CONSENSUS-BASED INSTRUCTION: EFFECTS ON STUDENTS' ATTITUDE TOWARDS BIOLOGY AND ACHIEVEMENT IN BIOENERGETICS

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The dissertation attached hereto entitled **CONSENSUS-BASED INSTRUCTION: EFFECTS ON STUDENTS ATTITUDE TOWARDS BIOLOGY AND ACHIEVEMENT IN BIOENERGETICS** in partial fulfilment of the requirement for the degree of Doctor of Philosophy in Education (major in Biology Education), is hereby accepted.

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To the precious memories of these souls

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Abstract

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Consensus-Based Instruction: Effects on Students' Attitude Towards Biology and
Achievement in Bioenergetics.

Adviser: Ricardo T. Bagarinao, Ph. D.

In this study, the effects of consensus-based instruction (CBI) on attitude towards biology and achievement in bioenergetics of college students in a biological science class were investigated. The aim was to compare the CBI class with the class taught using the conventional instruction approach (CIA) in terms of their component and overall posttest mean scores in the Attitude Towards Biology Scale (ATBS) and their posttest mean scores in the Bioenergetics Achievement Test (BAT). The moderating effects of sex and learning styles as well as the relationship between students' attitude and their achievement were also examined.

Two intact classes were compared using the non-equivalent pretest-posttest control group quasi-experimental design. One group used CIA while the other employed the CBI approach. In CBI, students were given the chance to raise an issue in the learning plan, negotiate, propose an alternative, participate in a 'grand conversation', decide using consensus, and adhere to the agreed implementation process. They were also tasked to arrive at a consensus answer on a focus question related to the day's lesson. Aside from the standardized Canfield Learning Style Inventory, data were collected using expert-validated researcher-made instruments tested for reliability such as the Learning Needs Analysis Protocol, Questionnaire on the Importance of Democratic Practices in Classroom, ATBS and BAT. Videos, journal and informal interviews were used as additional data sources. Thirty students per group were randomly selected for comparison after those with incomplete data and absences were removed from the sampling frame. Using the respective pretest mean scores of the dependent variables as covariates, Analyses of Covariance were used in testing the main effects of instructional approach as well as its interaction effects with sex and learning styles. In comparing the instructional groups in terms of BAT achievement, *t*-test for independent samples was employed. Multiple regression analysis was performed to determine the relationship between students' attitude and their achievement.

The study concluded that CBI approach is effective in improving students' overall attitude towards Biology specifically in developing positive perception of biology teacher, improving keenness to learn Biology and enhancing enjoyment of the subject. Males show greater interest in Biology than females, but this is independent on the approach used. Thus, it can be said that CBI does not discriminate between sexes. CBI also addresses students' needs without bias to their learning styles. Students' interest towards Biology significantly predicts achievement in bioenergetics. Among males, overall attitude in Biology significantly predicts their achievement while among females, it is keenness to learn Biology. Even if CBI is not found to be effective in improving students' achievement, pieces of evidence point to its usefulness in nurturing their reasoning skills.

It is recommended that a longer investigation using CBI may be done to ensure that the dosage of intervention is adequate. The protocols, instruments, and activities developed from this study may be used by other teachers in creating their own classroom-based consensus models. Some suggested topics for future research include the effects of CBI on developing students' 21st century skills and CBI's impact on enhancing teachers' technological pedagogical content knowledge, among others.

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Chapter 1

INTRODUCTION

Background of the Study

A college student was once given a chance to take a removal exam in biology. He negotiated with his teacher the possibility of having more multiple choice items in the test rather than enumeration and identification because he was not good at memorizing facts. But the teacher imposed on what he wanted the test to be like. The hopeful student passed the exam but was not satisfied with his grade. He sent the teacher haunting text messages. The teacher was so sorry because had he listened to the context of the student, the ending would have been different and the erstwhile rapport between them would not have been marred.

The above is a personal anecdotal account of the researcher which led him to investigate context-based curricular interventions to avoid students' disappointment with biology. This experience is a snippet of an international trend dubbed as "swing from science" characterized by the declining number of college students choosing to pursue science careers leading to the emergence of an international 'crisis in science.'

One of the reasons singled out why this phenomenon happens is the students' growing negative attitudes towards science which consequently compromises their achievement, dissipates their interests and distorts their worldview of what science should be like (UNESCO, 2010). This trend is a threat to the society's economic prosperity and future because science and technology forms the backbone of a knowledge-based economy (Osborne, Simon & Collins, 2003). Thus, the development of positive attitudes towards science among students becomes an important and uncontested goal of science education (Ong & Yeo, 2012).

Filipino students in general, hold a positive attitude towards science (Talisayon, de Guzman, & Balbin, 2006). Nevertheless, their performance in mathematics and science during the last few decades was utterly disappointing (Imam et al., 2014). Challenged to address these issues, science teachers over the generations have been searching for the best method of teaching. But, how then can science teachers engage students and offer them a kind of science that is an exact opposite of the one they rejected? What else can still be done to enchant learners to the wonders of science and increase their performance?

An emerging teaching approach has been documented in literature that is based on the concept of consensus, a decision-making model utilized by organizations, communities and groups in coming to a unanimous decision, one that works for everyone. Adapters of this approach 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). Recognizing the promises and claims of this emerging approach, this investigation put together the two prominent consensus models in classrooms as reported in research literature – whole class consensus and consensus within groups in the context of a lesson, and thus named Consensus-Based Instruction (CBI). In CBI, students can negotiate the teacher-prepared learning plan for a particular unit and revise it via the consensus decision-making process to ensure that the negotiated elements of the learning plan are workable for everyone including the teacher. In the implementation of the lesson, the teacher poses an engaging question related to the topic and divides the class into groups where they would discuss the possible answer to the question and eventually come up with only one answer derived from a consensus decision. Then a group representative reports the consensus answer to the class. The teacher scaffolds and leads the class to the correct answer when necessary.

There are five gaps in literature which this study aimed to address and eventually contribute in the theory of an effective biology education. This is perhaps the first investigation of its kind that hybrids whole-class and within group consensus models and the very first that empirically tested the effectiveness of consensus against the conventional instruction approach. Second, this study addressed the rarity of research about attitudes of college students towards biology by developing an attitude scale whose components are reflective of their context and locale. Third, this study developed an alternative conception-based achievement test consistent with the TIMSS cognitive domains that gauged the effectiveness of CBI in improving learning since there is no hard evidence whatsoever that links the use of consensus process to students' performance on tests. Fourth, several intervention studies failed to consider variables inherent to students that may possibly interact with instructional interventions and affect outcomes. This study addressed this gap by analyzing whether the effects of CBI on students' attitude and achievement are moderated by sex and learning styles. And lastly, this study sheds additional evidence on the nature of the 'attitude-achievement' hypothesis particularly when a democratizing approach is introduced, because the relationship between the two remains blurred.

Statement of the Problem

This study aimed to determine the effects of consensus-based instruction (CBI) on attitude towards biology and achievement in bioenergetics among college students enrolled in biological science class at the College of Business and Accountancy in a state university in the MIMAROPA Region during the second semester of school year 2015-2016.

Specifically, this study sought to answer the following questions:

1. Are the overall mean scores in attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology and effort in learning Biology of the class exposed to CBI higher than those of the class taught using conventional instruction approach (CIA)?
2. Is the mean score in Bioenergetics Achievement Test of the class exposed to CBI higher than that of the class taught using CIA?
3. Does sex moderate the effects of instructional approach on:
   a. Students' attitude towards Biology; and
   b. Students' achievement in bioenergetics test?
4. Does learning style moderate the effects of instructional approach on:
   a. Students' attitude towards Biology; and
   b. Students' achievement in bioenergetics test?
5. Are the overall mean scores of students' attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher, keenness to learn Biology, enjoyment of

Biology, anxiety towards Biology and effort in learning Biology related to their Bioenergetics Achievement Test scores?

Significance of the Study

For teachers, teacher trainers and educators, findings of this study may serve as a model of how democratized learning could be done in a specific context consistent with the goal of developing lifelong learners who take responsibility of their own learning. The consensus-based instruction protocol developed from this study, particularly the negotiables, could serve as a guide on how consensus can be generated, how it will influence content delivery and how it will impact student achievement and their attitude towards science, in general.

For curriculum developers and textbook writers, findings of this study may help them address and understand students' voices particularly about their growing disappointment of school science as being disconnected and lacking meaning and relevance. Rather than placing standards at the core of instruction, CBI hopes that curriculum standards will be flexible enough, open for modification in order to fit to the learners' contexts. For textbook writers, results of the study can provide an idea in the development of a multimodal-based learning material along with assessment activities at the end of the unit that may address the perceived needs of a diverse group of users.

For policy makers and officials of the University, this study hopes to bridge the gap on the norm of instruction in the college level where many students are without voice in the teaching-learning transactions. As such, a strong policy that will support and empower teachers and students to negotiate instruction and arrive at a consensus without sacrificing the outcomes or standards is needed. This policy could be made concrete in the form of seminars and trainings.

Scope and Delimitation of the Study

The scope of the study was from December to February of the second semester of School Year 2015-2016. It involved two intact classes of college students enrolled in NatSci 102 (Biological Science) at the College of Business and Accountancy in a state university in the MIMAROPA region. These two classes were taught by the researcher only during the discussion of the topic on bioenergetics which included lessons on metabolism, photosynthesis and cellular respiration.

Among the limitations of this study are 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 sex, the non-synchronization of lessons between the CBI and the CIA 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 CBI. Thus, findings of this study must be interpreted in the light of these constraints.

Chapter 2

REVIEW OF LITERATURE AND CONCEPTUAL FRAMEWORK

This part contains relevant information culled from research literature and studies to enrich the understanding and conceptualizations of the following topics: (a) consensus, (b) consensus in the classroom, (c) philosophical and theoretical basis of consensus in the classroom, (d) learning styles, (e) attitude towards science, (e) achievement in Biology, and (d) attitude and achievement. Towards the end of this review, the need for this study is justified in order to address the gaps in knowledge. This section also comprises the conceptual framework of the study, the hypotheses, and the definition of terms.

Consensus

This section opens with the conceptual definition of the term 'consensus', followed by the claims made about its relevance and importance in decision-making theory. The discussion rolls out with the complexity of using the term clinching at the possible absence of consensus about its meaning. Majority of the discussion revolves around the exposition of views about consensus as a decision rule, a decision-making process, and as both a decision rule and a process. A brief discussion about the use and application of consensus over the years has been included to provide a historical background about this practice.

Meaning of consensus. Consensus is defined by Merriam-Webster as "group solidarity in sentiment and belief, unanimity, general agreement," and finally, "the judgment arrived at by most of those concerned." It was first introduced into the English language in 1843 from the Latin *consentire, cum* meaning 'with' or 'together with', and *sentire* meaning to 'think' or 'feel' which etymologically would mean to 'think or feel together'. The root of consensus is the word *consent*, meaning to give permission to. The interaction that leads to consensus or at least attempts to find consensus is called the consensus process (Sartor & Brown, 2004).

Some facilitators and authors argue that consensus is one of the most pragmatic approaches to achieve conflict resolution (Moscovici & Doise, 1994), the most appropriate and always the most desirable approach (Butcher, 2002) and ideal way to decision-making (Sager & Gastil, 1999), one of the most commonly used democratic decision rules that are perceived by most people to be fair, normal, and appropriate (DeStephen & Hirokawa, 1988; Johnson & Johnson, 1997; Mansbridge, 1983; Nielsen & Miller, 1992, 1997), and the only ethically sound decision-making technique for facilitated groups (Freeman, 2002.). Consensus is valued because it embodies inclusiveness, cooperation, collaboration, maximizing agreement, relationship building, and respect for all viewpoints (Hartnett, 2012).

However, Williams (1976) pointed out that during the late 20th century, using the word consensus was extremely hard as it connotes a range of interpretations "from the positive sense of seeking general agreement through the sense of relatively inert or even unconscious assent of orthodox opinion and conventional wisdom, to the implication of a 'manipulative' kind of decision making" (p. 68). In the analysis of Lee Jones (1981), even Merriam-Webster's definition of the word shows a declining conviction of its meaning from "group solidarity, unanimity" to "judgment of most of those concerned" which seemed to be going down from the 100 percent agreement implied by the term "unanimity" to the something over 50 percent agreement implied by the term "most." Due to the difficulty of giving consensus a meaning, Williams (1976) in his time presented three key postures which might likely unfurl about how consensus is and will be conceptualized in the social sciences and allied disciplines: (a) policies undertaken on the basis of an existing body of agreed opinion, (b) a policy avoiding or evading differences or divisions of opinion in an attempt to secure the center or occupy the middle ground, and (c) the deliberate evasion of basic conflicts in which certain issues are effectively excluded from political argument.

For his part, Franks (1987) cited two sources of how consensus is possibly understood. First, is the Arab word *ijma* which Spengler (1922) described as a magian idea that regards the unanimous opinion of the elect as the immediate divine Truth. In this view, the mind of God and the mind of the community are thought to be the same, in that, if consensus is found, truth is established. The other one is the notion of organic solidarity (Durkheim, 1893, 1997) which viewed consensus as one resulting from or is expressed in differentiation and is likened to the coherence of the parts of the human body. In this standpoint, the individuals are no longer similar but different and it is precisely because they are different that consensus is achieved. According to Franks (1987), it is along this continuum - community as the repository of authority and legitimacy on one end, and the expert on the other end - that different meanings of consensus could fall.

However, for some authors, there is a need to link consensus to other terms in order to understand its meaning better. Sager and Gastil (1999) put forward that in defining "consensus" it is helpful to distinguish between a "consensus outcome" and the "consensus decision rule." They adopted Johnson and Johnson's (1997) definition of "consensus outcome" as the group members' unanimous agreement on a particular issue or course of action, and "decision rule" as a complex, time-consuming social process during which members must reach full agreement prior to coming to a final decision that all of them find acceptable (Gastil, 1993).

