerging challenges in genetics education effectively.

REFERENCES

Adeogun, A. A., & Olisaemeka, B. U. (2011). Influence of school climate on students' achievement and teachers' productivity for sustainable development. *Online Submission*, *8*(4), 552-557.

Ahmeda, I., Hamzah, A., & Abdullah, M. N. (2020). Effect of emotionally positive classroom atmosphere on student social-emotional competence. *International Journal of Innovation, Creativity and Change*, *8*(12), 320-339.

Aivelo, T., & Uitto, A. (2021). Factors explaining students' attitudes towards learning genetics and belief in genetic determinism. *International Journal of Science Education*, *43*(9), 1408-1425. https://doi.org/10.1080/09500693.2021.1917789

Allen, G. E., & Baker, J. J. (2017). *Scientific process and social issues in biology education*. Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-44380-5

Al-Said, K. (2023). Influence of teacher on student motivation: Opportunities to increase motivational factors during mobile learning. *Education and Information Technologies*, *28*(10), 13439-13457. https://doi.org/10.1007/s10639-023-11720-w

Baldwin, J. A., Ebert-May, D., & Burns, D. J. (1999). The development of a college biology self-efficacy instrument for nonmajors. *Science Education, 83*(4), 397-408. https://doi.org/10.1002/(SICI)1098-237X(199907)83:4<397::AID-SCE1>3.0.CO;2-%23

Berger, J., & Karabenick, S. A. (2011). Motivation and students' use of learning strategies: Evidence of unidirectional effects in mathematics classrooms. *Learning and Instruction, 21*(3), 416-428. https://doi.org/10.1016/j.learninstruc.2010.06.002

Bernstein, D. A. (2021). Teaching styles and troublesome students. *Canadian Psychology*, *62*(4), 367-376. https://doi.org/10.1037/cap0000279

Bryant, S. K. (2017). *Self-efficacy sources and academic motivation: A qualitative study of 10th graders* (Doctoral dissertation, East Tennessee State University).

Cebesoy, U. B., & Oztekin, C. (2018). Genetics literacy: Insights from science teachers' knowledge, attitude, and teaching perceptions. *International Journal of Science and Mathematics Education*, *16*, 1247-1268. https://doi.org/10.1007/s10763-017-9840-4

Chen, S. Y., Chu, Y. R., Lin, C. Y., & Chiang, T. Y. (2016). Students' knowledge and attitudes towards biotechnology revisited, 1995-2014: Changes in agriculture biotechnology but not in medical biotechnology. *Biochemistry Molecular Biology Education, 44*(5), 475-491. https://doi.org/10.1002/bmb.20969

Ekong, N. J., Anongo, M. C., Okrikata, E., & Akpan, G. A. (2015). Influence of selected variables on students' academic performance in genetics and their implications for effective application of Stem Education. *Journal of Emerging Trends in Educational Research and Policy Studies, 6*(4), 331-337. https://hdl.handle.net/10520/EJC181665

Fraser, J. M., Timan, A. L., Miller, K., Dowd, J. E., Tucker, L., & Mazur, E. (2014). Teaching and physics education research: Bridging the gap. *Reports on Progress in Physics*, *77*(3), 032401. https://doi.org/10.1088/0034-4885/77/3/032401

Hagay, G., Peleg, R., Laslo, E., & Ayelet, B. T. (2013). Nature or nurture? A lesson incorporating students' interests in a high-school biology class. *Journal of Biological Education, 47*, 117-122. https://doi.org/10.1080/00219266.2013.773363

Johnson, D. W., & Johnson, R. (2007). *Creative controversy: Intellectual challenge in the classroom* (4th ed.). Edina: Interaction Book Company.

Johnson, D. W., & Johnson, R. T. (2013). Restorative approaches in schools: Necessary roles of cooperative learning and constructive conflict. In *Restorative approaches to conflict in schools* (pp. 159-174). Routledge.

Johnson, D. W., & Johnson, R. T. (2015 Constructive controversy: Teaching Students How to Think Creatively. In: Vollmer, A., Dick, M., Wehner, T. (eds) Konstruktive Kontroverse in Organisationen. uniscope. Publikationen der SGO Stiftung. Springer Gabler, Wiesbaden. https://doi.org/10.1007/978-3-658-00263-3_4

Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2020). Cooperative learning in higher education: A meta-analysis. *Educational Psychology Review, 32*, 759-785.

Johnson, R. W., & Johnson, R. T. (2016). Cooperative learning and teaching citizenship in democracies. *International Journal of Educational Research, 76*, 162-177. https://doi.org/10.1016/j.ijer.2015.11.009

Korir, D. K., & Kipkemboi, F. (2014). The impact of school environment and peer influences on students' academic performance in Vihiga County, Kenya. *International Journal of Humanities and Social Science*, *4*(5), 1-12.

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

Kundu, A., & Ghose, A. (2016). The relationship between attitude and self-efficacy in mathematics among higher secondary students. *Journal of Humanities and Social Science*, *21*(4), 25-31.

Liu, X., Zhao, L., & Su, Y. S. (2022). Impact of parents' attitudes on learning ineffectiveness: The mediating role of parental self-efficacy. *International journal of environmental research and public health*, *19*(1), 615. https://doi.org/10.3390/ijerph19010615

Minson, J. A., & Chen, F. S. (2022). Receptiveness to opposing views: Conceptualization and integrative review. *Personality and Social Psychology Review*, *26*(2), 93-111. https://doi.org/10.1177/10888683211061

Nam, C. W. (2014). The effects of trust and constructive controversy on student achievement and attitude in online cooperative learning environments. *Computers in Human Behavior, 37*, 237-248. https://doi.org/10.1016/j.chb.2014.05.007

O'Neill, T. A., Hoffart, G. C., McLarnon, M. M., Woodley, H. J., Eggermont, M., Rosehart, W., & Brennan, R. (2017). Constructive controversy and reflexivity training promotes effective conflict profiles and team functioning in student learning teams. *Academy of Management Learning & Education*, *16*(2), 257-276. https://doi.org/10.5465/amle.2015.0183

Sadi, O., & Uyar, M. (2013). The relationship between self-efficacy, self-regulated learning strategies and achievement: A path model. *Journal of Baltic Science Education, 12*(1), https://doi.org/21-33. 10.33225/jbse/13.12.21

Schwarzer, R., & Jerusalem, M. (1995). Generalized self-efficacy scale. In J. Weinman, S. Wright, & M. Johnston (Eds.), *Measures in health psychology: A user's portfolio. Causal and control beliefs* (pp. 35-37). Windsor, UK: Nfer-Nelson.

Sen, S., & Yilmaz, A. (2016). Devising a structural equation model of relationships between preservice teachers' time and study environment management, effort regulation, self-efficacy, control of learning beliefs, and metacognitive self-regulation. *Science Education International, 27*(2), 301-316.

Seymour, V. (2016). The human–nature relationship and its impact on health: A critical review. *Frontiers in public health*, *4*, 260. https://doi.org/10.3389/fpubh.2016.00260

Sri, R., Arum, S., Anisyah, D. A., & Noor, F. M. (2018). High school students' attitudes about socioscientific issues contextualized in inquiry-based chemistry instruction. *ICEMT*, 80-84. https://doi.org/10.1145/3206129.3239436

Teng, Z., Cai, Y., Gao, Y., Zhang, X., & Li, X. (2022). Factors affecting learners' adoption of an educational metaverse platform: An empirical study based on an extended UTAUT model. *Mobile Information Systems*, *2022*(1), 5479215. https://doi.org/10.1155/2022/5479215

Tichy, M., Johnson, D. W., Johnson, R. T., & Roseth, C. (2010). The impact of constructive controversy on moral development. *Journal of Applied Social Psychology, 40*(4), 765-787. https://doi.org/10.1111/j.1559-1816.2010.00597.x

Wernersbach, B. M., Crowley, S. L., & Bates, S. C. (2014). Study skills course impact on academic self-efficacy. *Journal of Educational Development, 3*(7), 14-33.

https://www.jstor.org/stable/i24614027

Yau, H. K., & Leung, Y. F. (2018). The Relationship between Self-Efficacy and Attitudes towards the Use of Technology in Learning in Hong Kong Higher Education. In *Proceedings of the International Multi-Conference of Engineers and Computer Scientists* (pp. 832-834).

Zeidler, D. L. (2014). Socioscientific issues as a curriculum emphasis: Theory, research, and practice. In *Handbook of research on science education, volume II* (pp. 697-726). Routledge.

Zeidler, D. L., & Sadler, T. D. (2023). Exploring and expanding the frontiers of socioscientific issues. In *Handbook of research on science education* (pp. 899-929). Routledge.

Zeidler, D. L., Herman, B. C., & Sadler, T. D. (2019). New directions in socioscientific issues research. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1-9. https://doi.org/10.1186/s43031-019-0008-7

Zhang, Y., & Li, Z. (2023). The use of constructive controversy to improve students' understandings of and attitudes towards animal welfare in China. *Journal of Biological Education*, *57*(5), 1048-1061. https://doi.org/10.1080/00219266.2021.2011768

DOI: https://doi.org/10.17509/pdgia.v22i3.66462
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700