SITUATED LEARNING AND BIOLOGY EDUCATION: EFFECTS OF CONSTRUCTIVE CONTROVERSY STRATEGY AND GENETICS SELF-EFFICACY ON SECONDARY SCHOOL STUDENTS' ATTITUDE TO GENETICS CONCEPTS

APRENDIZAGEM SITUADA E EDUCAÇÃO EM BIOLOGIA: EFEITOS DA ESTRATÉGIA DE CONTROVÉRSIA CONSTRUTIVA E DA AUTOEFICÁCIA GENÉTICA NA ATITUDE DE ALUNOS DO ENSINO MÉDIO EM RELAÇÃO A CONCEITOS DE GENÉTICA

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Abstract. Genetics Concepts (GCs) as received a great deal of attention in recent times due to its importance in human being development and society wellbeing at large. However, recent advancements in genetics, have sparked significant public controversy, in areas like reproductive cloning, ordering genetically modified infants, genetic therapy, modification of animals and crops species, organs farming, and sex determination. Also, available reports have shown that students exhibited negative attitude to GCs, while previous interventions failed to incorporate socioscietific issues into the teaching of GCs. In this regard, it is important to raise genetics literate citizens who will be equipped with the fundamental information, positive attitude and skills needed in genetics using Constructive Controversy Strategy (CCS). The study was anchored to situated learning theory, while the pretest-posttest control group quasi-experimental design using 2x3 factorial matrix was adopted. An intact class of secondary school two science students from six public school was randomly assigned to CCS (121) and conventional strategy (119). Five instruments were used. Data were analysed using analysis of covariance at 0.05 level of significance. There was a significant main effects of treatment on student' attitude ($F_{(1;215)}$=4.42; partial η^2=0.02) to GCs. The participants exposed to CCS had better attitude to GCs (60.85) than those taught with CS (55.15). Genetics self-efficacy had significant main effect on students' attitude to GCs ($F_{(2;214)}$= 3.12; partial η^2=0.03), in favour of participants with low genetics self-efficacy. Treatment and self-efficacy had significant interaction effect on students' attitude to GCs ($F_{(2;213)}$ = 3.04; partial η^2 = 0.05). Constructive controversy strategy enhanced secondary school students' genetics concepts in Oyo State, Nigeria. Biology teachers should adopt this strategy in teaching genetics concepts and related socioscientic issues in genetics concepts.

Keywords: Attitude to genetics concepts, Constructive controversy strategy, Genetics self-efficacy, Situated learning

Resumo. Os Conceitos de Genética (GCs) têm recebido muita atenção nos últimos tempos devido à sua importância no desenvolvimento do ser humano e no bem-estar da sociedade em geral. No entanto, os recentes avanços na genética provocaram uma controvérsia pública significativa, em áreas como a clonagem reprodutiva, a encomenda de bebés geneticamente modificados, a terapia genética, a modificação de espécies de animais e culturas, a criação de órgãos e a determinação do sexo. Além disso, os relatórios disponíveis mostraram que os alunos exibiram uma atitude negativa em relação às GCs, enquanto as intervenções anteriores não conseguiram incorporar questões sociocientíficas no ensino das GCs. A este respeito, é importante formar cidadãos alfabetizados em genética que estejam equipados com a informação fundamental, atitude positiva e competências necessárias em genética, utilizando a Estratégia de Controvérsia Construtiva (CCS). O estudo foi ancorado na teoria da aprendizagem situada, adotando-se o desenho quase experimental pré-teste-pós-teste de grupo controle, utilizando matriz fatorial 2x3. Uma turma intacta do ensino secundário, dois estudantes de ciências de seis escolas públicas, foi aleatoriamente designada para CCS (121) e estratégia convencional (119). Foram utilizados cinco instrumentos. Os dados

foram analisados por meio de análise de covariância com nível de significância de 0,05. Houveram efeitos principais significativos do tratamento na atitude dos alunos ($F_{(1;215)}$=4,42; η2 parcial=0,02) em relação ao GCs. Os participantes expostos à CCS tiveram melhor atitude em relação ao GCs (60,85) do que aqueles ensinados com a CS (55,15). A autoeficácia genética teve efeito principal significativo na atitude dos alunos em relação ao GCs ($F_{(2;214)}$ = 3,12; η2 parcial = 0,03), em favor dos participantes com baixa autoeficácia genética. O tratamento e a autoeficácia tiveram efeito de interação significativo na atitude dos alunos em relação aos GCs ($F_{(2; 213)}$ = 3,04; η2 parcial = 0,05). A estratégia de controvérsia construtiva melhorou os conceitos de genética dos alunos do ensino secundário no estado de Oyo, na Nigéria. Os professores de biologia devem adotar esta estratégia no ensino de conceitos de genética e questões sociocientíficas relacionadas em conceitos de genética.

Palavras-chave: Atitude em relação aos conceitos de genética, Estratégia de controvérsia construtiva, Autoeficácia genética, Aprendizagem situada

1. INTRODUCTION

Biology as one of the branches of biological science, includes the study of living organisms, in terms of their morphology, physiology, reproduction, anatomy, chemical processes, molecular interactions and functions, heredity, distributions, and their evolution overtime. Biology comprises many branches and sub-disciplines, which include; evolution, genetics, microbiology, botany, zoology, anatomy among others. The study of biology is vital for the formation of global knowledge that serves as the foundation for modern science and technological advancement in any country. It allows the individual to learn about man and other organisms, as well as how they interact among themselves and their environment.

The importance attached to the subject from secondary school biology curriculum to biological science related courses at tertiary institutions shows the essential role of the subject in our modern society. This vital role is not limited to the growth and developmental process of individual, it is also essential to the advancement of scientific goals in any country. In furtherance of this, the Federal Ministry of Education (FME, 2013) states that the main goals of studying biology include the acquisition of necessary scientific skill(s), essential knowledge needed by secondary school students to further their studies in biology and related disciplines, development of positive attitude to science, and relevant ability needed by students in the application of biological theories to their day-to-day life, among others. Although biology is offered at secondary school as an optional subject, due to its importance and relevance in our contemporary society and to achieve the stated objectives, it means that the subject needs to be taught to Nigeria citizens in order to comprehend the contents thematised under it and to actively participate in any societal issues that arise due to its application in our society.

Biology as a subject interface and interacts with different fields of human thought and endeavours such as engineering, industrial, financial, communal, cultural, technology as well as religious domains, among others. These multidimensional reciprocities bring about a lot of individuals, societal and cultural problems, frequently referred to as socioscientific issues in biology, which always necessitate a response from the members of that particular society in form of reasoning, reflecting and judgement making. Socioscientific issues in biology are contentious, real-world and socially relevant problems that are caused by the application of biological knowledge and are appealing to the society due to the moral dilemmas they raise (Sadler, Barab and Scott, 2007), where people from different premises hold different key beliefs, explanations, understanding, motives, interests, values, political agendas, and such issues are not easily resolved by facts or evidence. For instance, during the COVID-19 pandemic era, many citizens, spiritual

leaders, politicians and government officials made different egregious claims and theories based on what they felt, self-philosophy, and ideology, rather than on known scientific proof and evidence (Powell, Newton and Zeidler, 2021). Examples of such issues include dealing with sex determination and discrimination, fingerprinting in crime detection, use of human foetal tissue in biomedical research, reproductive genetic technology, nutrition (safety of genetically modified foods (GMFs)), and pandemic, among others.

Studies have shown that little interest is shown in these socioscientific issues largely present in the school biology curriculum. Instead, scientists were more inclined to discuss the benefits, applications and social use of science in the areas of innovative scientific discoveries, health, new medical inventions, politics, and economics, with little consideration on the socioscientific issues created by the so-called advances in biology (Wellcome, 2016). In biology, these issues are infused in some concepts that are part of the senior secondary biology curriculum. Concepts like nutrition, reproduction, ecology, pollution and genetics, among others. Of these, genetics has received a great deal of attention in recent times due to its importance in human being development and society wellbeing at large.

Genetics is an important topic in Nigerian senior secondary school biology curriculum, its studies genes, how genes are inherited and transfer, as well as the variation, functions and behaviours of genes. The sub theme found under genetics include: principles of heredity, the transmission of inheritable characters from parents to their offspring via genes, and variation; differences that occur within the individuals of a species, sex determination, probability, application of probability, sex-linkage, and use of heredity principle. The application of genetics knowledge in the areas of bioengineering/biotechnology, gene therapy for curing of genetic diseases, crop and animal production, paternity testing and crime detention, among others has improved human life considerably (Ekong, Anongo, Okrikata and Akpan, 2015). However, recent advancements in genetics, have sparked significant public controversy, including reproductive cloning, ordering genetically modified infants, genetic therapy, genetically modified species, modification of animals and crops species, organs farming, and sex determination. In this regard, the inclusion of social scientific-related issues in the learning of genetics will equip learners with the fundamental information and skills they will need for future careers in genetics and related fields (Levinson, 2006).

Sri, Arum, Anisyah and Noor (2018) emphasised that whatever knowledge or skills students are learning, they will have feelings about what they get from the outcomes of that learning. Such feelings can influence their future understanding of that concept. The feelings of like and dislike for a particular concept play a critical role in blocking or enhancing learning of such concept and they are major determinants of what will be learned in any class situation. In any learning situation, people tend to learn quicker that concept to which they possess a positive attitude. Any subject or concept towards which one has an unfavourable attitude would be difficult to learn or might not be learnt at all. Attitude to genetics concepts can be described as a combination of feelings, beliefs and values to genetics that is a product or effect of genetics as well as genetics class (Ekici and Hevedanli, 2010). In the 2006 Programme for International Student Assessment, it was stated that students' attitude to science contents is a major factor that influence their understanding of such content and acquisition of related skills (OECD, 2006). While Newell, Tharp, Vogt, Moreno and Zientek (2015) believed that the way students face knowledge, especially their attitude to genetics is one of the variables influencing their understanding of genetics concepts.

In spite of the importance of attitude to students learning in biology, Kamau, Mwania and Njue (2018) claimed that students' attitude to biology still remain negative. Also, studies have shown

that students have negative attitudes to genetics due to the perceived difficulty nature of the concepts (Dinah, 2013). Chen, Chu, Lin and Chiang (2016) observed that students show negative attitude to some aspects of genetics such as cloning of human cell, sex determination and selective abortions. While Cimer (2012) in their separate studies reported that secondary school students have negative attitudes to genetics as a result of teachers' style of teaching biology. Previous studies have attributed this negative attitude to skipping classes, low in-class participation, and placing a greater emphasis on examination scores than on learning of genetics content (Armbruster, Patel and Weiss, 2009). Also, a close examination of related literature also indicated that students' variables like gender, perceived interest, beliefs, religious affiliations/cultural background and instructional strategies used, influenced students' attitudes to genetics and related socioscientific issues (Hagay, Peleg, Laslo and Ayelet, 2013). Dinah (2013) attributed students' negative attitudes to biology to a lack of relevant textbooks, laboratory equipment, and related teaching and learning instructional materials. While Adesoji (2008) indicated that students' attitude to science subjects depends on the method of instruction adopted.

The development of positive attitude to genetics concepts is an important step in addressing the various issues related to genetics and the society at large. To address the aforementioned challenge in students' attitude to genetics concepts, there is a need for appropriate strategy that supports students' active participation and at the same time incorporate related issues into the learning of genetics concepts. A variety of innovative active learning strategies that can enhance students' cognitive, affective, and psychomotor domains in genetics concepts and related issues have been proposed by several scholars in field of biology education, such as, computer simulation and game puzzle packages, problem-solving and discovery strategies, 5E learning strategy, problem-solving and discussion, among others. In spite of this, the negative attitude to genetics classroom still persist. The researcher attributed these to the fact that most of these strategies did incorporate the socioscientific issues in genetics to the teaching and learning of genetics concepts, correction of misconceptions, as well as the application of the gained knowledge in genetics concepts. Among the strategies that allows the incorporation of socioscientific issues to genetics learning and provide an opportunity to apply the gained knowledge is constructive controversy.

The constructive controversy strategy was introduced by Johnson and Johnson in 1979. It is a structured cooperative learning strategy that is facilitated in groups of four students with six students on rare occasions. Pairs are given perspectives to plan, present, and discuss within the context of a cooperative model aimed at reaching consensus on a decision or reasonable conclusion, or at the very least, agreeing on the best arguments on both sides (Johnson, Johnson and Stanne, 2000). The teacher's position in this strategy is to direct and inspire students to think by introducing them to controversial issues. According to Johnson and Johnson (2016), constructive controversy occurs when two people's ideas, facts, assumptions, hypotheses and opinions are incompatible and they attempt to reach an agreement that represents their best reasoned judgement. It relates to deliberate discourse, creative problem solving, critical discussion, cognitive conflict, argumentation, and inquiry-based advocacy. Furthermore, constructive controversy fosters creativity, innovation, critical thinking, and empathy, all of which are skills that will not only improve discussion, but are of value outside the classroom (Johnson and Johnson, 2016).