In a paper attempting to reach a consensus on terminologies used in coordination and decision-making research (Pyritz et al., 2011), two terms related to consensus surfaced: consensus decision, and shared consensus decision. The paper reported that *consensus decision* occurs when group members choose between two or more mutually exclusive actions to reach a consensus on the group level (Condradt & Roper, 2005; King, et al., 2008, Sueur & Petit, 2008a,b) while a *shared consensus decision* is achieved when all members contribute equally and independently of individual identity to the decision outcome wherein consensus is usually determined by a quorum or by averaging over all votes (Conradt & Roper, 2005; Sueur & Petit, 2008a,b).

Given these various perspectives, Franks (1987) was making a point on hinting that there still seems to be no consensus at all as to the meaning of consensus! The same sentiment was also echoed by Sartor and Young Brown (2004), authors of the book *Consensus in the Classroom,* who suggested that any group seeking to use consensus should develop its own definition - by consensus. The articles of Didcoct and DeLapa (2000) about the *12 Myths of Consensus* and of Briggs and Reid (2001) about *True Consensus, False Consensus* are helpful in understanding what consensus is all about and what it is not.

Three major themes about how consensus is conceptualized are more pronounced in literature: (1) as a decision rule; (2) as a decision-making process; and (3) as both a decision rule and a process. These conceptions clearly connect consensus to the problem of decision-making and the authority to make decisions (Franks, 1987).

Consensus as a decision rule. The rule used by a group to reach a decision is called a decision rule. This can be differentiated in terms of where they fall along an autocratic-participative continuum (Nielsen & Miller, 1992; Sager & Gastil, 1999). The group decision rules known as "decision by authority" and "decision by expert" lie at the autocratic end of the continuum; "decision by minority" and "decision by majority rule" occupy more central positions, and "decision by consensus" is located at the participative end of the continuum. Consensus (unanimous agreement) and majority rule (50% +1) are the most commonly used democratic decision rules in the United States (DeStephen & Hirokawa, 1988; Johnson & Johnson, 1997; Mansbridge, 1983; Nielsen & Miller, 1992, 1997).

Freeman (2002) argued that consensus is required in order to stay consistent with the axiomatic value of free and informed choice by a group. Of interest is the affirmation of Robert Schwarz (1994), one of the best known theory-based facilitators that points to consensus as the heart of the ground rules for a facilitated group.

> Consensus means that everyone in the group freely agrees with the decision and will support it. Even if one person cannot agree with a proposed decision, the group does not have a consensus.
>
> Consensus ensures that each member's choices will be free choices and that each will be internally committed to the choices. Consensus decision making equalizes the distribution of power in the group, because every member's concerns must be addressed and every member's support is required to reach a decision. (p. 83-84)

As to its distinction from the majority rule, Sager and Gastil (2006) distinguish the two in the context of the discussion process. A consensus discussion can drag on indefinitely if one or more group members continue to oppose the most popular proposal while majority rule can close a debate as soon as a majority is identified. Majority discussion often leads to a clash between the two most widely supported positions, which may be customized through amendments, whereas consensus can require integrating every group member's preference into a coherent whole that can earn unanimous support. While voting encourages a win/lose mentality, consensus process encourages a sense of togetherness, striving toward what's best for the whole (Didcoct & DeLapa, 2000). However, Hartnett (2012) argues that the true opposite of consensus process is not majority rule as is commonly claimed but adversarial debate. Consensus seeks agreement and aims to enable people to negotiate disagreements and to find collective solutions (Cunningham, 2014). It generates decision about which everyone says, "I can live with it" (Bens, 1997). It is in the way that a group discusses its decisions that determines whether it is using a consensus or adversarial debate (Hartnett, 2012).

Freeman (2002), on the other hand proposed a more flexible and practical definition of consensus which distinguishes "agreeability" from "acceptability" – that is when everyone in the group either agrees with the decision or can accept and support it. By this, he also proposed that groups can still use other decision rules along with the consensus process such as consensus-minus-one, consensus-minus-two, and supermajority voting, with 90 percent, 80 percent, 85 percent, 75 percent, etc. agreement needed to pass the proposal, or first trying for unanimity and having a supermajority voting fallback (Christian, 2012).

Consensus as a decision-making process. As a decision-making process, method or technique, Didcoct and DeLapa (2000) describe consensus as a creative practice weaving together an agreement in unity out of all the different perspectives, concerns and understandings present in the meeting. It is not a voting process and it is not about unanimity. Briggs and Reid (2001) refer to it as a method that models shared power and responsibility and is based on values such as cooperation, trust, honesty, creativity, equality and respect. The consensus process is firmly grounded in a recognition and value of the whole person (Didcoct & DeLapa, 2000) and on the fundamental belief that each person has a piece of truth, in that, each member of the group must be listened with respect (Briggs & Reid, 2001). One argument advanced by Didcoct and DeLapa (2000) is that not everyone accesses wisdom through the intellect. By incorporating feelings, intuition, experience, body wisdom, insights, and personal reflection, consensus process gives individuals with different styles greater opportunity to participate which is helpful in gaining access to multiple levels of information leading to a more inclusive, fully informed and effective agreements.

Towards this end, Briggs and Reid (2001) invoke five main elements to be in place in order for consensus to effectively work: (a) willingness to share power; (b) informed commitment to the consensus process; (c) common purpose; (d) strong agendas; and (e) effective facilitation.

Briggs and Reid (2001) propose that in order to reach consensus and avoid chaos in meetings, the group needs to adopt some ground rules such as using a facilitator, ensuring everyone's participation, speaking only for oneself, avoiding interruption, seeking a solution, observing time, having an agenda and sticking to it, allowing one speaker at a time, listening with respect, avoiding personal attacks or blaming, observing confidentiality, and taking silence as an agreement, among others.

Briggs and Reid (2001) stressed that in the consensus process, no votes are taken. The procedure begins with the introduction of ideas or proposals, next is discussion, and eventually the arrival at the point of decision. In making a decision, a participant in a consensus group has three options: to block, to stand aside, or to give consent. To block means to prevent the decision from going forward which is done only when the proposal if adopted, would violate the morals, ethics and safety of the whole group. This right should be exercised with great care because it has a lifetime limit. To stand aside is a stance of principled non-participation when a member cannot personally support a proposal, but feels it would be all right for the rest of the group to adopt it. This option absolves the individual from any responsibility for implementing the decision in question. To give consent means that one is willing to support the decision and stand in solidarity with the group despite one's disagreements. However, when consensus decisions will be changed, they can only be done by reaching another consensus.

Consensus as both a decision rule and a process. The view about consensus as both a decision rule and a process, and the distinction between them, was first pointed out by Kaner et al. (1996) in the book *Facilitator's Guide to Participatory Decision Making*. This was referred to later as consensus-with-unanimity (Christian, 2012). In this perspective, consensus is viewed to be made up of two parts. The first part is the *process* which is characterized by the intention to hear from everyone in the group, asking clarifying questions, expressing concerns, and modifying and improving the proposal. The second part is the *decision rule* or the percentage of agreement needed to pass a proposal which may be 100 percent, or "unanimity" or "full consent."

Hartnett (2012) proposed that understanding the difference between these two terms is helpful in gaining clarity and capacity to consider each component independently and in making consensus work for different types of group. He 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 to pass a proposal. He argues that this distinction will pave the way to see that a consensus process can be used with different types of decision rules thereby implying the possibility of having a collaborative, cooperative and agreement-building discussion even if unanimity is not required. In the same way, this distinction also clarifies that just because a group requires unanimity does *not* mean that they are using a consensus process.

Brief history of consensus. The use of consensus in making decisions has been around in history. In the notes of Schutt (2001), it was reported to be utilized by families, tribes, indigenous peoples, and cooperative groups in order to take care of everyone and accommodate their needs. In the 1600's, a religious group from England called the Quakers or Religious Society of Friends, developed consensus as a way of balancing individual rights and insights against the needs of the whole group by recognizing every person's access to the truth and by acknowledging that any person could be wrong. This group thus viewed truth as an incorporation of every individual truths.

He went on recounting that the process improved with the introduction of facilitation and emotional blocks in 1950's by the Human Potential Movement. By 1960's several leftist groups encouraged participatory democracy. However, the process broke down because of dominating leaders, power plays, manipulation and rhetorical speech-making. With the rise of the Feminist Movement in the 1960's, the importance of expressing feelings, vulnerability, compassion as well as strength for both males and females was emphasized. However, the free-flowing meetings without leaders resulted in the "tyranny of structurelessness" worsened by hidden leadership, manipulation, and power plays. In the mid-1970's, prevailing ideas and conceptions of consensus were put together by the Non-Violent Direct Action Movement and contextualized it as a non-coercive, non-hierarchical, and facilitator-guided process of decision-making which respects each person's truth through decentralized decisions made at the lowest level possible. From then on, activist groups, intentional communities, collective businesses have all developed and refined the process which is now used by professional group facilitators in a large variety of settings, from cohousing community, nonprofit board, watershed council, international organizations, political protest to classroom management thereby further developing the model and its effective application. More formal consensus methods such as Delphi and nominal group have become visible tools for solving problems in health and medicine (Fink, et al., 1984). While consensus is well-practiced in several areas, there are a handful studies that apply the concept to the teaching and learning processes in the classroom.

Consensus in the Classroom

In most classrooms, the teacher serves as giver of information and students are recipients (MacDougall, 2013). Frequently, learners encounter authoritarian, top-down classroom models that are constructed solely from the teacher's interests, goals and expectations or requirements, leaving little room for student input (Blinne, 2013). Students' voices are often left out in the educational processes because their parents and teachers make decisions for them which often block their innate desire to learn (Sartor & Young Brown, 2004). When learners often have little say even in the most basic structure of a course, achieving optimal engagement is difficult. Learners learn best when learning is most meaningful to them (Blinne, 2013).

It is from the students' innate desire to learn from which Sartor and Young Brown (2004) contend that the consensus process can be a powerful approach in giving students the opportunity to contribute to decisions that determine their learning environment. It holds the promise of creating a more dynamic, democratic and egalitarian learning community where learners feel comfortable to challenge the status quo (Hooks, 1994; Freire, 1998; Wolk, 1998; Shor & Pari, 2000; Sartor & Young Brown, 2004) and where participants collaboratively share their own ideas about teaching and learning styles and the educational system as a whole (Blinne, 2013). When learners become actively involved in their learning, they are thought to better adapt to both individual and the 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). The consensus process might provide a way out in the long-time argument that has gone deadlock between a group of researchers who claims that instruction is best provided in a format that matches the preferences of the learner and those that argue that style match does not significantly contribute to improved performance because students have the potential to accommodate all teaching approaches (Zhang, Sternberg, & Fan, 2013).

Gergen (1982) claims that by recognizing knowledge as a communal creation, consensus would be an experiment in negotiated problem-solving. Because the process requires some deal of negotiation (Schwartzman, 1989). Hartnett (2012) has a point in his previous argument on thinking flexibly about the meaning of consensus. According to Moscovici and Doise (1994), negotiation is another way of resolving conflict which involves "trade-offs" between the parties leading to an acceptable level of compromise. Sartor and Young Brown (2004) however argue that consensus needs no compromise. In compromise, people who are in disagreement about an issue each agree to sacrifice something in order to reach a decision that is tolerable to everyone. But consensus is a conscious agreement by everyone in that a decision is not final until everyone in the group agrees with it. It is synergistic which includes all concerns, needs and perspectives without sacrifice – and in so doing, leads to a better decision. Nevertheless, they encourage adapters of consensus to try the approach in their own way, style and flavor. In the pedagogical context, however, both consensus and negotiation aim to promote educational democracy and involve students in all the major decisions concerning their learning.

Research literatures point at two levels by which the consensus process has been applied in the context of making decisions in the classrooms. First is consensus at the level of the whole class as a group, and the other one is at the within group level in the context of a lesson.

Whole class consensus. Sartor and Sutherland (1992) and Sartor and Young Brown (2004) documented their experiences about the consensus process in their self-contained classrooms in one middle school in California (Sartor & Sutherland, 1992; Sartor & Young Brown, 2004). The same process was replicated in an international school in Helsinki. In these classrooms, all the decisions normally made by the teacher alone are turned over to the class as a whole. A consensus is reached when everyone agrees, including the teacher. Through this process, the group as a living organism is allowed to emerge, so no two consensus classrooms look the same. Sartor and Young Brown (2004) express this more profoundly in their book *Consensus in the Classroom*:

> We believe that there are as many right ways to do consensus as there are groups who have developed this decision-making strategy, and we want to encourage each of you – in collaboration with your students – to find your own way to do it…in your own way and style, with your own flavor. Teachers working in secondary and college settings will no doubt have to make more radical adaptations... (p. 4)

In contextualizing the consensus process in their classes, they spent the first day and the first two weeks building a sense of community through trust activities, cooperative games and development of a common vision out of everyone's individual goals. Then, they introduced the consensus process by giving students a single decision to consider on the first day like deciding on what homework should be done. In grading the homework, list of criteria for evaluation was generated through brainstorming the first time it was due. The list was posted on the bulletin board all year where additional criteria could be added to it anytime. In marking their work, students shared it first with their classmates and received feedbacks on its strength and weaknesses. From these, students graded their own work and gave reasons why they deserved the grade. On the part of the teacher, he or she may agree or disagree with the grade based on personal judgment of the quality of the work but more strongly based on the reason given by the student.

On the second day, they conducted their first formal classroom meeting by writing "Agenda" on the chalkboard and asked students what they wanted to talk about.

Students and teacher suggested topics but decided on the topic that is most important to discuss first. A corner of the chalkboard was set aside for the ongoing agenda which can be added by anyone at any time. The source of an agenda could be a problem someone perceives, an administrative decision the teacher would make, or an idea someone wants to try (i.e., judicial system, classroom management plan, room arrangement). Then the next step was the discussion process. They advised adapters to stay with the discussion and trust the consensus process even when the discussion seemed to be endless. They argued that in the consensus process, it is not the content of the decision that is important but the process that the group is going through.

And the final step was the call for consensus which could be expedited by voting. When the decision is a selection among preferences, the choices were first listed on the board and examined if there is anything anyone cannot go along with. Aside from voting, students could be required to make any of these consensus decisions: say yes, stand aside, or block. Or, they used colored cards: green for agreement, red for disagreement, and orange for consent but with a concern to be heard. The authority could sometimes be delegated to a committee by asking it to work out a recommendation which the group approves or disapproves by consensus. The preference with the most votes became the choice.

In another investigation, Mitchell et al. (2009) explored how a veteran first-grade teacher collaboratively negotiated the implementation of a project with her students while at the same time, addressed grade-level standards. Negotiated learning is a process involved when the teacher deliberately establishes a structure to enable students to have an ongoing say, as a group in all elements of the learning process such as the content, emphasis, teaching and assessment methodology, evaluation, and even the selection of guest speakers, and other teachers, as well as the logistical elements like location, times, days, child-care facilities, etc. The approach is mainly based on the theoretical paper of Clark (2006) that described a more collaborative and dynamic process to the project approach that involves children in: (1) developing their own questions about the topic, (2) making predictions about possible answers, (3) thinking of ways to test their hypotheses, (4) negotiating with the teacher various ways they might represent their findings, and (5) taking time to solve their own problems through trial and error.

Literature report that the learning goals, the methods by which these learning goals can be met, and the means by which achievement of these goals can be assessed are the typical negotiations that can be done in a classroom setting (Laycock & Stephenson, 1994). In the revelatory single-case study conducted by Mitchell et al. (2009), the teacher worked out the negotiation process by first reviewing the benchmarks for the core content areas in order to determine the knowledge and skills the children still needed to learn. Knowing the requisite standards and knowing students' interests enabled her to "manipulate the standards to fit the children's interests rather than to manipulate the children to fit the standards" (p. 342). Then, she organized a 'grand conversation' – a student-directed class discussions in which children have the opportunity to critique, debate, and extend upon one another's ideas (Peterson & Eeds, 1990) – to encourage the children to generate specific project topics. Third, she used participatory style in helping students make decisions. She encouraged them to agree, disagree or expand upon one another's ideas. As a result, there was a negotiated decision between her and the children in terms of project focus, project presentation, and the integration of writing. They appeared satisfied that the project incorporated individual needs and interests, and addressed science standards.

In her study, Blinne (2013) integrated learners' decision-making by involving her students into the design process of the course structure and content of a syllabus which she argues would invite a more democratic learning process. She contends that the syllabus is crucial in setting the tone for the type of learning community a teacher hopes to create. Opening up opportunities for the syllabus to perform as a living, negotiated document allows learners to explore their educational identities by taking a more active role in establishing the ideological and discursive environment of the class (Barwashi, 2003; Hudd, 2003; Fasset & Warren, 2007). However, before she started with the syllabus, she first employed the following guiding questions to help learners explore their needs and interests:

1. What topics or areas are of greatest interest to the class? What are the goals, expectations, and learning needs for this course?
2. How can the classroom space be best adapted to be conducive to cultivating enhanced communication? Should the desks be kept in rows? In circle? Sit on the floor? Go outside? Change the flow and open space? How often should the space be changed to accommodate the learning goals?
3. How can the readings and discussions be best connected to everyday lives?
4. How can multiple learning styles be best supported and engaged with throughout the semester?

Starting with these questions, Blinne (2013) claimed that she and her students were able to discuss how learning spaces, content, and contexts have the power to produce, affirm, or resist classroom interaction, allowing them to look deeply and critically at how they have been socialized as learners. Likewise, they were also able to explore multiple options for constructing a syllabus. For instance, they set aside time during the first week of class, asking learners to work together in small groups to discuss what their expectations are of themselves and each other, their expectations of the teacher, what constitutes disruptive behaviors and committed and active participation, as well as "good" and "bad" discussions. After setting up their classroom policies and expectations based on group consensus, they sign a classroom agreement, acknowledging individual and group responsibility for their learning process.

In order to negotiate and balance their learning needs while still leaving room to embrace or depart from their syllabus, Blinne's (2013) always returns to the guiding questions repeatedly. To connect the readings and discussions to their everyday lives, learners were required to submit teaching activities and various types of media. To stay current on each learner's process, she also incorporated process feedback through journaling and in-class quick-writes. If something is not working, they know immediately and create a new direction.

Other investigations related to negotiating the course syllabus include that of Hudd (2003) who offers a "skeleton syllabus" which includes readings and some course structure but allows learners to participate in the creation of classroom assignments as well as the assessment of their work. Conversely, Fassett and Warren (2007) experimented with a graduate pedagogy class, asking participants on the first day to build the entire course syllabus from scratch, taking three class sessions to allow them to better understand critical pedagogy. In Danielwicz and Elbow's (2009) contract grading system, they give up power over grading but not over rules and course structure, whereas Moreno-Lopez (2005) and Shor (1996) negotiate class structure and policies but maintain more control in grading. Moreno-Lopez (20005) offers yet another option in which she recreates a syllabus and contract grading system: during the first week of class, she allows learners to negotiate the policies by stepping out of the room and allowing them to discuss in private. After participants present changes, she negotiates the process and leaves this open to re-negotiation throughout the course by continually redesigning the syllabus.

Within group consensus in the context of a lesson. In Japanese elementary schools, the use of consensus building discussion in the context of a classroom lesson is one of the four significant components of structuring mathematical inquiry lessons: *hatsumon* (initial math question/problem that the teacher gives to initiate a rich conceptual discussion), *kikanjyushi* (students' individual or group-based problem solving as the teacher walks by their desks), *neriage* (whole class discussions) to compare and contrast different strategies and build consensus on the problem solving, and *matome* (summary) (Fernandez & Yoshida, 2004; Shimizu, 1999).

Among the four components, the *neriage* stage is considered to be the most crucial stage where Japanese teachers encourage students to listen to other students' ideas carefully and consider the strengths and weaknesses of different problem-solving strategies. Then the teachers facilitate discussions to co-determine which strategy is the most reasonable and efficient one. According to Shimizu (1999):

> The term Neriage describes the dynamic and collaborative nature of the whole-class discussion during the lesson. In Japanese, the term Neriage means *kneading up* or *polishing up*. In the context of teaching, the term works as a metaphor for the process of polishing students' ideas and of developing an integrated

> mathematical idea through the whole-class discussion…Once students' ideas are presented on the chalkboard, they are compared and contrasted orally. The teacher's role is not to point out the best solution but to guide the discussion toward an integrated idea. (p. 110)

In the study of Inoue (2010), the concept of *neriage* was used as a cross-cultural framework for teachers to effectively orchestrate whole group discussions for deep mathematical learning in order to implement an effective inquiry model in mathematics classrooms. The investigation used video-based lesson study, participated in by six 4th and 5th grade US teachers and three Japanese teachers who acted as advisors. Teacher participants were asked to bring a 15-20 min videotaped segment of consensus building discussions from their classrooms which became the focus of the lesson study, a cyclical Japanese model of professional development for teachers. Through reflecting on their lessons and other teachers' lessons , teacher participants went through a process of self-transformation and developed many realizations for incorporating consensus building in a way that is congruent to what has been emphasized for students' meaning-making and engagement, such as social negotiation of meaning (Cobb et al., 1991; Voigt, 1991), social involvement in mathematical discourses (Turner et al., 1998), and authoritative teaching that support student autonomy and personal interest (Walker, 2008). The study came up with guiding posts for teachers in order to effectively incorporate *neriage* in their lessons: (a) teachers should know what they are asking; (b) anticipate students' responses during lesson planning; (c) release control to students; (d) never hesitate to provide traffic control; and (e) always follow up.

Likewise, MacDougall (2013) recognizes the need for students to be taught the norms of social interaction and thus, urges science teachers to make explicit plans for productive student-to-student dialogue on top of the cognitive demands required to learn science content. He then presented three critical components of this dialogue process: (a) a focus question to engage student thinking about science content; (b) student-to-student communication; and (c) coming to a consensus either through text or through demonstration. McDougall (2013) cited two examples of how general agreement is arrived at through student-to-student collaboration, a case of the consensus process operating in the micro-scale.

The first example is a reading activity whose content focus is the Moon's gravitational effects on Earth. The anticipatory focus question was: "A weather reporter on TV said that hurricanes are more dangerous when the moon is full. Do you agree? Explain your answer." Student-to-student collaboration included partner talk and role play. Consensus was arrived at through a brief section of text where students search for the clues that will help answer the focus question and resolve any difference they have identified in their initial thinking. Then they engaged in partner reading and modification of answer to the focus question. If there were differences in responses, a "silent debate" strategy was used where students could switch papers, silently read what was written by their partner and then write their response. They continued to swap papers and argued through writing and citing points in the text until the pair reached a consensus.

The second example is a demonstration activity. The focus question was to predict the path of a marble as it exits a circular tube. The demonstration was preceded by a think-ink-pair-share (TIPS) strategy. For *think*, student thought about what the answer might be. For *ink*, student wrote the answer on the paper. For *pair*, students took turn explaining and listening. When explaining, they gave an answer and provided reasons for its correctness. When listening, students paid attention to the evidence given and might not interrupt. If there were widespread disagreements, the teacher may use the pair-square technique, in which two pairs combined to form a team of four. For *share*, teams were asked to share their answers. To come to a consensus, the teams voted for the likely prediction. Only after all these were done that the teacher demonstrated the activity.

Benefits of using consensus in the classroom. Sartor and Young Brown (2004) claimed that consensus process in the classroom is useful for teachers and classrooms at all levels, in all kinds of school settings. The major benefit revolves around the idea that learning responsibility is shared between learners and teachers, which serves to "create engaged, active, critically thinking citizens, that is to say, political subjects who can participate as decision-makers in the organization of their socio-cultural realities" (Moreno-Lopez, 2005, p.3). Sartor and Young Brown (2004) capsulized the benefits that can be gleaned from the consensus process in the classroom as follows: (a) shared authority and responsibility; (b) enhanced students' self-expression; (c) full student participation; (d) creative decision-making; and (e) development of a conscious community.

For teachers, Sartor and Young Brown (2004) believe that through this approach, they can gain a broader understanding of their students' needs, abilities, and concerns such that even their "top-down" decisions will become more informed. They argue that when teacher shares both the authority and the responsibility to the whole class, innovative decisions that respond to the specific needs of the group members are likely to arise. Students then can develop their personal authority and responsibility thereby avoiding power struggles and victimhood. For instance, in her attempt at democratic learning, Blinne (2013) found out that her students need H.E.L.P. in doing class content collaboration. First, learners want to be *heard*. They want to know that their ideas and input matters and that they can influence class direction. Next, learners want to be *excited* about their learning, and content should reflect their interests, making connections to their daily lives. Further, they want to be *liked* - knowing others support their contributions, recognizing their participation in the course, expressing care if they do not participate. Finally, learners want to be *personal*. They want their teachers to know their names, to hear their stories, and to approach learning in their own style.

Also through consensus (Wolk, 1998; Bruffee, 1999; Sartor & Young Brown, 2004), learners can become co-developers of the class curriculum, potentially reinventing how they see learning and themselves through a shift in structure, teaching them that education can be a practice of freedom (Hooks, 1994; Freire, 1998), and encouraging community building through democratic practice (Blinne, 2013). Involving students in the design process allows them the creativity to work together to fulfill their own learning goals within a group dynamic (Mitchell et al., 2009; Blinne, 2013). It helps children form good self-concepts about themselves, motivate them to investigate authentic problems (Mitchell et al., 2009), heighten their levels of engagement and improve their ability to apply learning to new contexts, their oral language, and their ability to make informed decisions . In classrooms that promote collaboration, behavior problems are minimized when students engage in productive and civil dialogue with guidance and structure provided by well-prepared teacher (MacDougall, 2013). Similarly, students and teacher alike can also develop more trust in one another and expand their capacity for self-expression - to speak up, to listen, to synthesize ideas, to have a sense for the whole community, and to recognize their own gifts, their wants, needs and feelings as well as their experiences, skills, and abilities. Likewise, the approach can give students the opportunity to learn how to participate more fully and responsibly in their classrooms, acquiring skills that will serve them well elsewhere in life especially in participating fully in social decision-making. The open and inclusive discussion of consensus can therefore enhance everyone's awareness of the whole issue being addressed or of variety of concerns and thus the class can move toward a conscious community (Sartor & Young Brown, 2004).

However, most of the benefits and effects of the consensus approach are from self-contained classrooms, and there was no attempt yet to scientifically measure its effects on academic performance or standardized tests. Nevertheless, its proponents maintain that when children feel safe and loved, they follow nature's plan to develop their higher intelligences. Pearce (2002) argued that such children will naturally and eagerly learn whatever the curriculum offered to them. Moreover, they claim that the consensus process possesses requisite models for developing critical and creative thinking, an essential basis of sound education.

Challenges of implementing consensus in the classroom. In spite of its philosophical appeal, Sartor and Young Brown (2004) admonish that consensus is often construed as false unanimity due to social pressure. When poorly practiced, it may seem more frustrating and inefficient than the more familiar forms of decision-making. They cited key concerns that must be addressed in its successful implementation: time, power differentials and academic achievement.

When a group is first learning how to make consensus work, it can be time-consuming to the point of abandoning it because many teachers feel they do not have time for collaborative learning (MacDougall, 2013). Given sufficient skill and structure however, the consensus process can be an efficient tool in engaging participants to listen in a deeper way to each other's perspectives and needs, not as debate points to be countered, but as concerns to be creatively addressed and included. In this way, there will be few or no more complaint as well as unanticipated roadblocks from the minority (Sartor & Young Brown, 2004).

Consensus decision-making is vulnerable to manipulation. Someone can always power play as it is a human vice. But if consensus is practiced well, it is no longer needless to resort to such tactic because participants know that their concerns and needs will be included. They will be empowered to speak up when something seems unfair, misleading, or otherwise uncomfortable. In this way, the quality of communication will be improved to a new level of honesty and intelligence (Sartor & Young Brown, 2004). Moreover, what is needed is to shift teachers' ideas about planning to embrace co-creating and participating in the learning context with the students (Blinne, 2013). Consensus in the classroom is more than just an instructional strategy or management system. It requires and creates a paradigm shift in a teacher's relationship with his or her students and in student's relationship with each other (Sartor & Young Brown, 2004).

In an era when standards and testing drive curricula, creating this environment is not easy as many learners have been silenced and excluded from their own educational process (Blinne 2013). However, current brain research and learning theory support the use of consensus in improving academic performance. Pearce (1992, 2002) integrated much of current brain and learning research in several books. He describes how fear and stress undermine higher brain functions. He explained that any kind of negative experience brings an automatic shift of attention and energy from the forebrain to the hindbrain. This shift shortchanges the intellect, cripples learning and memory, and locks the neocortex into service of the lowest brain. Pearce (2002) looks at testing as a threat that triggers the brain to shift to the hindbrain compromising what the higher intellect can do. In the consensus process, teachers provide an environment in which every learner feels respected, affirmed and safe – practices that can mitigate the effect of threats and stress among the learners – towards an improved performance on tests.

Philosophical and Theoretical Bases of the Use of Consensus in the Classroom

This section presents the philosophical and theoretical support for the use of consensus in the classroom. In terms of its philosophical elements, consensus is best supported by the postmodern philosophy of education which emphasizes the legitimacy of multiple perspectives. On how learning occurs during the consensus process and how meanings emerge from different levels of interactions, these are supported by the constructivist theory and the general systems theory. In terms of the authority, choice, and decision-making, consensus is backed up by the model of democratic education.

Postmodernism. The use of consensus in the classroom and its manifold features previously described is reflective of the postmodern philosophy of education. While Doll (1993) and Berquist (1993) acknowledge the difficulty of grounding the definition of the term "postmodernism" as it means different things to different people, Sartor and Young Brown (2004) describe it as the paradigm shift characterized mainly by moving away from the "modern" view of reality as linear, uniform, measured and determined toward a sense of reality as emergent, contextual, and co-created through interaction. According to Gojkov and Vrsac (2012) postmodernism emphasizes the contextual construction of meaning and the validity of multiple perspectives citing that in terms of old issues about truth and knowledge, a postmodernist would say: "The truth is what people agree about." Or "The truth is what works." Or "There is no Truth, but a number of small truths wandering around." They then characterized the key elements of this philosophy as follows:

1. Knowledge is constructed by people and group of people;
2. Reality is multi-perspective;
3. Truth is grounded in everyday life and social relations;
4. Life is a text;
5. Thinking is an interpretative act;
6. Facts and values are inseparable; and
7. Science and all other human activities are value-laden.

Gojkov and Vrsac (2012) use the term "postmodern pedagogy" to describe what education should be like in the postmodern age. In this paradigm, educators are viewed as co-constructors of knowledge. It holds that all cultures are of equal value and constitute equally important realities, thus, minority students must be empowered to fight against enculturation. The role of education in this perspective is to help students construct diverse and personally useful values in the context of their culture, yet not true or right in any universal sense. These values include striving for diversity, tolerance, freedom, creativity, emotions and intuition. Students are viewed to have no true self or innate essence, rather, selves are social constructs. Postmodern educators believe that self-esteem is a precondition for learning while education is a type of therapy. Rather than discovering them, education helps individual construct their identities in that only when people are empowered to attain their own chosen goals that individuals and society will progress.

Sartor and Young Brown (2004) expound on the demands this paradigm shift entails. Foremost, it calls for an altered sense of authority for both teacher and students in order to promote a more democratic social structure in the classroom. Then, it calls for more emphasis on inquiry, experiential learning, the questioning of assumptions, the blending of action and reflection, and seeking the synthesis of apparent polarities and conflicts. It also calls for the celebration of diversity, and the inclusion of all voices in the conversation. Ultimately, the postmodern paradigm calls for learning to be relevant to life both inside and outside the classroom.

Gibbs (1994) characterized the emerging paradigm in postmodern education which Sartor and Young Brown (2004) believed can be engendered by using consensus decision-making in the classroom as follows: emphasis on learning, emphasis on the whole, integrated knowledge and skills, student as active constructor of meaning, teacher as co-learner and facilitator, learning as a social activity, collaboration, student-directed learning, emphasis on process, learning grounded on "real world" contexts, open-ended and non-routine multiple solutions, shared development of goals and criteria for performance.

The use of consensus in the classroom is a timely response to the clamor of the Global Alliance for the Transformation of Education (GATE) about the educational challenges called for by the postmodern times (Sartor & Young Brown, 2004):

1. The recognition of each learner – young and old – as unique and valuable;

2. A true learning community in which people are taught to value their own personal strengths, and are empowered to help one another;
3. Meaningful opportunities for real choice at every stage of the learning process because genuine education can only take place in an atmosphere of freedom – of inquiry, of expression, and of personal growth; and
4. A truly democratic model of education that will empower all citizens to participate in meaningful ways in the life of the community and the planet.

GATE believed that these calls are all educational tasks and that the teaching and learning process cannot foster these values unless it embodies them. Sartor and Young Brown (2014) are convicted that the consensus process provides a structure that could go far toward answering these calls.

Constructivism. There is growing evidence that learning is about making connections, as such, learners must actively make connections in their own brains and minds that produce learning for them (Cross, 1999). The way how knowledge is generated through the consensus process is reflective of the constructivist theory of learning. Resulting from dissatisfaction with the behaviorist and traditional Western theories of knowledge characterized by teacher-centeredness and transmissive pedagogy (Yilmaz, 2008), constructivism which is anchored on the principles of meaning-making and knowledge construction (Fosnot, 1996; Phillips, 1995) has become the leading metaphor of human learning since the 1970s (Mayer, 1996). Cobern (1995) describes constructivism as a learning model suggestive of the following ideas:

1. Student is always active when learning takes place;

2. Active process is a process of making sense. Learning does not occur by transmission but by interpretation;
3. Interpretation is always influenced by prior knowledge; and
4. Interpretation is facilitated by instructional methods that allow for negotiation of ideas.

However, constructivism is not a single or unified theory (Yilmaz, 2008). Akin to all living religions, constructivism has many sects which venerate it as a 'powerful folktale' about the origins of human knowledge (Phillips, 1995). Despite differences in constructivist doctrines, it could be said that all followers of constructivism agree with the idea of viewing the learner as an active builder of his/her knowledge. One of the most obvious implications of this idea is that students are not *tabula rasa* because they already have the so called prior knowledge when they try to learn in school which according to Alexander (1996) is the one that serves as a "scaffold that supports the construction of all future learning" (p. 89). Another well-known assumption of the constructivist view of learning is the importance of connecting new and existing knowledge. Therefore, teachers should take into account students' prior knowledge to promote meaningful learning (Limon, 2001). Two sects of constructivism prominently figured in literatures are Piaget's cognitive constructivist theory (also called personal or radical constructivism) and Vygostsky's socio-cultural constructivist theory (also referred to as realist constructivism) (Liu & Matthews, 2005).

While Piaget's cognitive constructivist theory is widely interpreted as an intrapersonal process where knowledge is individually and idiosyncratically constructed or discovered, Vygotsky, on the other hand emphasized the central role of social environment in learning (Liu & Matthews. 2005). Vygostky believed that by interacting with their surroundings, learners are enculturated into their learning community and appropriate knowledge based on their current understanding. Learning is thus considered to be a largely situation-specific and context bound activity (Eggen & Kauchak, 1999: McInerney & McInerney. 2002; Woolfolk. 2001). The central aim of education in Vygotsky's theory is the development of intellect and rationality beyond situations (Liu & Matthews) which is both an internal and a social process that is complex and interwoven. Three themes are at the core of Vygotsky's theory. First, is the reliance on a developmental method to which a mental function is first thought of as an interaction between people, then, as a process within individuals (Wertsch, 1992). The second theme is 'mediation' to which he contends that mental processes can be understood only when the tools that mediate them are understandable. Third, is the origin of higher mental processes where he introduced the concept of Zone of Proximal Development (ZPD), described as the distance between the actual and the potential development level of an individual under the guidance of more knowledgeable others (MKO) (Vygotsky, 1978).

Vygotsky's ideas have strengthened the use of cooperative and collaborative group processes in classrooms (Slavin. 2000). The involvement of MKOs such as teachers, tutors, parents, classmates, friends or even computers helps learners improve their performance and develop new abilities, hence scaffolding. The concept of mediation likewise helped current classrooms to situate learning and instruction in an authentic context (McLeod. 2003). Brufee (1993) claims that in situations when the teaching-learning process is collaborated, knowledge is socially produced by consensus among knowledgeable peers. It is "something people construct by talking together and reaching agreement" (p. 3).

General systems theory. In terms of how knowledge and decisions emerge from the social group as a system, the consensus process demonstrates the General Systems Theory (GST) (Laszlo, 1972; Macy, 1991: Capra, 1996) in action. Arising from the biological sciences, this theory provides an explanation on how all systems work by exploring various phenomena in terms of dynamic patterns or relationship which underlies systems thinking. Systems theorists have noticed four patterns of relationship and information flow called invariants that are inherent in all living systems (Sartor & Young Brown, 2004): 1) nested hierarchy; 2) synergy; 3) homeostasis, and 4) adaptation.

The first pattern is called nested hierarchy or holonarchy where every Whole is construed as a part of larger Wholes. This pattern views every system to be made up of subsystems or systems within systems. The collective membership of a system governs the whole through an intricate web of interrelationships and information exchange. Similarly, if applied to education, all levels and parts of the educational system – students, teachers, and administrators – can contribute to decision-making. Albeit the currents school system operates under the top-down model of authority, teachers can still shift the model of hierarchy within the classroom and guide students toward class holonarchy.

The second pattern is synergy, better explained by the statement, "The whole is more than the sum of its parts." In this pattern, unpredictable properties and capacities emerge in each new level of systemic organization, thus, emergent properties or synergy in action. In the same token, consensus allows synergy to occur because of the full participation of all of members of a system. Through the dialogue that occurs in coming to consensus, the wisdom, new ideas and creative solutions of the class as a whole can emerge beyond anything any one individual member, even the teacher, might have invented. This is contrary to the majority rule which may suppress the very real needs and wisdom of one of the members. As a consequence, the health of the whole system may suffer. It is like letting the skin cells determine the right way to be a cell, because they are more numerous than the cells that exchange oxygen and carbon dioxide in the lungs.

The third pattern is homeostasis. Among living systems, homeostasis is a kind of fluctuating balance that maintains their form over time. Each Whole is self-sustaining and self-regulating, providing a resilience through all the internal and external fluctuations inherent in life. Likewise, a consensus classroom encourages a high level of individual responsibility so that each student can self-regulate rather than being constantly directed by the teacher. And the last pattern is adaptation. Systems adapt themselves to changes in their environment and it occurs constantly. Each Whole is therefore self-organizing and self-evolving. In the classroom context, consensus provides students with manifold opportunities to take in new information and reorganize themselves accordingly.

In GST, the third and fourth patterns of relationship have something to do with how systems respond to change while the first two patterns complement with two general principles – subsidiary and requisite variety. The principle of subsidiary indicates that decisions are best made at the lowest possible level within a nested hierarchy of systems. Similarly, consensus decisions need to be made at the level of the problem or question being addressed. The principle of requisite variety on the other hand indicates that systems need variety within themselves in order to respond to a variety of demands from their environment. Consensus encourages diversity, seeking out all the various perspectives of the group and finding a part for each member to play in decisions and solutions.

Democratic education. Dewey (1983), the father of progressive education, advocated democratic education as an educational approach more in accord with democratic ideals than the autocratic procedures of traditional schools. He believed that democratic social arrangements promote a higher quality of human experience for more people than do methods of repression, coercion or force. Gang (1989) asserts that democracy cannot be taught through non-democratic methods. The principles of democratic society have to be lived in the classroom if students are going to understand the full impact of their meaning.

Cowan (1960) argued that consensus is inextricably bound to the idea of democracy which concerns the consent of the governed:

> ...what distinguishes democracy from dictatorship...is not so much the number of citizens consenting but the conditions under which the consent is elicited; the vital point being the presence or absence of freedom not only in the process of voting, but also and much more important in the preceding process of discussion. (p. 24)

Waghid (2014) describes democratic education as an educational ideal in which democracy is both a goal and a method of instruction. It brings democratic values to education. Democratic schools are characterized by students' involvement in the decision-making process that affects what and how they learn. It is often specifically emancipatory, with the students' voices being equal to the teacher's.

In the paper of Korkmaz and Gumuseli (2013) democratic education has been defined as an educational context where young people have the freedom to organize their daily lives, where there exists equality between young people and adults, and where democratic decision-making processes are adopted.

Regarding the characteristics of democratic education, Balme and Bennis (2008) argue that it should promote the participation of students in the construction of the school's structure and vision, and allow students to regulate their own ways of learning and living, with adults acting as guides and consultants instead of directing student activities. One of the goals for democratic education articulated by Gang (1989) is to help students understand that a variety of solutions may be valid in any particular circumstance.

Democratic education may be embodied in various forms from the micro level within class democracy to the macro level of whole school democracy (Morrison, 2009). Korkmaz and Gumuseli (2013) elaborated on the features of democratic education as follows:

1. It is an effort towards making school a democratic microcosmos which can be realized by making democratic principles an integral part of school life (i. e. by creating a democratic community that applies democratic procedures such as elections or school councils);
2. It recognizes the multi-dimensionality of learners by taking inner motivation as the starting point of learning;
3. It recognizes self-management and responsibility of the learner;
4. It supports the learner to develop self-learning strategies and self-assessment by recognizing the ability of the learner to plan his/her learning;

5. Its curriculum includes content on democracy which promotes democratic principles as ordinary aspects of school life through dialogue based relations (Korkmaz & Gumuseli, 2013).

The works of Dewey and the literature on democratic schools identify four basic categories of the democratic education environment at classroom level. The first is decision-making/participation, where students are given the right to participate in decisions about class rules, values and principles, and sanctions to be applied in case of breaches of those as well as the right to participate in decisions on educational objectives, content, methods and evaluation. The second is curriculum-instruction, which refers to the democratic formulation of objectives, content, instructional methods and materials, and evaluation elements. The third is relations, which refers to the establishment of interpersonal relations and relations with students' families based on democratic values. And the fourth is the teacher, which refers to the characteristics, roles and responsibilities of the teacher from an authority to a facilitator (Korkmaz & Gumuseli, 2013).

Sartor and Young Brown (2004) believe that participation in a consensus classroom provides a structure for a democratic social arrangement in the purest sense – government by the people. It provides a form of democracy in which decisions are not reduced to "either – or" and multiple alternatives can be explored and synthesized. Ultimately, consensus provides students with daily experience in their capacity to bring about change, thus developing both the skills and attitudes necessary for effective democracy, in and outside the classroom. While engaged in the consensus process in the classroom, the teacher can function in the way Dewey (1938) hoped: "can exercise the wisdom of his/her own wider experience without imposing a merely external control" (p. 38).

Learning Styles

The question on how people learn is still an area of great interest, particularly in higher education (Wilkinson, Boohan & Stevenson, 2014). Learning is a dynamic process; Bankert and Kozel (2005) described it as the product of student and teacher activity within a learning environment. However, the instructional methods teachers use are not perfect as they may have their own share of pros and cons (Khanal, Shah & Koriala, 2014). The basic role of teacher therefore remains the same nevertheless, that is to recognize students' potential and consciously plan for their balanced personal development (Stellwagen, 2001). Literature report that teachers weave this role along with their other activities by creating a harmonious learning environment and giving the students tools that will assist them to become better learners (Dart et al., 2000; McAllister, 2010). One tool that can be utilized to facilitate this is a learning style inventory (Marcy, 2001), an important consideration in planning for an effective and efficient instruction and learning (Childress, 2001; Li et al., 2011). Learning styles is a term used to refer to the methods of gathering, processing, interpreting, organizing and thinking about information (Khanal, Shah & Koriala, 2014). Students have different learning styles that are distinct and consistent (Hsu, 1999; Chou & Wang, 2000) favoring particular methods of interacting with, taking in, and processing stimuli and information when they learn (Sirin & Guzel, 2006). This is the reason for the diversity seen in classrooms in regards to how students acquire information (Khanal, Shah & Koriala, 2014). When learning styles are considered, teachers can address learner's needs by utilizing a variety of teaching methods and teaching styles so that they will be exposed to both familiar and unfamiliar ways of learning, ultimately giving learners multiple ways to excel (Vaughn & Baker, 2001).

Wu (2014) reported that the concept of learning styles is rooted in ancient theories of medicine during the second century A.D. through the Greek Hippocrates which was further refined by Galen. Although originally a medical doctrine, the four humors doctrine (sanguine, choleric, melancholic, and phlegmatic) serves as the origin of the first temperament, trait or type theory of learning styles. As to its contemporary origin, accounts are conflicting. Pashler et al. (2008) traces it to the Myers-Brigg Type Indicator (MBTI) test which started to be popular in the 1940s while Buboltz et al. (2001) attributes it to Allport in 1937. In the last few decades, learning styles has become a highly influential area of tremendous attention (Pashler et al., 2008) comprising a large body of research (Coffield et al., 2004).

Meaning of learning styles. Learning styles have been defined in many different ways by different scholars including in their definitions aspect of individual's preference, ease, or even best way of learning (Wu, 2014). All however agree on viewing learning styles as a way of learning (Cakiroglu, 2014).

The most cited definition of learning styles is that of Fleming (2001) who describes it as the individual's preferred way of gathering, organizing, and thinking about information. Embracing the same idea, Felder and Silverman (1988) defined it as an individual's preferred way of acquiring, retaining and processing information, whereas Maushak et al., (2001) believe that it represents the ways in which individuals interpret, process, understand and integrate information. Savvas, El-Kot and Sadler-Smith (2001) contextualized the concept in terms of knowledge acquisition and drawing of conclusions.

More simplistic and understandable is the definition advanced by Oxford, Ehrman and Lavine (1991) who view learning styles as general approaches used by the students in order to learn a new subject or to cope with a new problem. It refers to their unique behavior in adapting to their environment (Foley, 1999).

The definition given by Keefe and Ferrel (1990) is more technical as they regard learning styles as the composite of characteristic cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to their learning environment. Along the same line of thought, Aragon, Johnson and Shaik (2002) look at them as behaviors related to the psychological, cognitive, and affective domains of interaction with learning environments. It involves learners' preferred ways to receive, process, and recall information during instruction which is related to learners' motivation and information-processing habits. Larkin and Budny (2005) believed that learning styles are biologically and developmentally imposed set of personal characteristics that makes the same teaching and learning methods effective for some and ineffective for others, which in the argument of Curry (1981) are related to the differences in cognitive approaches and processes of individual students' learning.

Learning style models. Learning style theories describe the extent of the learning approach used by individuals in learning different subjects or topics. Assumptions and foundations of learning style theories are different from each other as well as the basic tenets of each of the learning style theories which influence the learning attitudes of the students. Dunn and Dunn (1978) stated that students with different learning styles have distinct preferences during different instructional activities. Thus, various models have been proposed by theoreticians and used by educators in order to measure learning styles. Various instruments have also been used. The most frequently used learning theories in educational research are the following: Kolb experiential learning theory, Dunn and Dunn, VAK, Felder-Silverman Learning Style Model, the Gregorc Model and VARK model (Moayyeri, 2015).

Coffield et al. (2004) provided an extensive report which involved at least 71 learning style models. The models have some components different from each other related to the extent that they may change over time for learners. Some popular instruments were various extensions of Jung's (1970) psychological types and Gardner's (1993) multiple intelligences. One of the widely used models in this area was developed by Gregorc and Butler (1984) which has four combinations of perceptual qualities and ordering abilities: concrete sequential, abstract random, abstract sequential, and concrete random. In this model, it is considered that each individual can be strong in one or two of the four styles. In contrast, Felder and Silverman (1988) did not consider learning styles to be constant. According to them, learning preferences may change due to the time and situation. Fleming's (2001) VARK inventory, which includes visual, aural, read-write, and kinaesthetic perceptual styles, and the specific inventory of Felder and Soloman (1997), which measures learning preferences across four bipolar preferences _active-reflective, sensing-intuitive, visual-verbal, and sequential-global _ are well known examples derived from those models.

The Canfield learning style inventory. According to Francis et al. (1995), the Canfield Learning Style Inventory (LSI) is one well-known instrument for assessing student instructional preferences. Teachers have used the Canfield inventories to ascertain the learning preferences of their students and initiate class discussion of learning styles and course assignments. It has also been used to assess learning style preferences of various college student groups educator groups, incarcerated adults and graduate students (Eide, Geiger & Schwartz, 2001)

The use of Canfield LSI has gained support after the popular Kolb's LSI received substantial amount of criticism in the education literature particularly on its poor psychometric properties and on its limited focus on preferences for learning modes only giving rise to alternative learning style instruments (Eide, Geiger & Schwartz, 2001).

Individuals' preferences for learning is complex and multi-faceted. Based on this supposition of multifaceted preferences, the Canfield LSI attempts to assess individuals over several affective learning domains. The Canfield LSI is intended to be broader in scope and thus was developed to address multiple aspects of learning. The Canfield LSI includes 21 scales designed to assess four basic learning domains: (1) conditions for learning, (2) area of interest, (3) mode of learning, and (4) expectation for course grade. Scores from the first three domains are combined to create a learner typology that categorizes individuals into preferred learning types. The four learning domains along with the 21 scales that comprise them appear in Table 1.

The first learning domain, *conditions for learning*, refers to an individual's preferred dynamic surrounding the learning situation. These areas include the roles that people in the learning task assume, the structure of course materials, the ways in which goals are set, and the source of motivation (Canfield, 1988). The eight scales that are meant to comprise this domain are peer, organization, goal setting, competition, instructor, detail, independence, and authority. As depicted in Table 1, these eight scales are meant to capture the settings that the individual prefers when learning and include instructional type information as well as interpersonal preferences between the learner and the learner's instructor. Thus, Canfield derives the conditions for learning scales from a traditional classroom setting based on teacher-assisted instruction, and not on the independent acquisition of new information or skill (Eide, Geiger & Schwartz, 2001).

The second learning domain, *area of interest*, assesses the basic objects of study or course subject matter dealt with (Canfield, 1988). The four scales that are meant to comprise this domain are numeric, qualitative, inanimate, and people. The scales in this domain are meant to reflect the preferred subject matter of the individual, but on the surface seem to capture two different continuums – working with quantitative things, and working with objects vs. people. Nonetheless, these four scales comprise the area of interest domain and are intended to reflect an individual's preferences for the subject matter (Eide, Geiger & Schwartz, 2001).

The third learning domain, *mode of learning*, refers to the basic sensory and cognitive modality in which new information may be acquired. The four modes of learning assessed in the LSI are listening, reading, iconic (visual), and direct experience. The fourth domain, expectation for course grade, is self-contained and scores on these four scales are combined to give an overall expectation score (Canfield, 1988).

Table 1. Canfield LSI: Description of Learning Domains and Scales (Canfield, 1988)

Domain 1: Conditions for learning (eight scales): Preferred Situations or Context of Instruction Scale	
1. Peer	Enjoys teamwork, maintaining good relations with other students, having student friends, etc.
2. Organization	Desires clearly organized course work, meaningful assignments, and a logical sequence of activities.
3. Goal Setting	Wants to set own objectives, use feedback to modify goals or procedures, and make his or her own decisions on objectives.
4. Competition	Desires comparison with others, needs to know how he or she is doing in relation to others.
5. Instructor	Wants to know the instructor personally and have a mutual understanding and liking for him or her.
6. Detail	Likes to know specific information on assignments, requirements, rules etc.
7. Independence	Prefers working alone, determining his or her own study plan, and doing things independently.
8. Authority	Desires classroom discipline, maintenance of order, and having informed and knowledgeable instructors.
Domain 2: Area of Interest (four scales): Preferred subject matter or objects of study Scale	
1. Numeric	Prefers working with numbers and logic, solving mathematical problems, etc.
2. Qualitative	Likes working with words or language – writing, editing, talking.
3. Inanimate	Enjoys working with things – building, repairing, designing, operating.
4. People	Prefers working with people – interviewing, counselling, selling, helping.
Domain 3: Mode of Learning (four scales): Preferred manner of obtaining new information Scale	
1. Listening	Prefers hearing lectures, tapes, speeches etc.
2. Reading	Enjoys examining written information, reading texts, pamphlets, etc.
3. Iconic	Likes interpreting illustrations, movies, slides, graphs, etc.
4. Direct Experience	Desires hands-on or performance situations, such as shop, field trips, practice exercises, etc.
Domain 4: Expectation for Course Grade (five scales): Level of performance anticipated Scale	
1. A-expectation	Outstanding or superior level.
2. B-expectation	Above average or good level.
3. C-expectation	Average or satisfactory level.
4. D-expectation	Below average or unsatisfactory level.
5. Total Expectation	Weighted sum of A-, B-, C- and D- expectations.

To arrive at a categorization of learner types, the Canfield LSI combines several of the scale scores from the first three domains. The Canfield LSI Learner typology is broadly categorized into pure, mixed and neutral types. For pure types, learners can be typified as social, independent, applied or conceptual. Whereas, for mixed types, learners can be classified as social/applied, social/conceptual, independent/applied, independent/conceptual (Canfield, 1988).

For pure types, a social learner prefers extensive opportunities to interact with peers and instructors; has no strong preference for either applied or conceptual approaches; instruction involving small groups and teamwork will create the closest match. An independent learner on the other hand, prefers to work alone toward individual goals; has no strong preference for either applied or conceptual approaches; instructional techniques such as analysis of case studies or self-selected and self-paced programs will create the closest match. An applied learner prefers to work in activities directly related to real-world experience; has no strong preference for either social or independent approaches; instruction involving practicums, site visits, and team labs will create the closest match. A conceptual learner prefers to work with highly organized language-oriented materials; has no preference for either social or independent approaches; instruction involving lectures and reading will create the closest match (Canfield, 1988).

For mixed types, a social/applied learner prefers to have opportunities to interact with students instructors in activities closely approximating real-world experiences; instruction involving role-playing, group problem solving and supervised practicums will create the closest match. A social/conceptual learner prefers to have opportunities to interact with students and instructors using highly organized language-oriented materials;

instruction involving a balance of lecture and discussion will create the closest match. An independent/applied learner prefers to work alone toward individual goals in activities closely approximating real-world experience; instruction involving individual labs or unsupervised technical practicums will create the closest match. An independent/conceptual learner prefers to work alone toward individual goals with highly organized language-oriented materials; instruction allowing for independent reading, literature searches, and reviews will create the closest match (Canfield, 1988).

A neutral type learner has a neutral preference. He or she tends to have no clear areas of strong preference; may find adequate match in any other type, but may also find it difficult at times to become entirely involved (Canfield, 1988).

Importance of learning styles. Learning styles make the framework through which learners acquire knowledge and use their preferred approaches to process information in order to learn successfully (Moayyeri, 2015). The concept of learning style is very useful for identifying the internal and external variations in how individual learners learn and process information. It helps individuals to improve their interaction within education environments (Foley, 1999).

Researchers support that learning styles turn to have a real effect on the achievement of students (Cassidy, 2004; Reese, 2002), in that significant relationship is established between psychological preferences and academic performance (Bitran et al., 2004). In particular Nolting (2002) emphasized that students' academic achievement positively increases if they are aware of their learning style and how they learn best. Some studies had suggested that becoming aware of their learning styles help students learn. There was less agreement among students that knowing their learning style helped their performance in exams (Breckler, Joun & Ngo, 2009; Kumar & Chacko, 2012).

Research studies on learning styles have shown that learning can be enhanced through consideration of personal characteristics in design and delivery of the instruction (Dziuban, Moskal, & Hartman, 2004; Fearing & Riley, 2005). Because some learners tend to focus on facts, data or procedures, engaging with theories and mathematical models is appropriate. Other learners use visual information like pictures, diagrams, and simulations to understand better, while others can get more from oral and written information. Researchers have argued that learning style also functions as a useful indicator for potential learning performance (Kolb & Kolb, 2005; Smith & Ragan, 1999; Sun et al., 2008). The learning style inventory can likewise motivate teachers to move from their preferred modes to student's preferred modes. In so doing, they can reach more students because of the better match between teacher and learner styles (Lujan & Di Carlo, 2006).

Challenges in learning styles research. In the last few decades, despite the fanfare and voluminous studies, learning styles research remains complex and steeped in controversy with no consensus among scholars concerning research results and pedagogical implications (Wu, 2014). Many issues contribute to the "opaque, contradictory and controversial" (Coffield et al., 2004, p. 2) nature of this field such as fragmented research, the continuum nature of learning styles, a vast number of classification models, the potential dynamic nature of individual learning styles, the potential bias of sample populations, and the commercialism of measurement instruments. Additionally, there is no single definition of learning styles (Wu, 2014).

The controversy concerning learning styles involves a philosophical debate of whether learning styles are to be viewed as fixed or flexible. Coffield et al. (2004) in a literature review that identified 71 existing models of learning styles, evaluated in detail 13 of those models, and provided a theoretical framework to classify learning style models. The framework is a continuum based on how fixed or flexible learning styles are viewed and is grouped into the following models in increasing order of flexibility: constitutionally-based learning styles and preferences; cognitive structure; stable personality type; "flexible stable" (p. 12) learning preferences; and learning approaches and strategies.

Theoretically, the controversy in learning styles also involves whether the construct is viewed as dynamic and can change for an individual over time (Maushak et al., 2001). Pragmatically, another controversy of this field of study involves the ever expanding theoretical frameworks, instruments, and resulting commercialism (Coffield et al., 2004; Pashler et al., 2008) of those measurement instruments. Perhaps, the most controversial issue concerning learning styles is the tremendous conflict concerning the results of existing research studies as well as the implications of the research. Much of the controversy regarding research pertains to the meshing hypothesis or the idea that matching learning style with teaching style will improve student performance, which is one of the most common hypothesis (Pashler et al., 2008) or recommendations (Coffield et al. 2004) in related research. Wu (2015) reported that majority of studies involving learning styles pertain to this hypothesis.

However, the meshing hypothesis is strongly contradicted by some contemporary scholars (e.g.. Coffield et al. 2004; Pashler et al., 2008). Coffield et al., (2004) based this criticism on conflicting research, complexity of interactions between other constructs, complexity of the construct of learning, and the fact that it is pragmatically unrealistic. Pashler et al. (2008) also contend that there is no empirical basis for this hypothesis on the basis of lack of "methodologically sound studies" (p. 105) to support it. They further argued that causation has to be demonstrated by a crossover interaction shown through an experimental research design. Zhang, Sternberg and Fan (2013) in particular found out that the amounting research findings have not led to and are unlikely to lead to a conclusion as to whether or not there is a need for a style match between students and teachers. The mixed research findings, they averred, have brought the argument to a deadlock.

Attitude Towards Science

Meaning of attitude towards science. Concerns about attitude towards science are not new. In UK, a phenomenon called "swing from science" was raised after a 1965 inquiry about the flow of science and technology in higher education (Ormerod & Duckworth, 1975). Thenceforth, mounting evidence of the decline in the interest of young people in pursuing scientific careers continue to endure in many countries such that it becomes an international trend (Dearing, 1996; Smithers & Robinson, 1998; Osborne, 2003; Tytler, 2007; UNESCO, 2010; Campbell, 2013). The problem has become even more acute and the topic has been the subject of considerable exploration. These result in a better understanding about the nature of the problem but not the understanding of its remediation (Osborne, Simon & Collins, 2003).

Among the explanations suggested for that 'swing from science' or 'flight from science' crisis (Tytler, 2007) is the students' lessening interest in science and their disaffection with science and technology (Ormerod & Duckworth, 1975). Osborne, Simon and Collins (2003) cogently argue that for any society attempting to raise its standards of scientific literacy, the decline of interest in science is a serious matter of social concern and debate because it poses a serious threat to a nation's future and economic prosperity. Today, people are becoming more dependent on individuals with high level of scientific and technological expertise and competence (Osborne, Simon & Collins, 2003). It has been recognized that the standards of a country's achievement and competitiveness are mainly based on a highly educated, well-trained and adaptable workforce (Dearing, 1996). Hence, economic performance has a positive relationship with the numbers of engineers and scientists produced by a society (Kennedy, 1993).

From these contexts, the development of positive attitude towards science among students becomes an important goal of science education (Oliver & Simpson, 1998; Ramsden, 1998; Stark & Gray, 1999; TIMSS, 1999; Osborne, Simon & Collins, 2003; Martin, et al., 2008; Usak et al., 2009; Ong & Yeo, 2012). For one, holding positive attitude is positively related with increased enrolment in science courses, science achievement and interest in scientific careers (Norwich & Duncan, 1990). Likewise, positive attitude generated through formal science education could result in public engagement with science which Osborne, Simon and Collins (2003) claim to be the *sine qua non* of the public appreciation of science. Also, attitude is thought to predict individual's decision-making and action taking (Glasman & Albarracin, 2006). Unlike the often ephemeral nature of knowledge, attitudes, once formed, are enduring and difficult to change (Ajzen & Fishbein, 1980; Osborne, Simon & Collins, 2003). However, the concept of attitude towards science is somewhat nebulous, often poorly articulated and not well understood (Osborne, Simon & Collins, 2003) hence further investigation about it is current and relevant.

Osborne, Simon and Collins (2003) in their comprehensive review of several literatures about attitude towards science concluded that there is a lack of clarity about the meaning of the phrase. This appears to be brought about by its association with some terms and phrases like *behavior* and *scientific attitude* as well as the notion of science as either *societal* science or *school* science.

Merriam-Webster draws the line of difference by defining *behavior* as "the way a person or animal acts or behaves" and *attitude* as "a feeling or way of thinking that affects a person's behavior." Osborne, Simon and Collins (2003) reported that in several studies, instead of attitude, what was focused on was the behavior. They hold that *attitude towards science* is an affective concept which are the feelings, beliefs and values held about an object that may be enterprise of science, school science, the impact of science on society or scientists themselves. However, they cautioned that while the concept is essentially a measure of expressed preferences towards an object, it is not necessarily be related to one's displayed behavior. In contrast, scientific attitude is cognitive in nature and is linked to scientific thinking. It refers to a complex mixture of the longing to know and understand, a questioning approach to all statements, a search for data and their meaning, a demand for verification, a respect for logic, a consideration of premises, and a consideration of consequences (Gardner, 1975; Osborne, Simon & Collins, 2003). Societal science on the other hand refers to the science out of school (Breakwell & Beardsell, 1992) which is perceived by the students in terms of the medical and technological developments in the world around them and they usually associate with personal computers, television, video, telecommunications and developments in space (Osborne, Simon & Collins, 2003). Researchers argue that this is the kind of science that students usually perceive - high-tech, more socially relevant and prospective (Ebenezer & Zoller, 1993; Sundberg, Dini & Li, 1994). Conversely, school science refers to the science at school and is associated with science laboratories and science teachers (Breakwell & Beardsell, 1992). It is usually perceived by the students as a series of science milestones represented by the most important significant discoveries of the last century (Osborne, Simon & Collins, 2003). Researchers refer to this as the version of science promulgated by teachers - more theoretical, decontextualized and retrospective (Ebenezer & Zoller, 1993; Sundberg, Dini & Li, 1994). Interestingly, research found out that there is no significant association between attitude towards school science and attitude towards societal science and thus the two must be treated as distinct and separate entities (Breakwell & Beardsell, 1992).

Components of students' attitude towards science. Attitude towards science do not consist of a single unitary construct, but rather consist of a large number of sub-constructs all of which contribute in varying proportions towards an individual's attitude towards science. However, research often concerns attitude towards science in general. Only few have studied attitude towards a particular discipline like Biology and Physics (Cakici et al., 2011). Table 2 provides the summary of components of attitude towards science culled from various literatures. Some identified components are specific for Biology.

Table 2. Components of Attitude Towards Science as Reported from Literature

Fraser (1981)	Cheng and Yang (1995)
1. Social implications of science	1. Attitude to biology
2. Attitude to scientific inquiry	2. Attitude to learning of biology
3. Enjoyment of science lessons	3. Attitude to participating in biology inquiry activities
4. Leisure interest in science	4. Attitude to biologists and biology-related careers
5. Career interest in science	
Prokop, Prokop, & Tunnicliffe (2007)	Blalock et al. (2008)
1. Importance of biology	1. Attitude towards science
2. Interest in biology lessons	2. Scientific attitude
3. Understanding of biology processes	3. Nature of science
	4. Scientific career interests
Shah and Mahmod (2011)	Prokop, Tuncer, & Chuda (2007)
1. Keenness to learn science	1. Interest
2. Enjoyment in science learning	2. Career
3. Teacher interaction	3. Importance
4. Disinterest	4. Teacher
	5. Equipment
	6. Difficulty

However, the comprehensive review paper of Osborne, Simon and Collins (2003) provides a more inclusive incorporation of a range of components in measuring attitude towards science as follows:

1. The perception of the science teacher;
2. Anxiety toward science;
3. The value of science;
4. Self-esteem at science;
5. Motivation towards science;
6. Enjoyment of science;
7. Attitude of peers and friends towards science;
8. Attitude of parents towards science;
9. The nature of the classroom environment;
10. Achievement in science; and
11. Fear of failure on course.

Factors influencing attitude towards science. From their exhaustive review, Osborne, Simon and Collins (2003) reported that the factors influencing attitude towards science are sex, socio-economic status, teachers, curricula, and culture among others. Of these, they pointed out the crucial importance of sex and quality of science teaching.

Sex. It has been shown by several studies that boys have consistently more positive attitude to school science than girls. This effect is stronger in physics than in biology (Becker, 1989; Weinburgh, 1995). In the same way, girls' attitude to science are significantly less positive than boys (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). In an analysis of nationwide surveys taken from 1972 through 1990 showed that, at all education levels and in all age groups from 20 to 79 years, females had less confidence in science than males (Trankina, 1993). However, in the study of Weinburgh and Englehard (2010) among 294 students from 10th, 11th, and 12th grades enrolled in a Catholic high school in a major metropolitan area in the Atlanta, Georgia, they found out that females had more positive attitude toward biology laboratory than males. The same observation was gleaned by Abu-Hola (2005) among Jordanian pupils.

This sex difference is explained as a consequence of cultural socialization that offers girls considerably less opportunity to tinker with technological devices and use common measuring instruments (Johnson, 1987; Kahle & Lakes, 1983; Smail & Kelly, 1984; Thomas, 1986). Lack of experience in science leads to a lack of understanding of science and contributes to negative attitude to science (Kahle & Lakes, 1983). In the Philippines, an international study of Relevance of Science Education (ROSE) commissioned by the Norwegian government among 6,943 Grade-10 random samples reveals that Filipino students generally have positive attitude towards science in that it does not significantly differentiate between boys and girls (Talisayon, de Guzman & Balbin, 2006). They attribute this to the nearly equal participation of both sexes in science classes. The researchers suggest that this positive attitude is a good beginning and springboard for increasing student achievement nationally and internationally.

Classroom environment. Several studies also point towards the influence of classroom environment as a significant determinant of students' attitude towards science, subject choice (Osborne, Simon & Collins, 2003) and the tendency to continue with science education after high school (Woolnough, 1994). Of these, effective pedagogy (Simpson & Oliver, 1990) or the quality of science teaching they experienced (Ebenezer & Zoller, 1993) is claimed to have the strongest influence (Simpson & Oliver, 1990). In a qualitative investigation conducted by Hendley et al. (1995), one of the most common reasons given by students for liking or disliking the subject were teacher-related comments. Too, most positive attitude towards science have been found to be associated with a classroom environment having a high level of involvement, very high level of personal support, strong positive relationship with classmates, and the use of variety of teaching strategies and unusual learning activities (Myers & Fouts, 1992). Brown (1976) in his study of 2,800 secondary students extracted variables that could explain students' differences in attitude towards science: (a) nature of the teacher-pupil interaction in the science classroom, (b) teacher's patterns of communication with individual pupils and groups of pupils, (c) transmission of the teacher's expectations to the pupils, (d) topics that are covered in the lesson, and (e) strategies and tactics within strategies adopted by the teacher. Wallace (1996) and Osborne and Collins (2000) also advance that in environment when students have opportunities to take control of their learning and to enhance their role for personal autonomy, student engagement improves. With these reports from literature about the kind of classroom environment students desire, the use of consensus process is worth trying in order to remediate the problem on declining interest and attitude towards science.

Achievement in Biology

Imam et al. (2014) cited several reports documenting the disappointing performance of Filipino students in mathematics and science during the last few decades. They were stuck at the bottom in the 1984 and 1994 International Science Study. They also performed poorly in the 1996 Third International Mathematics and Science Survey and in the 1998 International Assessment of Educational Achievement. Nationally, they showed poor mastery in science and mathematics as evidenced by the results in the 2003 to 2009 National Achievement Tests.

One of the main concerns in science education is the need to improve students' academic achievement. This is not only because a higher achievement especially in science is the foundation for technical skills but also because higher achievement is particularly valued in a society which sets a high premium on academic success as the stepping stone for entrance into more prestigious occupations (Okoye & Okecha, 2008).

In the context of Biology in higher education, students' achievement in Biology is often looked up as a benchmark to evaluate the mode of teaching and learning (Osman & Kaur, 2014). In as much as improvement in achievement is desired, knowing the causes of the poor performance in Biology has also been the focus of researchers. (Yusuf &

Afolabi, 2010). The growing disenchantment from science was also partly triggered by the students perception of school science as difficult, dogmatic and correct (Fensham, 2004; Lyons, 2005). In Turkey, for example, students reported that the following topics in Biology are difficult: endocrine system and hormones, genes and chromosomes, mitosis and meiosis, nervous system, Mendelian genetics, matter cycles, and aerobic respiration (Tekkaya, Ozkan & Sungur, 2001; Cimer, 2012). Cimer (2012) cited several literatures that explain the sources these difficulties which include the nature of the topic, teachers' style of teaching, students' learning and studying habits, students' negative feelings and attitude towards the topic, and lack of resources. A number of researches have also been cited in the work of Yusuf and Afolabi (2010) about the factors affecting students' achievement in science such as test anxiety, attitude towards science, parental socio-economic status, self-efficacy, sex, parental influence, self-concept, ability, learning environment, peers and the teachers.

Sex and achievement in Biology. Findings of studies about the effect of sex on achievement in science are conflicting. Thus, it was hinted that teacher's attitudes, behaviors and pedagogical strategies should be examined for sex bias (SWE-AWE-CASEE, 2009) because several investigations suggest that males and females might react differently to different approaches (Okebokula, 1986; Odubunmi & Balogun, 1991; Young & Fraser, 1994).

Recently, Eddy, Brownell and Wenderoth (2014) reported that despite numerical dominance of females, sex disparities remain an issue in introductory biology classrooms. This is after studying 23 large biology classes for majors and found out that females consistently underperform on exams compared with males with similar overall college grade point averages. Their findings suggest that before sex equity in Biology can be purported, the many unexplored aspects of science identity development must be addressed first. One of these is to maximize the learning environment by modifying teaching to respond to the ever increasing diversity of students in classrooms.

Previous studies also showed that females scored lower than males in upper-division biology courses (Creech & Sweeder, 2012) and they also underperformed compared with males in an introductory-level biochemistry course when prior ability was controlled for (Rauschenberger & Sweeder, 2010). In the U. S., analysis of the 2005 results of the national assessment of students' achievement in science conducted by the National Assessment of Educational Progress (NAEP) revealed that males continue to outperform females in science achievement in Grades 4, 8 and 12 for the third year in a row. Females at all levels have made relatively little gains in their average science achievement scores since 1996 (SWE-AWE-CASEE, 2009). The Trends in International Mathematics and Science Study documents international trends related to science achievement among 46 countries where among U. S. eight-graders, males scored significantly higher overall than females in science (Mullis, Martin, & Foy, 2008). Levin, Sabar and Libman (1991) also claimed that the achievement of boys in all subject area of their study (earth science, biology, chemistry, and physics) was significantly better than the achievement of the girls. In a meta-analysis research conducted by Fleming and Malone (1983), they concluded that boys' achievement in science is significantly better than the achievement of the girls.

Contrary to the above results, the research of Ahmad (2013) among 289 grade 10 students revealed that girls have performed significantly better in life processes as compared to boys. In cognitive domains, they also performed significantly better in knowledge and reasoning levels. Among Jordanian primary pupils, it was revealed that girls outperformed boys in the end of the unit test in science (Abu-Hola, 2005).

A recent study however saw no difference in academic achievement between males and female in two courses: introductory biology and biochemistry (Lauer et al. (2013) which supported previous studies that have also documented no significant differences between boys and girls' performance in science (Ajewole, 1991; Catsambis, 1995; Greenfield, 1996).

Learning environment and achievement in Biology. Macbeth et al. (2000) found out that a learning environment that acknowledges the significance of student views can make a substantial contribution to classroom management, to learning and teaching, and to the school as a social learning space. Too, student views of teaching may reflect the ways by which they learn best (Phoenix, 2000). What students say about teaching, learning and schooling could probably provide the most important foundation for thinking about ways of improving teaching, learning and schools (Cimer, 2012). Thus, it is important that students' views must be taken into consideration, a major concern that will be addressed in this proposed study. While McKeachie et al. (1986) contend that the most effective teaching method depends on the goal, the student, the content and the teacher, they are convinced that the next best method is, "students teaching other students" (p. 63).

Alternative conceptions in Bioenergetics. Few if any students come to biology classrooms without significant prior knowledge of the subject. Thus they can never be considered blank slates, beginning with zero knowledge awaiting the receipt of current scientific understanding (Tanner & Allen, 2005). In the science education literature, many terms have been proposed to characterize their ideas: naïve beliefs, preconceptions, private versions of science, personal models of reality, persistent pitfalls, pre-instructional ideas, unfounded beliefs, and even mistakes (Wandersee, Mintzes, & Novak 1994). While there are rationales behind the use of each, Tanner and Allen (2005) deemed the use of the term 'alternative conception' as more appropriate, denoting student understandings of scientific concepts that are not aligned with the current understanding of scientists.

It has been reported in literature that students have alternative conceptions in metabolism, photosynthesis and cellular respiration, lessons that are covered in the bioenergetics unit (Tatar & Oktay, 2007; Kose, 2008; Keles & Kefeli, 2010; Parker et al., 2012; Svandova, 2014). It is therefore necessary to focus on the misunderstood points and carry out more studies on methods to reduce or eliminate such misunderstandings that can hinder learning (Tatar & Oktay, 2007).

Shown in Table 3 are the reported alternative conceptions on bioenergetics as reviewed from literatures (Tatar & Oktay, 2007; Kose, 2008; Keles & Kefeli, 2010; Parker et al., 2012; Svandova, 2014).

Table 3. Students' Alternative Conceptions in Bioenergetics

Metabolism

1. Enzymes only work for carbohydrates.
2. Enzymes are not made of proteins.
3. Enzymes get used up in the reaction between its substrate.
4. Enzymes can be killed not denatured because they are alive.
5. Every enzyme has the same optimum pH.
6. Metabolism is a reaction that occurs in the stomach to increase digestion.
7. Enzymes are viewed as catalysts that speed up a reaction, but the reactant is being used up in the reaction.
8. An enzyme is a substrate added which reacts with anything that has related properties – shape has no influence.
9. An enzyme and a substrate react no matter what conditions are absent or present.
10. All enzymes help break down a substance during a reaction.

Metabolism

11. Students incorrectly label for the substrate and the product, often using them interchangeably. The substrate was described as having its own active site, and it underwent an induced fit (rather than the enzyme).
12. Once an enzyme catalyzes a reaction, it is inactivated or used up, or that if the substrate was exhausted, the enzyme would be denatured.
13. Most beginning students have heard the word enzyme but do not know what enzymes are or what they do. Lack of concept is more common than misconceptions in this case.
14. Some students have heard that heat "kills" enzymes. Heat does denature, and therefore deactivate, proteins including enzymes, buts since proteins are not alive to begin with they cannot be killed.
15. After learning about temperature and enzymes, some students believe that the optimum temperature for all enzymes is human body temperature. This is true for humans, but is not necessarily true in other organisms, which may have different internal temperatures.
16. Many students forget that enzymes are proteins. This is an important connection to make, especially when studying genetics.

Thermodynamics

1. Energy is used up or lost.
2. If it stays in a system, energy will be conserved.
3. Energy degradation means decreasing in its quantity.
4. Energy degradation is opposite to energy's conservation.
5. Energy conservation means saving.
6. Burning *m* substance produces energy as much as mc^2.
7. Energy is stored in food and fuel.

Photosynthesis and Cellular Respiration

1. Photosynthesis and plant respiration are the same processes which only differ in designation and which part of the day the processes take place (photosynthesis – day; respiration – night).
2. Plants obtain all of their nutrients from the soil (matches everyday experience with plants, in which the only visible inputs are through the roots.)
3. Sunlight is a material that is somehow incorporated into the mass of the plant.
4. Pigment is a reactant or product of photosynthesis.
5. Photosynthesis continues in the absence of light.
6. Instead of understanding that plants are autotrophs that make their own food, many students take this to mean that plants are a source of oxygen or food for animals (by producing fruit for humans to consume).
7. Plants do not respire at all.
8. Photosynthesis is the means by which plants respire.
9. Students appear to confuse respiration with breathing, and thus view the former solely as a gas-exchange event. Because they believe that photosynthesis is the opposite of cellular respiration, it is also viewed as gas exchange or how plants breathe.
10. Respiration is often seen as the opposite of photosynthesis, because some reactants of photosynthesis, namely carbon dioxide and water, are the products of respiration, while oxygen, a reactant of respiration, is a product of photosynthesis. However, students do not realize that there are differences between the processes in chemical pathways, location in the plant, and when they occur (many students believe that photosynthesis occurs in the presence of light and respiration in the dark.)
11. Gases, such as the CO_2 used in photosynthesis, have little or no mass, are unimportant, or cannot account for the mass gain of photosynthetic organisms.
12. ATP for cellular use is a product of photosynthesis.
13. Atoms from CO_2 end up in ATP.
14. Minerals taken up by the roots make a significant contribution to the mass of the plant.
15. ATP (from any source) is moved throughout the plant.
16. ATP made during photosynthesis circulates throughout the plant.
17. Sunlight is converted into sugar.

Photosynthesis and Cellular Respiration

18. To produce ATP, plant uses respiration when in the dark and photosynthesis when in the light.
19. That plants grow is a sufficient explanation for mass gain, without referencing the source of the matter, the source of the energy or the processes of photosynthesis.
20. The sunlight makes plants healthier, more powerful and in more beautiful color.
21. The sunlight is the food of plants.
22. The food of a plant is water and minerals from the soil.
23. CO_2 is harmful for plants.
24. CO_2 is food for plants.
25. The sunlight is converted into food in photosynthesis.
26. Plants do not do respiration.
27. Plants do not use oxygen.
28. Respiration in plants only takes place when there is no light at night.
29. While photosynthesis in plants is the taking in of CO_2 and giving off of O_2 during the day, it is taking in of O_2 and giving of CO_2 at night.
30. Photosynthesis occurs with the rise of the rains to the sky and after evaporation, their return to the ground.
31. Photosynthesis is a gaseous exchange process during which CO_2 is taken in and O_2 is given off.
32. Plants grow up by photosynthesis, which occurs during the day.
33. Water moves into the leaves during photosynthesis.
34. Plant takes in CO_2 and change it to O_2.
35. Photosynthesis occurs in green plants all the time.
36. Photosynthesis is the production of energy for plant growth.
37. Photosynthesis takes place mainly in the leaves.
38. When plants carry out photosynthesis, they do not respire.
39. Photosynthesis can take place to not use water.
40. Photosynthesis can occur to not use sunlight.
41. The most important benefit to green plants when they photosynthesize is giving off oxygen.
42. Plants use CO_2 to carry out respiration and to produce O_2.
43. Plants photosynthesize and animals respire.
44. Plants use sunlight to live and grow.
45. Respiration occurs in no plant cells.
46. Respiration in plants does not take place in the presence of light energy.
47. Respiration in plants occurs only in their store roots.
48. Humans are giving off CO_2 in respiration; plants are giving off O_2 in respiration.
49. While respiration in green plants is the taking in of CO_2 and giving off of O_2 during the day, it is taking in of O_2 and giving off of CO_2 at night.
50. Respiration in plants is a gaseous exchange process during which O_2 is taken in and CO_2 is given off.
51. Respiration in plants is the taking in of CO_2 and giving off of O_2 at night.
52. Trees respire with the oxygen produced by the smaller green plants.
53. Respiration in green plants takes place only during the day.
54. Plants respire through the leaf's stomata.
55. Photosynthesis and respiration function in an opposite and contrasting manner.
56. Photosynthesis and respiration in plants are only a gas exchange event.
57. Plants eat minerals.
58. Plats feed on water.
59. The soil supplies water and food for plants.
60. Plants feed on the bacterial decompositions.
61. Plants get their food from the soil through their roots.
62. Plants are called producers since they are food and oxygen sources for the other organisms.
63. Plants are called producers since they give fruits and vegetables to humans.
64. Leaves have special pores to exchange gases.
65. The leaf's main job is to capture the rain and the water vapor in the air.
66. The leaf's main job is to give off oxygen.
67. The leaf's main job is to give off carbon dioxide.

Photosynthesis and Cellular Respiration

68. Photosynthesis is a chemical process to obtain energy.
69. Photosynthesis occurs mainly in the leaves.
70. Water moves into the leaves during photosynthesis.
71. Plants respire through their leaves because gas exchange occurs in the stomata in leaves.
72. Plants carry out anaerobic respiration at night.
73. Plants respire to digest their food.
74. Salt, minerals, air and sunlight are the plant's food.
75. Fertilizer is the plant's food.

Attitude and Achievement

In general, attitudes, goals, and interests have been identified as important for student's understanding, learning, and their academic success (Usak et al., 2009). A great deal of research has accumulated concerning the importance of the relationship between learner's attitude and achievement, which is fundamental in science education (George, 2006; Osborne, Simon & Collins, 2003; Weinburgh, 1995). The essential premise permeating much of the research is that attitude precedes behavior (Osborne et al., 2003) metaphorically reduced to a simplistic notion that the best milk comes from contented cows (Fraser, 1982).

However, Osborne, Simon and Collins (2003) found out that within literature, there are some disagreements about the nature of the causal link between attitude towards science and science achievement. Their review of several research reports yielded correlation coefficients ranging from none to moderate to strong relationships. But there is a limited literature concerning the relationship between attitude and biology achievement in college because most studies addressed the issue on elementary and high school students in general science subjects (Cakici et al., 2011). Recent investigations concerning biology however subscribe to such results as well. In a 2009 study among 1,301 university students in Turkey, Usak et al. found out that attitude towards biology accounted only for about 2.5 percent of the variance on biology achievement suggesting a weak, although statistically significant association between the two variables. The study of Caciki, Aricak and Ilgaz (2011) among 890 grade 9 and 10 students also in Turkey found out that attitude towards the biology course significantly predict their achievement in biology (ß=0.17, p<0.001). In Pakistan, the study of Ali and Awan (2014) among 1,885 grade 10 students found out that attitudes towards science are significantly related with achievement in physics (R=0.24, p<0.01), chemistry (R=0.25, p<0.01), and biology (R=0.26, p<0.01).

Osborne, Simon and Collins (2003) also raised another concern in the literature about the disagreement on which should be taken as the dependent variable between attitude and achievement. They cited some researchers contending that achievement is the causal factor affecting attitude towards science while others suggested that attitude affects science achievement. These scholars conclude that the only tenable position is to acknowledge that the two are inescapably linked in a complex interaction citing research findings that early childhood experiences serve as a major influence on academic interest. They likewise claim that feelings of enjoyment and interest in science combined with success in higher science courses are likely to lead to a positive commitment towards science that is enduring. Nevertheless, they also cautioned that it was only a partial picture and children can achieve highly in science without holding positive attitude towards it. These various perspectives in literature justify the need to investigate the relationship between attitude towards biology and biology achievement in the context of the Filipino college students.

Need for the Study

While there are several studies that gave students the opportunity to negotiate and co-construct with teachers the plans and designs of instruction, very few however categorically mentioned that the consensus process was used in making those instructional decisions. Some other studies employed the consensus process, not in making a whole class decision but in the context of a classroom lesson within small groups. Most notably, findings of studies thus far about the benefits and effects of consensus and its variants are limited within the investigators' self-contained classrooms. This setup can inevitably cast reservations as to the generalizability of the reported benefits. There was never a structured and objective attempt to investigate and test the effects of the consensus process using a comparison group, particularly across two significant goals of science education– students' achievement and attitude towards the subject. This study is perhaps, the very first experiment that developed a protocol in conducting a consensus-based instruction in Biology and empirically tested its effectiveness against the prevailing instructional approach.

Studies about students' attitude towards science abound in literature but most of them are focused on general science. Only very few surveys target students' attitude towards Biology. Moreover, most studies only covered elementary and secondary school students and very few looked at the issue among college students. Determining college students' attitude towards Biology is very timely and current because many problems and challenges the world faces are biology-related such as medical advancements, environmental degradation, climate change, GMOs and the like. It has been acknowledged that the development of a positive attitude towards science is one of the goals of science education because this is the *sine qua non* so that the public will appreciate science and many would pursue careers that are related to science and technology. One major concern however is that the components of students' attitude towards science and Biology vary from one context to another. This concern was addressed by considering all the components together and extracting the significant factors that are reflective of the college students' attitude towards Biology within the bounds of the locale of the study.

Bioenergetics is among the topics reported by students as difficult to learn. Aside from being chemical and molecular, students find it hard to imagine several biochemical processes included in this topic. Acknowledging that the main purpose of any educational intervention is to improve learning, there was no hard evidence whatsoever that links the consensus process to students' performance in achievement test. This study developed a misconception-based achievement test on bioenergetics consistent with the TIMSS cognitive domains to be used as gauge in validating the alleged effects of the consensus process.

Findings of the learning styles research are conflicting and as such, there have been suggestions to study how those styles interact with other instructional variables in improving performance. To match the teachers' teaching style to individual student's learning style has been criticized to be pedagogically impractical due to its complexity in implementation in the classroom setting. It has been suggested instead to employ different teaching styles to allow students to learn in many different ways. Acknowledging reports about the limitations of other learning style inventory instruments, this study used a learning style inventory that covers multiple aspects of students' learning and tested whether learning style moderates the effects of instructional approach on attitude and achievement. Likewise, another moderator variable was considered - sex.

Finally, the blur in literature about the relationship between students' achievement and attitude towards science in general and Biology in particular makes this investigation worth pursuing. With the contradicting findings reported, this study adds additional evidence to the very nature of the 'attitude-achievement' hypothesis particularly when a democratizing approach is introduced.

Conceptual Framework

Informed by the findings from the review of related literature and studies, the conceptual framework of this study is depicted in Figure 1. The relationships of variables from each other are also elucidated in the subsequent discussion. This framework represents an effective instructional approach in Biology that is based on consensus where students' voices are incorporated into their educational processes. Originating from the manner by which pre-historic tribes and indigenous people make decisions in order to take care of everyone and accommodate their needs, the use of consensus has been applied in various settings thenceforth, and is now gaining the support of several educators and researchers at all school levels (Sartor & Sutherland, 1992; Shore, 1996; Hudd, 2003; Sartor & Young Brown, 2004; Fasset & Warren, 2007; Danielwicz & Elbows, 2009; Moreno-Lopez, 2005; Mitchell et al., 2009; Inoue, 2010; Blinne, 2013; MacDougall, 2013). The intervention is called Consensus-Based Instruction (CBI) which upholds the conscious agreement of everyone in all instructional decisions that are normally done by the teacher alone. In this study, instructional decisions refer to the decisions made about the different aspects of a learning plan in bioenergetics. In the CBI group, the students' learning needs, learning styles, preferences and interests were acknowledged. Then, they were allowed to negotiate with their teacher the teaching and learning transactions to be implemented as stipulated in the learning plan. These were decided upon via consensus to ensure the adherence of every participant, including the teacher, to the agreed processes. These features of CBI reflect a postmodern, constructivist, democratic and student-centered view of learning which are consistent to 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). On the contrary, in the group that used traditional instruction, all aspects of the learning plan emanated from the teacher. Students were not allowed to negotiate nor decide through consensus. Two variables which are reported to be the main goals of science education in general, and biology in particular were used as the points of comparison between the two groups to rule out the effect of CBI: students' attitude and their achievement.

Two other factors prominently figured in literature that may moderate teachers' instructional approach are students' 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) and sex (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). They have been implicated to have correlative to causative roles in variation in student's

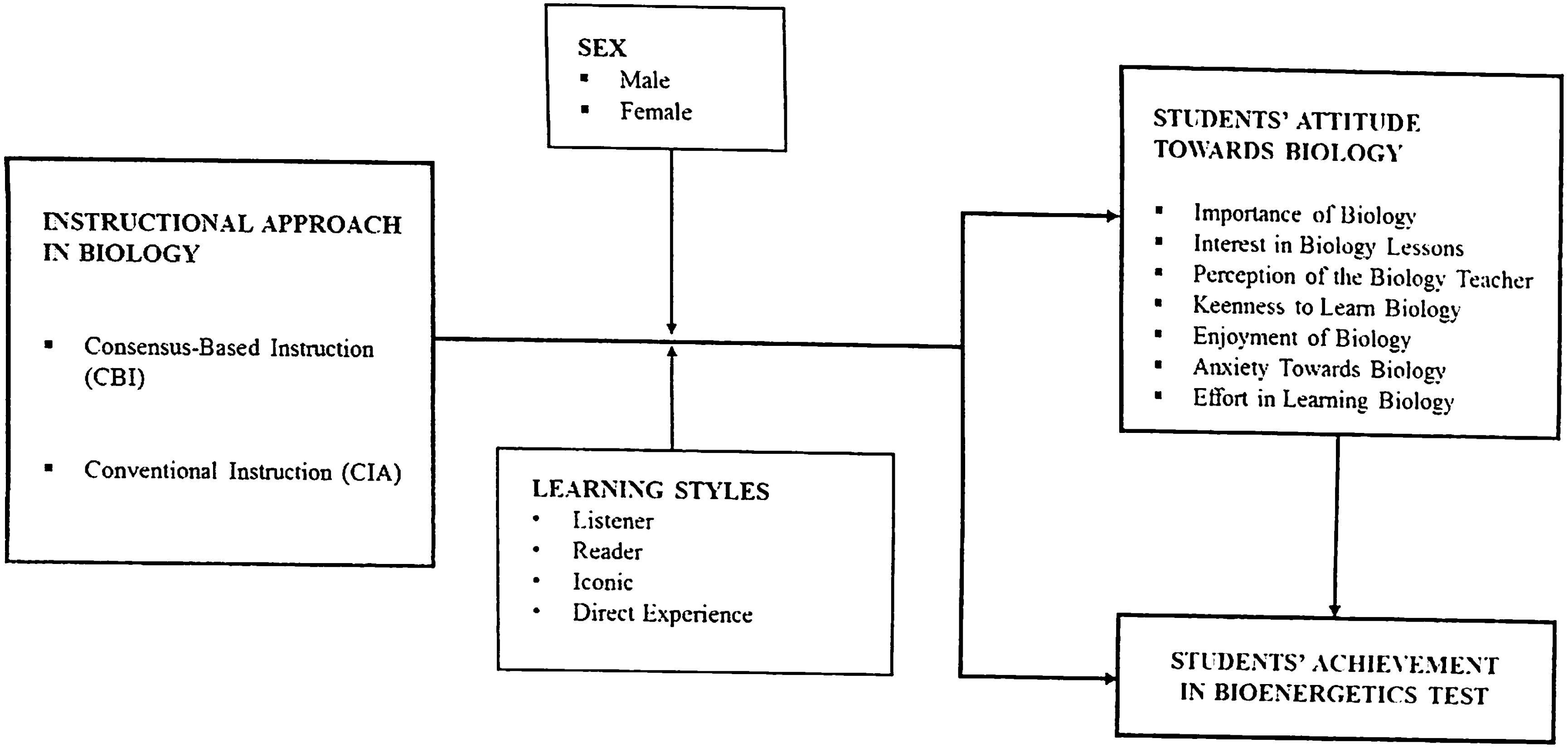


Figure 1. Consensus-Based Instruction Conceptual Framework

attitude and performance and thus their inclusion in the framework helped explain how CBI affected the study's dependent variables as influenced by these two factors.

Investigating students' attitude towards Biology is not new. However, the lessening interest in science and disaffection with science and technology are among the reasons implicated to have triggered an international crisis in science masked by the terms 'swing from science' or 'flight from science', a phenomenon characterized by the declining interest of young people in pursuing science careers (Ormerod & Duckworth, 1975; Dearing, 1996: Smithers & Robinson, 1998; Osborne, Simon & Collins, 2003; Tytler, 2007; UNESCO, 2010; Campbell, 2013). This crisis if not remediated would pose threats to the future and economic prosperity of a nation because it has been acknowledged that a country's economic performance depends on the number of engineers and scientists it produces (Kennedy, 1993; Dearing, 1996; Osborne, Simon and Collins, 2003). Thus, developing positive attitude towards science is an important goal of science education (Oliver & Simpson, 1998; Ramsden, 1998; Stark & Gray, 1999, TIMSS, 1999; Osborne, Simon & Collins, 2003; Usak et al., 2009; Ong & Yeo, 2012) and so, of biology education. Relevant to this concern is the growing clamor from literature that classroom environment particularly effective pedagogy or the quality of science teaching the students experience plays the strongest influence in the development of positive attitude towards science (Simpson & Oliver, 1990; Ebenezer & Soller, 1993; Osborne, Simon & Collins, 2003). Such environment is further portrayed as one that provides students with opportunities to take control of their learning and develop their role for personal autonomy (Wallace, 1996; Osborne & Collins, 2000). The researcher believes that this desired setting can be supported by the CBI approach and can contribute for the improvement of students' attitude towards biology. Thus, the arrow linking the box for instructional approach and the box for students' attitude towards biology illustrates this effect.

Students' achievement in Biology, as with other disciplines, is more often looked up as the benchmark to evaluate the effectiveness of curricular and instructional interventions. It is often considered as a valid indicator of students' learning and thus, becomes one of the main concerns in science education (Osman & Kaur, 2014). This is of importance in countries where higher achievement is particularly valued because it serves as a stepping stone for entrance into more prestigious occupations (Okoye & Okecha, 2008). To engender higher achievement, McKeachie et al. (1986) expounded that "students teaching other students" (p. 63) is one of the top teaching methods there is. Likewise, it has been argued that learning environment that acknowledges the significance of student views can probably provide the most important foundation for thinking about ways of improving teaching, learning and schools (Macbeth et al., 2000; Phoenix, 2000; Cimer, 2012). All these claims are addressed by CBI. As the arrow points out, it is thought to be an effective approach in improving students' performance in biology.

The line that links the box for attitude towards Biology and the box for students' achievement in Biology signifies a relationship, an investigation that is fundamental in science education, popularly premised at the idea that attitude precedes behavior (George, 2006; Osborne, Simon & Collins, 2003; Weinburgh, 1995). However, the relationship between the two variables as reported in literature is not precise. Too, there is a disagreement about the nature of causal link as to which variable depends on what

(Osborne, Simon & