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CONSENSUS-BASED EDUCATION: ITS EFFECT ON COLLEGE STUDENTS' ACHIEVEMENT IN BIOENERGETICS AS MODERATED BY GENDER AND LEARNING STYLES

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Abstract. *Involving students in making an educational decision is claimed to produce better outcomes. The effect of consensus-based education (CBE) on achievement in bioenergetics as moderated by gender and learning styles was determined. Two undergraduate biology classes were compared employing the quasi-experimental design, one using CBE and the other taught the conventional way. The Biology Achievement Test (BAT) was the main data collection tool used, supplemented with questionnaires, learning style inventory, videos, journal, and informal interviews. ANCOVA tested the effect of educational approach and the moderating effects of gender and learning styles while t-test compared the BAT scores between the groups. Results show that CBE can be a feasible alternative approach to teaching biology as it fairly addresses issues on gender and learning styles. It has also helped students develop their reasoning skills and improve their appreciation of democratic practices in the classroom.*

Key words: *educational decision-making, consensus-based education, learning style effect, gender effect, achievement in bioenergetics.*

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Introduction

In the Philippines, improving students' achievement is one of the primary goals of science education. Several reports documented the disappointing performance of Filipino students in science during the last few decades both in national achievement tests and international surveys (Gonzales et al., 2004; DepEd-EFA, 2015). The problem even persists when these students go to college.

One of the most important but often difficult subjects to teach and to learn in an introductory college biology course is bioenergetics, which includes the topics metabolism, photosynthesis, and cellular respiration. Aside from being abstract, many students have alternative conceptions about these topics (Tanner & Allen, 2005; Tatar & Oktay, 2007; Kose, 2008; Keles & Kefeli, 2010; Parker et al., 2012; Svandova, 2014). These are implicated in hindering students' learning thereby affecting their achievement in the course (Ozcan, 2003; Tatar & Oktay, 2007). Students' achievement in Biology, as with other disciplines, is an indicator of students' learning as well as the effectiveness of educational interventions, and thus, becomes one of the main concerns in science education (Osman & Kaur, 2014). A lot of factors have been reported to affect student achievement in science (Yusuf & Afolabi, 2010) and over the years, science teachers have been searching for the best method of teaching. To this end, the claim that a learning environment that acknowledges the significance of student views to probably provide the most important foundation for thinking about ways of improving teaching, learning and schools, merits further research (Macbeth et al., 2000; Phoenix, 2000; Cimer, 2012).

An emerging teaching approach, which traced its roots from the social sciences, has been documented in the literature that is based on the concept of consensus. Consensus is a decision-making model utilized by prehistoric tribes and adopted by organizations, communities, and groups in coming to a unanimous decision, one that works for everyone (Schutt, 2011). In literature, the term consensus is conceptualized as either a decision rule,

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a decision-process, or as both a decision rule and a process (Didcoct & DeLapa, 2000; Freeman, 2002; Hartnett, 2012; Christian, 2012; Cunningham, 2014). Hartnett (2012) suggested to use the term "consensus" when denoting to a collaborative and agreement-seeking process, and the terms "unanimity" or "full consent" when referring to the decision rule that requires full agreement in making decisions. Adapters of using consensus in making educational decisions premised their arguments on the core idea that students' voices are often left out in their own educational process as they are silenced by the authoritarian, top-down classroom models. They claim that these undemocratic practices discourage optimal students' engagement and block their innate desire to learn (Sartor & Young Brown, 2004; Blinne, 2013).

Contrary to teacher-based educational decisions, the use of consensus in education is reported to promote shared authority and responsibility in making decisions. It enhances students' self-expression and encourages full student participation, stimulates creative decision-making, nurtures the development of a conscious community, shows that education can be a practice of freedom, and helps learners to form good self-concepts, heighten their level of engagement, and improve their ability to apply learning in new contexts (Hooks, 1994; Freire, 1998; Wolk, 1998; Bruffee, 1999; Sartor & Young Brown, 2004; Mitchell et al., 2009; Blinne, 2013; MacDougall, 2013). This approach is reflective of a postmodern, constructivist, democratic and student-centered view of learning which are consistent with the persistent call for a more dynamic, more democratic and more egalitarian learning environment which are thought to produce better student outcomes (Hooks, 1994; Freire, 1998; Wolk, 1998; Shor & Pari, 2000; Sartor & Young Brown, 2004; Hartnett, 2012).

Literature points to two models by which the consensus process has been applied by teachers in the context of making educational decisions. First is the whole class consensus model where the students raise an issue, negotiate or propose an alternative, engage in discussion, call for consensus decision, and adhere to the agreed process (Sartor & Sutherland, 1999; Sartor & Young Brown, 2004; Mitchell et al., 2009; Blinne, 2013). The other model is consensus within a group in the context of a lesson where the teacher asks an engaging focus question requiring an individual or group-based problem solving, followed by student-to-student communication or whole class discussion, and ends with a consensus answer to the focus question (Inoue, 2010; MacDougall, 2013).

While these models gave students the opportunity to negotiate and co-construct with teachers the educational plans and designs, very few however comprehensively described the method by which consensus was generated in making those educational decisions. Most notably, findings of studies about the benefits and effects of consensus and its variants were limited to the investigators' self-contained classrooms. This setup could inevitably cast reservations as to the generalizability of the reported benefits. Also, prior to this research, there was never a structured and objective attempt to determine and test the effects of the consensus process using a comparison group and there was no hard evidence whatsoever that linked the consensus process to students' performance on an achievement test. To address these gaps, the present research put together the two prominent consensus models in classrooms and named it Consensus-Based Education (CBE). Its effectiveness was tested in improving students' achievement in bioenergetics against a comparison group taught using the conventional education (CE).

This research also tested the moderating effects of gender (Breakwell & Breadsell, 1992; Erickson & Erickson, 1984; Harding, 1983; Harvey & Edwards, 1980; Hendley et al., 1996; Johnson, 1987; Jovanovic & King, 1998; Kahle & Lakes, 1983; Robertson, 1987; Smail & Kelly, 1984) and learning styles (Eide, Geiger & Schwartz, 2001; Coffield et al., 2004; Pashler et al., 2008; Zhang, Sternberg & Fan, 2013; Wilkinson, Boohan & Stevenson, 2014; Khanal, Shah & Koriala, 2014; Wu, 2014; Cakiroglu, 2014; Moayerri, 2015) on students' achievement. Teacher's pedagogical strategies are advised to be examined for gender bias (SWE-AWE-CASEE, 2009) because males and females might react differently to different approaches. Likewise, Pashler et al. (2008) argued that the effect of learning style on students' performance has to be demonstrated by a crossover interaction through an experiment.

Methodology of Research

Research Design

The non-equivalent pretest-posttest control group quasi-experimental design was employed because the participants were from two intact classes in a natural school setting where the random assignment was not possible, and the distraction of class structure was avoided to the minimum. This design is suggested to be the best option for school-based research where classes are formed at the start of the year and it is neither practical nor feasible to assign the students randomly to treatments, as discussed in the work of Ross and Morrison (2004). The scope of the research in terms of participants were the college students enrolled in college biological science class which were limited to two classes only. The biology topic covered was biogenetics over a period of 12 teaching sessions across six weeks.

Samples of Research

The participants in this research were the college students enrolled in two NatSci 102 (Biological Science) classes, at the College of Business and Accountancy in a state university in the MIMAROPA region of the Philippines. Their schedules were arranged such that when bioenergetics would already be the topic to be discussed, the researcher would take over as the class instructor. The classes were chosen based on the following criteria: same academic program, same classroom, a comparable size to achieve the 30 actual samples needed for comparative analysis, and similar day yet comparable time schedule (CBE = 9-10 a.m.; CE = 2-3 p.m.). Between the two, the class that employed consensus-based education was selected by drawing of lots. For the purpose of controlling variance error due to inequality of sample size and other confounding factors, students from each group were further screened during data analysis such that those with absences and incomplete data were excluded from the sampling frame. Thirty students from each group were drawn using random numbers, except for the seven male students from the CBE group who were all forced to become the representative samples for their group. Data from these actual samples were used for comparative analysis. Table 1 summarizes the sample selection and the age structure of the actual samples by group and gender.

Table 1. Summary of sample selection and age structure of the actual samples by educational group and gender.

	CBE Group			CE Group		
	Male	Female	Total	Male	Female	Total
Class size	7	47	54	19	45	64
Number of students with absences and incomplete data	0	5	5	11	19	30
Number of qualified samples	7	42	49	8	26	34
Number of actual samples	7	23	30	7	23	30
Mean age (in years) of actual samples	17.57	16.96	17.10	17	17	17

Instruments

Learning Needs Analysis Protocol (LNAP). It is a self-administered protocol modified from Blinne (2013) which was used in assessing students' learning needs. These needs were used as inputs during the whole class and within group consensus discussions. The list of questions was submitted for content validation by three experts: a teacher with a Ph.D. in biology education, a campus director with a Ph.D. in educational psychology and a master's in science education, and an associate professor with a Ph.D. in educational management and also with a master's in science education. The instrument was revised as suggested.

Questionnaire on the Importance of Democratic Practices in the Classroom (QIDPC). This is a 10-item researcher-made instrument administered for students in the CBE group which determined their perceptions about the importance of democratic practices in the classroom across a four-point Likert-type scale, 1 as not important, 2 as slightly important, 3 as important, and 4 as very important. This instrument was submitted to the same experts who validated the LNAP whose suggestions were incorporated in the revised form. It was pilot tested in a biological science class of 50 students in the same College as of the actual respondents, but this class was not chosen as a sample. The data from the pilot test were used in computing for the internal consistency of the instrument, which is to check if all items within the questionnaire are measuring the same thing. The Cronbach's alpha value was 0.701 which means that the developed instrument is acceptable for use and thus, reliable (George & Mallery, 2000).