The underlying suppositions of the strategy are that when people are faced with a problem, they have an initial understanding and judgement, but when they are confronted with other people's decision that differ from their own, they experience intellectual disagreement and cognitive confusion (Johnson, and Johnson, 2016). This is thought to contribute to epistemic

curiosity, which encourages the development of a more appropriate cognitive perspective and a stronger thinking process through the comprehension of other people's viewpoints and reasoning. The reconceptualisation and reorganisation of decision follows the adaptation and accommodation of one's own viewpoint. This method is anticipated to lead to more innovative and high-quality solutions. The benefits of a constructive controversy strategy include; students learn to consult, students learn to appreciate the opinions of others, students learn to think critically and reflectively, and students learn to cultivate engagement. Although there are a few observed limitations, the presence of personal qualities that want to stand out and it can be difficult to reach a conclusion at times. Constructive controversy has been found to improve students' achievement, better problem-solving, decision making, as well as other important learning outcomes like reasoning, views, argumentation, self-confidence, dispositions, high order thinking, activities participation, and social and personal interactions (Johnson and Johnson, 2009).

The teaching and learning of genetics concepts involve planning, organising, and performing tasks in order to provide solutions to biological issues. Research indicates that self-efficacy can effectively predict students' future academic performance, and some studies also suggest that it has stronger predictive power than other non-cognitive variables (Schunk and Pajares, 2009). Self-efficacy is a term that implies the ability of students to learn new skills and activities, usually in a particular academic field. It could also imply the ability to plan, organise, investigate, and perform a given tasks in a specific science-related subject effectively. Bryant (2017) reported that self-efficacy is a factor that motivates students to achieve stated learning goals and tackle difficulties they may encounter in their learning. He further stated that high self-efficacious students are more likely to accept more difficult activities, have better time management skills, are more persistent in the face of challenges, have lower anxiety, are more flexible in adopting different learning strategies, and can adapt to different teaching and learning situations.

Bandura (2006) explained self-efficacy in the context of social cognitive theory, which states that human achievement is dependent on interactions between one's behaviours and personal and environmental variables. Students' vicarious experiences, persuasions from others, and physiological responses assist them in evaluating their actual performance in any learning situation. Also, students who have a high self-belief in biology are more likely to employ cognitive and regulatory strategies in a systematic way and are less likely to give up when faced with challenges (Ersanla, 2015). Therefore, it is very important for students to have strong self-efficacy as it will be required when they try to exert control over their academic learning settings that is based on novel strategies that integrate thinking skills, learning of new skills, as well as organising and solving issues in a science classroom (Bryant, 2017). Supporting this claim that self-efficacy is a strong potent factor that predicts students' learning, Alpacion Camañan, Gregorio, Apanlaan and Tudy (2014) stated that low self-efficacy of students is a factor affecting cognitive (achievement) and affective (attitude) domains.

Furthermore, Wernersbach, Crowley and Bates (2014) suggested that those who have less confidence in themselves and their abilities to complete a given task or face an obstacle are easily discouraged, while those who believe in themselves are always determined to successfully complete a give task in spite of challenges. Based on the researcher's knowledge, the majority of studies carried on students' self-efficacy in science focused on mathematics and physics, while research on biology has been scarce. Based on the above submissions, it is important to examine secondary school biology students' self-efficacy in order to determine its effect on their content knowledge, reflective thinking and attitude to genetics concepts in biology. Based on the

foregoing, it is imperative to determine the effect of constructive controversy and self-efficacy in genetics concepts on students' attitude to genetics concepts.

1.1 Hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance:

Ho1: There is no significant main effect of treatment on students' attitude to genetics concepts?

Ho2: There is no significant main effect of self-efficacy on students' attitude to genetics concepts?

Ho3: There is no significant interaction effect of treatment and self-efficacy on students' attitude to genetics concepts?

2. Theoretical Framework

2.1 Situated Learning Theory (SLT)

Situated learning theory places emphasis on the importance of socio-cultural context in the process of understanding and learning. The theory of situated learning was developed by Lave and Wenger in the early 1990 based on the works of Dewey, Vygotsky, and others (Clancey, 1995) who believed that students would learn better if they actively participated in their learning through different activities, context, and culture based on the domains of learning rather than simply listening to teachers in classrooms. This point of view asserts that understanding and learning should not be separated from contexts where they occur. To the advocates of this theory, learning is not a process that occur independently of the environment, as a result, it cannot be viewed as isolated acts that occur only in our thoughts as persons. That is this theory is founded on the premise that facts or ideas are linked to the specific contextual environments where it occurred or the applied domain of the knowledge being acquired, which is especially relevant where practical skills are very important. These environments or context is formed and articulated, by students and their facilitators (teachers) as well as facts, information, human and non-human learning materials, and also the rules that govern learners' participation and discussions. When learners actively engage with groups of participants that make up these environmental contexts, it could be said that the learning process has started (Mohammed, 2016).

The theory is relevance to this study by allowing students engagement with real activities at the same time it provides the teacher a natural advantage in facilitating intellectual apprenticeship in the classroom; use concepts that are abstract and difficult in nature; reflection incorporated strategies where students were provided with the learning situations or conditions to critically analysis and make informed decisions by interacting with real activities; gives room for student to learning by doing and to sustain a strong link among attitude, knowledge and practice, and permits culture groups learning. This theory provides teachers with the opportunity to evaluate individual's learning in terms of process and products, and allows the understanding of individual as a person not just as a mere receiver of organised knowledge and activities.

3. MATERIALS AND METHODS

Research Design: The pretest-posttest control group quasi-experimental design (this is due to the manipulation of the independent variable).

Selection of Participants: Senior Secondary School II students in Oyo state were the participants. In order to offer all of the local government areas in the three senatorial districts an equal chance to participate in the study, one local government area (LGA) was randomly selected

from each of the three senatorial districts in Oyo State, for a total of three local government areas. From the three local government areas, nine senior secondary schools were chosen at random (that is, three schools from each LGA). The schools chosen must be willing to engage in the study and must be geographically apart from one another. Each of the nine schools randomly assigned an intact class of senior high school II biology students in science class to each of the experimental and control groups.

Research Instruments: The following instruments were used.

Instructional Guide for Constructive Controversy Strategy (IGCCS): The Constructive Controversy Strategy instructional guide is a stimulus instrument adapted from Johnson and Johnson (2007) processes of constructive controversy using the phases and steps involved in its conceptual model. The instrument used for participants in the experimental group. The validity was ascertained by presenting copies to the candidate's supervisor and three lecturers in science and technology education department. IGCCS was scrutinized for its appropriateness and relevance to curriculum content, precision and accuracy of the steps involved and its usability. Corrections, modifications, and ideas suggested were all taken into account during the course of the production of the final instrument.

Students' Attitude to Genetics Concepts Questionnaire (SAGCQ): The SAGCQ is a 30-item instrument constructed by the researcher to assess students' attitude to genetics. The instrument measures students' feelings, beliefs, values and usefulness and impacts of genetics. The instrument was graded on a four-point Likert scale, from Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD). The participants were asked to tick one of four possible replies to indicate their level of agreement or disagreement with each statement. The positive statements were given a score of SA = 4, A = 3, D = 2, SD = 1, whereas the negatively worded statements were reversely scored.

The items from the instrument were presented to the researcher's supervisor and lecturers who are experts in measurement and evaluation in order to establish its validity in areas of language construction, precision of focus, clarity of purpose, and brevity of ideas for the target population. The views of the experts were incorporated into the instrument's final draft. The instrument was trial-tested on SS 2 students that were not part of sample students that participated in the main study to ensure its reliability. Cronbach's Alpha formula was used to establish the instrument's internal consistency. This reliability technique is applicable for this instrument because each test item is supposed to measure the same latent feature on the scale, this reliability technique is applicable for this instrument. The reliability coefficient of 0.83 was obtained.

Self-efficacy in Genetics Concepts Scale (SeGCS): The SeGCS was adapted to access the self-efficacy of students in genetics. The SeGCS consists of 28 items adapted from Schwarzer and Jerusalem (1995) General Self Efficacy Scale and Biology Self-Efficacy developed by Baldwin, Ebert-May and Burns (1999). Schwarzer and Jerusalem (1995) instrument contains 10 items on a four-point scale of Exactly true-4, Moderately true-3, Hardly true-2 and Not at all true-1. Cronbach alpha was used to establish the internal consistency of GSES by the authors which gave alpha coefficients between 0.76 and 0.90. Baldwin, et al (1999) instruments of 23 items was made on a 5-point rating scale from Totally confident, Very confident, Fairly confident, Only a little confident and Not at all confident. The internal consistency reliability for the instrument yielded Cronbach's alpha coefficients of 0.89. The instrument was modified to a four-point Likert response scale of Strongly Agree, Agree, Disagree and Strongly Disagree. To read genetics, some items were recreated. These changes were made to fit the study's objectives and the participants' skill levels. In scoring, Strongly Agree = 4, Agree = 3, Disagree = 2 and Strongly Disagree = 1, were

assigned to statements that are positively stated, while negatively worded statements were reversely scored.

The validity of the SeGCS was ascertained by the researcher's supervisor and lecturers who are experts in measurement and evaluation to establish the suitability of the items in term of language construction, precision of focus, clarity of purpose and suitability for the target population. Their comments were taken into account when designing final draft of the instrument. The 34 items instrument was pilot-tested on a SS 2 students that were not among the sample students select to participate in the main study to ensure its reliability. The Cronbach's alpha formula was used to establish the instrument's internal consistency. This reliability technique is applicable for this instrument, because each test item is supposed to measure the same latent feature on the scale. The reliability coefficient of 0.88 was obtained. After which, only 28 items were found to be good enough for the study.

Treatment Procedure for Constructive controversy strategy:

Step 1: Grouping and assigning responsibilities

i. Students were divided into groups of four members
ii. Students were separated into two pairs after being randomly assigned to four-person teams. Each pair was assigned one of the two sides of the debate established in Step 2 at random.

Step 2: Definition of problem and researching positions

i. Teacher provided background information on the topic and related controversial issue either using lecture or text materials.
ii. Students evaluated their assigned positions by providing a brief description of the topic and at least have five explanations for their positions

Step 3: Research and prepare a position

i. Students reassemble again in their 4-member teams, with each pair presenting the best probable argument for their given position, while the second pair does the same for their own given position.

Step 4: Open discussion

i. Students continued to provide support for their assigned viewpoints, by critically analysing the opposing argument and pointing out the flaws and weakness, as well as defending their own assigned roles against the opposing pair's attack.

Step 5: Reverse Perspectives

i. Students made the strongest case feasible for other side of the argument.
ii. Students referred to their notes and provide new information to check whether the provided information is accurate. Here, students tried to perceive the problem from both sides.

Step 6: Reconceptualisation, synthesis, integration

i. Students dropped their assigned roles.
ii. Summarised and used the best reasoned ideas of the four group members, and integrate it into a joint accepted position on the problem's solution by learning, reflecting and understanding other's perspectives.
iii. Students wrote a group report (by making use of given handout procedure) outlining their decision with supporting rationale and evidence,
iv. Teacher clarified any misconceptions.

Step 7: Assessment

i. Each student took a test on the topic and the given positions to see how well the group worked together.
ii. The group celebrated their accomplishments and each member's hard work.

Methods of data analysis: The inferential statistics of analysis of Covariance with the pretest scores as covariates. The magnitude of the mean scores of the different groups and which group has the highest mean score were determined using the Estimated Marginal Mean (EMM). All null hypotheses were evaluated at a significance level of 0.05. Descriptive statistics and content analysis were used to examine the study lone research question.

4. RESULTS

4.1 Testing of Hypotheses

Ho1a: There is no significant main effect of treatment on students' attitude to genetics concept
This null hypothesis 1a sought to find out whether the attitude of students to genetics concept is improved after exposure to the treatment and control conditions. To test this Ho1a, ANCOVA analysis was conducted and the summary of the result is presented in Table 1.

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 after adjusting for pre-attitude. Table 1 revealed the p-value of 0.04 which was significantly lesser than p0.05. This result gave strong evidence that the null hypothesis 1a was rejected at the 0.05 level of significance. This implies that the observed difference in the adjusted post-attitude mean scores of students to genetics concepts in biology after they were exposed to the treatment and control groups was significant. 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

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.

Ho2: There is no significant main effect of self-efficacy in genetics concepts on students' attitude to genetics concepts

To test this null hypothesis 2a for non-rejection. The ANCOVA analysis summary in Table 1 was explored at $p<0.05$ and the result interpreted as follows.

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 $\eta^2 = 0.03$) was significant after controlling for pre-attitude at $p<0.05$. The p-value of 0.34 is significantly lesser than the 0.05 level of significance, 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 with confidence interval ranging from 57.44 to 65.64, followed by moderate genetics concepts self-efficacious students with adjusted post-attitude mean score of 59.22 with confidence interval ranging from 55.26 to 63.19, while high genetics concepts self-efficacious students had the lowest adjusted post-attitude mean score of 53.22 with confidence interval ranging from 48.06 to 58.39. 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) Self-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 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.

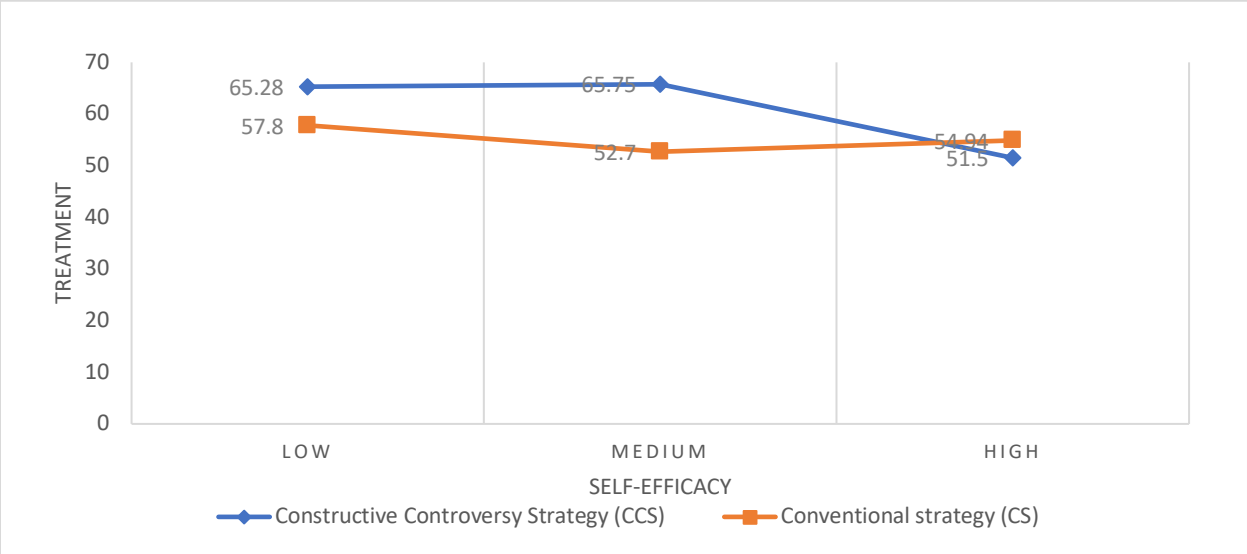
Ho3: There is no significant interaction effect of treatment and self-efficacy on students' attitude to genetics concept

To determine whether there is no statistically significant two-way interaction effect of treatment and self-efficacy on students' attitude, the ANCOVA summary in Table 3 was explored and the treatment x self-efficacy row is interpreted and the result is presented as follows.

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. The p-value of 0.03 is significantly lesser than 0.05 level of significance, this indicates that the probability of obtaining the observed F-value given the null hypothesis 3a was true. Thus, the effect of the treatment on students' post-attitude to secondary school biology genetics concepts after controlling for pre-attitude depends on students' self-efficacy in genetics concepts. 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 determine the magnitude of the differences among the post-attitude mean scores of the students across treatment groups and the three levels of self-efficacy, and also to explore the nature of the interaction effect, the line graph is presented in figure 1.

Graph 1. Treatment and self-efficacy in genetics concepts on students' attitude to genetics concepts



Graph 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 their counterparts with low self-efficacy in constructive controversy strategy (65.28), low self-efficacy students in conventional strategy (57.90), medium self-efficacy students in convention strategy (52.70), while high self-efficacy students in constructive controversy strategy recorded the least adjusted mean score (51.50) in post-attitude mean score to genetics concept in biology. This means that the treatment is more suitable for medium genetics concepts self-efficacious students in enhancing their attitude to secondary school biology genetics concepts. Graph 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.

5. DISCUSSION

5.1 Main effect of treatment on secondary school students' attitude to genetics concepts

The main (constructive controversy and socioscientific issue-based strategies) effect of treatment on genetics concepts post-attitude of students in biology was significant. This means that a significant difference existed in students' post-attitude to genetics concepts in biology after the application of the intervention across the three strategies. The result further indicated that students in SsI-based group had better post-attitude, followed by their counterparts in the constructive controversy group and those in the conventional strategy with the lowest adjusted post-attitude mean score to genetics concepts in biology. This outcome implies that constructive controversy and socioscientific issue-based strategies were 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. The reason for this adjusted mean difference in attitude of students in constructive controversy and conventional strategies 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 (Johnson and Johnson, 2009). In addition, this may be due to the fact that constructive controversy strategy through positive conflict helps students in understanding issues, generating reasoned solutions, and reinforcing relationships among students and facilitating development of positive disposition to learning.

This may 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 (Jenkins and Lonsdale, 2007). Furthermore, the strategy also helps them to value the importance of involvement in argument and the process of making decision, that is, as they constantly develop positive attitude toward the given task, the greater the commitment to implement what they agreed upon (Johnson and Johnson, 2009).

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.

5.2 Main effect of self-efficacy on secondary school students' attitude to genetics concepts

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 after controlling for students' pre-attitude to genetics concepts. This means that the difference in students' post-attitude to genetics concepts based on their self-efficacy level (low, medium and high) was 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 provided with a positive learning environment, which could play a critical role in developing low self-efficacious students' confidence. Another reason may be due to the fact 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 and 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 Kund and Ghoshe (2016), that relationship existed between higher secondary students' attitude to mathematics. But this current study is in variance with Kund and Ghoshe' findings (2016) that high self-efficacy students had the highest mean score in mathematics at higher secondary level. The research study of Icoz (2012), is also in tandem with this current finding, who in independent work found high correlations between students' attitude and self-efficacy to chemistry lessons.

5.3 Interaction effect of treatment and self-efficacy in genetics concepts on secondary school students' attitude to genetics concepts

Treatment and self-efficacy interaction on students' attitudes to genetics concepts in biology had significant effect. This indicates that CCS depend on students' level of self-efficacy in genetics concepts in biology. That is being low, medium or high efficacious has different effect on the treatment applied. This implies that when applying this strategy, different students' self-efficacy levels (low, medium and high) must be given a great consideration in order to enhance students attitude to genetics concept. It was also observed from the result that students with medium self-efficacy in CCS had better post-attitude to genetics concepts in biology. This may be because this strategy helps these students in making an effort to learn genetics concepts through group discourse, perspective views where they can apply reasoning and reflect and utilise newly gained knowledge to resolve controversial issues during genetics concept leaning.

This finding is supported by the findings of Sadi and Uyar (2013), Diseth (2011) that students who are more efficacious about performance in the biology classroom are more successful than those who are more concerned about their ability to do well in biology lesson. This finding is confirmed by the research report of Sadi and Uyar (2013) which indicate that higher level of self-efficacy directly associated with the learning strategies adopted in biology learning environment. This finding of the current study is lent credence to by the research works of Al Dafaei, Ismail, Samsudin and Shakir (2013), that self-efficacy of students is a potent factor that strongly mediate the relationship that existed between teacher use of instructional strategies and students' attitude. This finding is corroborated by the finding of Sen and Yilmaz (2016), who found a correlation between strategies used and self-efficacy of students. This present finding is corroborated by the assertion of Berger and Karabenick (2011) that the mode of cooperative learning instructions used can be determine by self-efficacy of students.

6. CONCLUSION

The study concluded that constructive controversy strategy was more efficient in improving students' attitude to genetics concepts and related socioscientific issues in secondary school biology when compared to conventional strategy. Students' genetics self-efficacy in genetics concepts influenced their attitude to genetics concepts. Treatment and students' self-efficacy in genetics concepts interaction on their attitudes to genetics concepts in secondary school biology had significant effect. While, medium self-efficacious students in constructive controversy strategy had better attitude to genetics concepts when compared to others. Based on these findings, the following recommendations were made:

i. There is a need for biology teachers to adopt the constructive controversy strategy in the teaching and learning of genetics concepts in biology teachers in order to improve students' attitude to genetics concepts.
ii. There is need to explore socioscientific issues that are related to the needs of genetics concepts learning in biology, especially those that are local and national to our everyday life, needs to be done to support the implementation of constructive controversy strategy in biology learning.
iii. Teachers should consider the self-efficacy status of their students when adopting the constructive controversy strategy as it has influenced its adoption in the teaching and learning of genetics concepts.

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