Canfield Learning Styles Inventory (CLSI). This is a 30-item instrument developed by Canfield and Knight (1983), with four options in each item that assessed student's preferences for learning over several affective learning

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domains: (1) conditions for learning, (2) area of interest, (3) mode of learning, and (4) expectation for course grade. Twenty-four options were used to determine student's preferred manner of obtaining new information, which was the domain used in typifying the respondents' learning styles in this research, such as listening, reading, iconic and direct experience. This domain of the CLSI has a reported Cronbach's alpha values of between 0.79 – 0.84.

Bioenergetics Achievement Test (BAT). This is a 35-item researcher-made test that assessed students' learning from the topic bioenergetics. It was developed by considering the unit plan contained in the course syllabus as well as the students' alternative conceptions about the topic. In the development of the test, alternative conceptions on metabolism, photosynthesis and cellular respiration were reviewed from literature and became the basis of constructing the instrument. The Trends in International Mathematics and Science Research (TIMSS) framework for science cognitive domain was the model adopted in initially appraising the cognitive level measured by the test items. This model categorizes science cognition into three domains: knowing, applying and reasoning. Each domain has sublevels of cognitive skills (Table 2). The first draft was submitted to four biology content experts from reputable universities in the country for content validation: an associate professor with a Ph.D. in biochemistry, a professorial lecturer with a Ph.D. in zoology, a researcher with a Ph.D. in genetics, and an associate professor with a Ph.D. in plant biology. They inspected the questions and circled those that were unclear and had some grammatical issues, checked the consistency of the questions against the topics indicated in the course syllabus, and wrote suggestions on improving the items. All these were incorporated in the revision of the achievement test. To check the validity of the initial appraisal done on the cognitive levels measured by each item against the TIMSS-based framework, the content-validated achievement test was further sent to two biology education specialists for evaluation. Their comments and suggestions were incorporated in the finalization of the instrument. Then, the final form of the achievement test was pilot-tested to 80 students who had just undertaken their biological science course in the previous semester from the College of Education at the same university. From the results of the pilot test, a Cronbach's alpha value of 0.719 was generated establishing the acceptability and reliability of the instrument.

Table 2. Table of specification for the Bioenergetics Achievement Test.

Science Cognitive Domain (TIMSS-based) Metabolism	Topic/Item Placement			Total/ (%)
	Photosynthesis	Cellular Respiration		
Knowing				11 (31)
Recall/Recognize		6, 7, 9	12, 13, 14	
Define	1			
Describe		8	19, 29	
Illustrate with examples	2			
Demonstrate knowledge of scientific instruments				
Applying				14 (40)
Compare/Contrast/Classify/ Distinguish		10, 11, 18	20	
Use models				
Relate	4		27	
Interpret information/diagram	3, 5	16, 17	26	
Find solutions			30	
Explain			28, 23	

Science Cognitive Domain (TIMSS-based) Metabolism	Topic/Item Placement			Total/ (%)
	Photosynthesis	Cellular Respiration		
Reasoning				10 (29)
Analyze			31, 32, 33	
Integrate/Synthesize				
Hypothesize/Predict		22	34	
Design		21		
Draw conclusions	15		35	
Generalize				
Evaluate		24, 25		
Justify				
Total/ (%)	6 (17)	13 (37)	16 (46)	35 (100)

Aside from these research instruments, quantitative data were supplemented by information from the video-recorded class sessions, researcher's journal and informal interviews with students.

The Teaching Intervention

Permission from the University President through the Vice President for Academic Affairs and Dean of the College of Business and Accountancy was sought to introduce the proposed intervention and other research protocols among the students enrolled in biological sciences in the said college. Schedules of the classes to be studied as well as their subject teacher were arranged. Prior to the introduction of the intervention, CLSI was administered by the subject teacher to the students both in the CBE and CE groups. Unfortunately, a typhoon devastated the province the next day. Classes were canceled and preliminary data collection activities were aborted due also to Christmas break. Data collection resumed when classes reopened. Both classes were already turned over by the subject teacher to the researcher for the experimental research which covered the topic on bioenergetics. In the CBE group, two more data gathering instruments were administered by the researcher: the QIDPC and LNAP. Four dry-run sessions for the purpose of acclimatization to the recording device, orientation and familiarization were allotted before the respondents were pretested for BAT. Thereafter, lessons about metabolism, photosynthesis and cellular respiration were discussed to both groups, following the agreed process with consensus group activities in the CBE group, and the prevailing method in the CE group. After 12 class-hour sessions (one hour more for the CBE group), the QIDPC and BAT were administered as posttests to the CBE group while the CE group only answered the BAT.

In the group where CBE was implemented, authority and responsibility for making decisions about the learning plan (LP) were shared by the teacher with the whole class. In the context of this experiment, the approach began by introducing the CBE process to the class using slide presentation. After which the LP was presented and discussed. It was initially prepared by the teacher to save time but it was only meant as a template. Each student was given a copy of the LP.

In CBE, consensus was practiced in two levels – whole class consensus and consensus within a group. In the whole class consensus, students raised issues about items in the LP on bioenergetics that they could not work with by negotiating and proposing an alternative. The class then engaged in what is called the "grand conversation" wherein students and teacher brainstormed, discussed and built upon each other's ideas. Only then that a consensus decision was made. Consensus in this context means, a unanimous agreement. So until everyone agrees including the teacher, the class could not proceed. In the call for consensus, three hand gesture options were used: raised open hand for *yes*; close-open hand for *abstain*ing; and a closed fist for *blocking*. For those blocking and abstaining, they were further asked by the teacher, "What one thing you would want to change in order for you to clearly support the decision?" If consensus was achieved, the class would adhere to the agreed process, otherwise, the grand conversation would continue. Change or modification to the general agreement would require another round of consensus process.

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The second feature of CBE as executed in this experiment was the generation of consensus within the level of a group in the context of a lesson. Here, the teacher asked specific focus questions related to a particular lesson under the topic bioenergetics. This was labeled 'consensus group activity.' It was addressed to the class who were grouped based on their dominant preferred mode of acquiring information. Facilitated by a group leader, students discussed among themselves the most plausible answer to the focus question. Consensus answer to the question was arrived at by unanimous agreement. The group was given a leeway on the manner by which they could arrive at a general agreement - orally or by using the hand gestures similar to how it was done in generating whole class consensus. The group's consensus answer was presented to the class by a representative. If answers to the focus question were not unanimous for all groups, scaffolding was done by the teacher.

In the CE class, the teacher stuck to the developed learning plan and relied on his own judgment of what he thought was the best way to deliver the topics without asking any input from the students. The students were not allowed to negotiate their learning needs, difficulties and preferences. Thus, all of these aspects remained as teacher's assumptions. However, because of the faster pacing of educational delivery in the control group, CBE class was one meeting longer than the control. To address ethical issues such as depriving the students in the CE of the possible advantages of CBE, the researcher ensured that the objectives of the LP were attained for both groups in that they only differed in terms of the negotiated elements of the LP and the consensus group activities. These were done by the researcher by studying very well the LP as well as keeping a planner and a journal. Table 3 shows the educational comparison between the two approaches.

Table 3. Comparison of Educational Activities between CBE and CE classes.

Educational Activities	CBE	CE
Pre-Educational activities and acclimatization to video-recording device		
Pretest	Canfield Learning Style Inventory (CLSI)	
	• Administration of the Questionnaire on the Importance of Democratic Practices in Classroom (QIDPC)	Getting to know each other/ Self-introductions

• Orientation	Introduction of the use of consensus-based education, both whole class and within group consensus.
	Presentation of the learning plan in bioenergetics.
	• Negotiation of the learning plan following the suggested whole class consensus process:
	  • Raise an issue
	  • Negotiate
	  • Grand conversation
	  • Call for a consensus
	  • Adhere to the agreed process
	• Consensus within group
	  • Focus question
	  • Group discussion
	  • Consensus answer
	  • Presentation and scaffolding
	• Administration of the Learning Needs Analysis Protocol (LNAP) and discussion of the results using whole class and within group consensus.
		Presentation and discussion of the learning plan in bioenergetics.
		• The learning plan was good as approved.
		• Students were not allowed to negotiate any part of it.

• Negotiation of Learning Plan through Consensus	Items of LP negotiated through consensus: • Medium of education: *Taglish* (mix of English and Filipino) • Checking of attendance: Students sign on the attendance sheet. • If with a valid excuse, the student with absence will not be deducted points. • If with a valid excuse, students' requirement will still be accepted and not be graded zero. • Alphabetical seat plan. • Use of *stootsies* (scorecards which the teacher can easily dispose of in appraising the quality of students' answers. During recitation, the teacher gives the appropriate scorecard that matches the quality of students' answers. The latter just sign their names on the scorecard). • Suggested teaching strategies: trivia, video clips, games, observation activities with worksheets which can be done at home, experiment and hands-on activities, and slide presentation of quizzes with accompanying visuals.	• English • The teacher checked the attendance. • One point deduction per absence, excused or unexcused. • Non-acceptance and zero grade for requirement submitted late. • Alphabetical seat plan. • Use of teacher signature in recitation cards. • Pure lecture with a slide presentation. • Quizzes were also administered with a slide presentation.

Educational Activities	CBE	CE

• Implementation of the Learning Plan (Trial)	• Education was based on the agreed process with additional group consensus activities within the group.
	• Review of Cell Structures
	  • *Trivia:* What is the largest known cell?
	  • *Video clip with worksheet*: Overview of cell structures
	  • *Consensus group activity (CGA) #1*: Make a consensus group decision about the Top 3 most important structures that are necessary for the cell to survive. Support your decision with convincing reasons.
		• Based on the teacher-prepared learning plan.

• Pretest	Bioenergetics Achievement Test (BAT)	
Educational Activities		

• Implementation of the Learning Plan in Bioenergetics	• Metabolism
	  • *Video clips:* metabolic pathway; feedback inhibition
	  • *Trivia:* Do you know that those spicy foods can boost your metabolic rate?
	  • *CGA#2:* Based on the video-based experiment, in which cup do you think will the gelatin NOT solidify? Support your decision with what you have learned about the enzymatic activity.
	• Photosynthesis
	  • *Trivia:* Do you know that the pea aphid is the only insect that is capable of photosynthesis-like energy production? Do you know that the enzyme RUBISCO is just an acronym?
	  • *Video clips:* Light-dependent and light independent reactions.
	  • *Game:* Peel me, I peel you!
	  • *CGA#3:* Which of the materials needed for photosynthesis do you think is converted to plant's food and contributes most to plant's mass? Why do you think so? (10 mins.)
	• Cellular Respiration
	  • *Trivia:* Do you know that the mitochondrion has a limited amount of DNA? Do you know that yeasts are very important in beverage and baking industries?
	  • *Video clips:* Glycolysis, transition reaction, Krebs cycle and electron transport chain.
	  • *Other visuals:* Use of lego pieces and post-it notes in illustrating the oxidation of glucose by NADH and $FADH_2$ and production of ATP.
	  • *Game:* Traffic lights
	  • *CGA #4:* Do you think plants also oxidize glucose to release energy (cellular respiration)? Why or why not? Be scientific in your consensus answer.
	  • *Experiment:* Swell Lab: Experiment on yeast fermentation
	  • *CGA #5 (During the yeast experiment):* What do you think will happen to the balloon in each bottle? Why do you think so?
		• Based on the teacher-prepared learning plan.

• Poster making (learning outcome)	• Evaluated based on criteria generated through whole class consensus.	• Based on criteria set by the teacher.
Post-Educational Activity		
Post-test	QIDPC & BAT	BAT

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Data Analysis

Descriptive statistics such as the mean, standard deviation, minimum and maximum scores were used in the BAT scores to present preliminary information. The *t*-test for independent samples was used for testing the significant difference in posttest scores in BAT between CBE and CE because the pretest scores were the same for both groups. Two-Way Analysis of Covariance (ANCOVA II) was employed in determining the interaction effects between educational approach and gender, and between educational approach and learning styles on students' posttest mean scores in BAT. Pretest values for their corresponding posttest mean scores in BAT were used as covariates. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariates. In addition to these quantitative statistical analyses, students' perceptions in the CBE group about the importance of democratic practices in the classroom before and after they were exposed to the intervention were analyzed using *the t*-test for paired samples. Data were analyzed using SPSS 16.0. Supporting qualitative evidence were then gleaned from observation notes, data sheets, questionnaires, recorded videos, and interviews.

Results of Research

Comparison of Students' Achievement in Bioenergetics Test across Educational Approach

Both the CBE and CE groups incidentally had equal pretest mean score in BAT (10.40). But after the intervention, those in the CBE group obtained higher posttest mean score (15.40) than those in the CE group (15.27) (Table 4). A *t-test* for independent samples was conducted to compare the effectiveness of the two educational approaches in improving students' achievement in bioenergetics test. Levene's test revealed that the two groups have equal variances ($F = 0.275$, $p = .602$). It was found out that there was no significant difference between the two educational approaches on posttest mean scores in bioenergetics achievement test ($t = 0.114$, df = 58, $p = .910$) (Table 5).

Table 4. Comparison of posttest mean scores in bioenergetics achievement.

Educational Approach in Biology	Posttest BAT Score (POSTBAT)	
	Mean	SD
CBE (n = 30)	15.40	4.37
CE (n=30)	15.27	4.69

Table 5. *t*-test analysis for independent samples on students' achievement in bioenergetics test across educational approaches.

	Levene's Test for Equality of Variances		t-test for Equality of Means			
	F	*p*	t	df	*p* (2-tailed)	Mean Difference
POSTBAT (equal variance assumed)	0.275	0.602	0.114	58	0.910	0.133

The use of gained scores for analysis neither established the difference (CBE = 4.87, CE = 4.97) but when the gained scores were categorized in a five-point interval, interesting results were gleaned (Table 6). The range of scores gained by the students exposed to CBE was 18 (from -2 to 15), while those in the CE group was 16 (from -4 to 11). It is also noticeable that the CBE group has two students whose scores did not increase or possibly decreased in the posttest as compared to CE group which has 6. Interestingly, there were five students from the CBE group whose gained scores were above 10 points as compared to one in the CE group.

Table 6. Gained scores in BAT across educational groups.

BAT Gained Score	Educational Approach		Total
	CBE	CE	
0 and below	2	6	8
1 – 5 points	13	13	26
6 – 10 points	10	10	20
Above 10 points	5	1	6
Total	30	30	60
Minimum Gain	-2	-4	
Maximum Gain	15	11	

Likewise, when gained scores on an item-by-item analysis was conducted across bioenergetics achievement scores disaggregated by topic and by cognitive domain, another noteworthy trend was seen (Table 7). In terms of the topics covered, CBE group obtained higher gained score in 10 out of 16 items (62.5%) related to cellular respiration. As to the cognitive domains measured by the test items, CBE group outperformed the CE group in 7 out of 10 items (70%) at the domain of reasoning.

Table 7. Comparison between CBE and CE groups on frequency of items with gained scores across BAT components.

BAT Components	Frequency of BAT Items with Gained Score			Total
	Favoring CBE	Favoring CE	Tie	
By Topic				
Metabolism	2 (1,15)	3 (2, 4, 5)	1 (3)	6
Photosynthesis	6 (7, 9, 11, 16, 22, 24)	6 (8, 10, 17, 18, 21, 25)	1 (6)	13
Cellular Respiration	10 (13, 14, 23, 28, 29, 30, 31, 32, 34, 35)	6 (12, 19, 20, 26, 27, 33)	0	16
Total	18	15	2	35
By Cognitive Domain				
Knowing	6 (1, 7, 9, 13, 14, 29)	4 (2, 8, 12, 19)	1 (6)	11
Applying	5 (11, 16, 23, 28, 30)	8 (4, 5, 10, 17, 18, 20, 26, 27)	1 (3)	14
Reasoning	7 (15, 22, 24, 31, 32, 34, 35)	3 (21, 25, 33)	0	10
Total	18	15	2	35

Perceptions of the Students in CBE Group on the Importance of Democratic Practices in the Classroom

In the CBE group, students' perceptions about the importance of democratic practices in the classroom changed after they were exposed to the intervention. Results of the paired samples *t*-test (Table 8) show that there is a significant difference between their pretest (3.23) and posttest mean scores (3.40) on the QIDPC, $t = -3.009$, $p = .005$.

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Table 8. Paired samples statistics for students' perceptions on the importance of democratic practices in classroom.

	Variables	N	Mean	Std. Deviation	Mean Difference	t	df	*p* (2-tailed)
Pair 1	PREDEMOC	30	3.23	0.29	-0.17	-3.009	29	0.005
	POSTDEMOC	30	3.40	0.34				

Moderating Effects of Gender on Students' Achievement in Bioenergetics Test

In the class exposed to CBE, males obtained higher posttest mean score (16.86) than females (14.96) (Table 9). The same observation can be found in the conventional class. The overall posttest mean score of the 14 males for this test was 17.21, whereas, for the 46 females, it was 14.76. To determine if this observed difference among males and females is significant and whether a gender-by-educational approach interaction exists, the two-way ANCOVA was employed (Table 10). Pretest BAT score was used as a covariate. Preliminary checks were conducted to ensure that there was no violation of the assumptions of normality, linearity, homogeneity of variances, homogeneity of regression slopes, and reliable measurement of the covariate. After adjusting for pretest scores, there was no significant interaction effect (F= 0.026, p = .873). Neither of the main effects were statistically significant, treatment: F = 0.000, p = .985; and gender: F = 2.081, p = .155.

Table 9. Descriptive statistics for students' achievement in Bioenergetics Test (Educational approach by gender).

Treatment	Gender	n	Pretest		Posttest	
			Mean	SD	Mean	SD
CBE	Male	7	10.71	1.98	16.86	5.11
	Female	23	10.30	3.02	14.96	4.14
	Total	30	10.40	2.79	15.40	4.37
CE	Male	7	11.57	3.41	17.57	5.00
	Female	23	10.04	2.65	14.57	4.47
	Total	30	10.40	2.86	15.27	4.69
Total	Male	14	11.14	2.71	17.21	4.87
	Female	46	10.17	2.82	14.76	4.27
	Total	60	10.40	2.80	15.33	4.49

Table 10. Tests of between-subjects effects for achievement in Bioenergetics Test (Educational approach by gender).

Source	Type of III Sum of Squares	df	Mean Square	F	p
Corrected Model	242.985a	4	60.746	3.523	.012
Intercept	315.469	1	315.469	18.296	.001
CV: PREBAT	174.832	1	174.832	10.139	.002
TREATMENT	.006	1	.006	.000	.985
GENDER	35.881	1	35.881	2.081	.155
TREATMENT* GENDER	.443	1	.443	.026	.873
Error	948.349	55	17.243		
Total	15298.000	60			
Corrected Total	1191.333	59			

a. R Squared = .204 (Adjusted R Squared = .146)

Moderating Effects of Learning Style on Students' Achievement in Bioenergetics Test

In the class exposed to CBE, iconics obtained the highest posttest mean score (16.10) over readers (15.42) and listeners (14.50). In the CE class, however, iconics also scored the highest (17.70) but listeners (14.60) scored higher than the readers (13.50). The overall posttest mean score of the 20 iconics for this test was 16.90, whereas, for the 18 listeners and 22 readers, it was 14.56 and 14.55, respectively (Table 11). After adjusting for pretest scores which were used as covariates, there was no significant interaction effect of learning styles on students' achievement in bioenergetics test (F= 0.246, = 0.783). Neither of the main effects were statistically significant, treatment: F = 0.010, p = .921; and learning styles: F = 0.962, p = .389 (Table 12).

Table 11. Descriptive statistics for students' achievement in Bioenergetics Test (Educational approach by learning style).

Treatment	Learning Style	*n*	Pretest		Posttest	
			Mean	SD	Mean	SD
CBE	Listening	8	9.88	1.73	14.50	5.63
	Reading	12	10.83	3.19	15.42	3.60
	Iconic	10	10.30	3.13	16.10	4.43
	Total	30	10.40	2.79	15.40	4.37
CE	Listening	10	9.30	2.58	14.60	3.41
	Reading	10	9.60	1.96	13.50	4.25
	Iconic	10	12.30	3.13	17.70	5.54
	Total	30	10.40	2.86	15.27	4.69
Total	Listening	18	9.56	2.20	14.56	4.38
	Reading	22	10.27	2.71	14.55	3.94
	Iconic	20	11.30	3.21	16.90	4.95
	Total	60	10.40	2.80	15.33	4.49

Table 12. Tests of between-subjects effects for achievement in Bioenergetics Test (Educational approach by learning style).

Source	Type of III Sum of Squares	df	Mean Square	F	p
Corrected Model	247.146a	6	41.191	2.312	.047
Intercept	297.276	1	297.276	16.687	.001
CV: PREBAT	140.629	1	140.629	7.894	.007
TREATMENT	.179	1	.179	.010	.921
LS	34.288	2	17.144	.962	.389
TREATMENT*LS	8.753	2	4.376	.246	.783
Error	944.188	53	17.815		
Total	15298.000	60			
Corrected Total	1191.333	59			

a. R Squared = .207 (Adjusted R Squared = .118)

Discussion

The effect of using consensus on academic performance or scores on standardized tests is one of the major challenges against consensus (Sartor & Young Brown, 2004). As of yet, there was no empirical research from which

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results of the current research can be compared. Although the mean posttest BAT scores of students in the CBE group was 0.13 higher than the CE group, it was not enough to establish that the difference was significant. The use of gained scores for analysis neither established the difference. However, when the gained scores were categorized in a five-point interval and an item-by-item analysis was conducted across bioenergetics achievement scores grouped by topic and by cognitive domain, proofs of CBE's effectiveness were apparent. For example, five students in the CBE group had gained more than 10 points as compared to only one in the CE group. Students in the CBE group also gained higher score in 10 out of 16 items on the topic related to cellular respiration. Of the three bioenergetics lessons, cellular respiration is considered to be the most difficult, and it is probably due to the consensus group activities, trivia, games, video clips, and other negotiated items in the learning plan that they were able to gain more points in the BAT posttest as compared to the CE group. The result showing that the CBE group outperformed the CE group in 7 out of 10 items at the domain of reasoning is a reflection of what Sartor and Young Brown (2004) claimed that consensus serves as a channel to create critically thinking citizens. It possesses requisite models for developing critical thinking (Pearce, 2002). Didcoct and DeLapa (2000) profoundly emphasized that not everyone accesses wisdom through the intellect. By incorporating feelings, intuition, experience, body wisdom, insights and personal reflection, consensus process gives individuals opportunity to participate which is helpful in gaining access to multiple levels of information.

Although statistical test results say otherwise, the above are some evidence supporting the beliefs of Sartor and Young Brown (2004) that when learners feel safe and loved, they follow nature's plan to develop their higher intelligence and eagerly learn whatever the curriculum offered them (Pearce, 2002). The latter author also argued that an environment of respect and affirmation, which is reflective of a CBE classroom, promotes learning, as against an environment characterized by fear, stress, and threat which can cripple memory and learning. It is just difficult to associate such environment to the CE group because the current research did not impose such negative environment and experience to that group.

Despite this result, there appears to be a preference to CBE as indicated by these comments of three students in an informal spot interview (translated in English): "At first, I hated biology because I said to myself what can I get from it, it seems like it is boring. But when consensus was introduced, it was seemingly enjoyable that you were learning a lot." "Sometimes the student is afraid of the teacher. It is important that the student and teacher must meet somewhere so that the student will learn." "If consensus has been used, we agreed and resolved our differences in whatever it is that our group wants to do."

That those students exposed in CBE showing significant improvement in their perceptions of the importance of democratic practices in the classroom is a proof supporting what Blinne (2013) observed that students wanted to be heard, that they wanted to know that their ideas and input matters and that they can influence class direction. They appear to appreciate and recognize the importance of educational activities as a practice of freedom (Hooks, 1994; Freire, 1998) as well as the development of a conscious community through democratic practice (Blinne, 2013). The finding is also a validation of consensus as an approach that provides students with daily experience in their capacity to bring about change, thus developing both the skills and attitude necessary for effective democracy, in and outside the classroom (Sartor & Young Brown, 2004). It appears then that students deemed it important that they are asked of their difficulties and preferences, they are being involved in revising the learning plan, or in developing criteria of how their work will be evaluated.

CBE has also challenged the researcher's technological pedagogical content knowledge (TPCK). It was noticeable that among the negotiated elements of the learning plan, students wanted to include strategies that demanded teacher's technological pedagogical content knowledge such as the use of video clips. Assessing which of the video clips available on the internet gives accurate information at the level of understanding of the students also required a strong grasp of pedagogical content knowledge. This challenge is doubly hard on an island where internet connection is very slow. TPCK was also important in selecting which trivia to share, which game to be played, which question to ask and which experiments or activities are to be done. These things were beyond the influence of the students in this experiment and thus, were left to the teachers' personal judgment, experience, and consideration of the learners' needs.

Based on the researcher's reflective experiences from this research, to be successful at implementing CBE, biology teachers have to move from being the authorities both in classroom management processes and content, down to facilitators. They must be good group facilitators with effective communication and group dynamic skills. Facilitation is central to consensus, therefore, those teachers with high levels of facilitating skills are likely to benefit from CBE. Moreover, other traits include teachers' willingness to share with the students the authority and responsibility of learning. Too, they must be good curriculum planners and implementers and demonstrate a genuine interest in hearing students' voices and addressing their learning needs. They must also exude reasonable patience, honesty, friendliness, open-mindedness and cheerfulness, among others. In general, they must demonstrate the postmodern, social constructivist, democratic and student-centered features of biology teachers highlighted in the literature.

In the context of consensus within groups, teachers can be successful in this aspect of CBE if they possess average to high TPCK. In particular, they must be knowledgeable of what they are asking. Focus questions in consensus group activities can only be engaging if they are carefully thought of. They must involve higher level thought processing skills such as decision-making and problem-solving which are best accomplished in groups. Likewise, good focus questions enable students to make connections to real-world objects, events, and situations and tap their diverse perspectives and experiences. For millennial learners, negotiations with the use of technologies in the classroom will no longer be a surprise, thus a technology savvy teacher will likely find CBE a feasible educational approach.

Reports in literature are conflicting about the effect of gender on achievement in science, particularly in Biology. The findings of the current research confirmed reports of previous studies about the non-significant difference in male and female performance in Biology (Lauer et al., 2013; Ajewole, 1991; Catsambis, 1995; Greenfield, 1996). However, evidence from this research contradicts those reports about females performing better in Biology (Abu-Hola, 2005; Ahmad, 2013) or males dominating it (Fleming & Malone, 1983; Erickson & Erickson, 1984; Levin, Sabar & Libman, 1991; Mullis, Martin, & Foy, 2008; SWE-AWE-CASEE, 2009; Rauschenberger & Sweeder, 2010; Creech & Sweeder, 2012; Eddy, Brownell, & Wenderoth, 2014). One factor that must be looked into this result is the sample size per group, where females were almost three times more than males, thus offsetting the significance of mean difference (2.45).

The non-significance of difference in achievement across students' learning styles is consistent with the assumption of consensus that when learners become actively involved in their learning, they adapt better to both individual and group's preferred learning styles, utilize alternative pathways, and provide the space to make choices regarding the learning approach and learning environment that work for everyone (Sartor & Young Brown, 2004; Blinne, 2013). This unbiased effect of learning styles implied that CBE is a non-discriminatory approach to biology education that is equally comparable with the conventional method.

Limitations of the Research

Among the limitations of this research were the unequal sample size of male and female groups which might have affected the results of the statistical analysis about the moderating and main effects of gender, the non-synchronization of lessons between the CBE and the CE groups brought about by the time-consuming learning needs analysis in the former which was addressed by conducting a make-up class in the treatment group, and the ethical issue behind depriving students in the control group the advantages of CBE. Moreover, the absence of statistical significance could be possibly explained by the insufficient dosage of intervention due to the short duration of the experiment. Thus, findings of this research must be interpreted in the light of these constraints.

Conclusions

This research ascertains that involving students in making educational decisions through consensus process can be a feasible alternative approach to teaching biology at the college level other than the conventional method. The open, democratic, affirming and collaborative environment in consensus-based education affords fair accommodation of students' individual learning styles without compromising achievement. Just by knowing that their voice matters and their opinion on varied issues counts, whether it is a whole class issue or an answer to the focus question, the approach has the potential of facilitating the development of reasoning skills among the learners, thus, switching on other entry points of information aside from intellect. In this approach, teachers are given leeway in discovering more their students' interests and difficulties which are beneficial inputs in improving their teaching practice that is a reflection of their collective preferences. However, in order to further capture the other effects of using consensus in science education, a qualitative analysis of group dynamics during consensus group activities can be comprehensively examined within the context of developing science process skills and 21st-century skills.

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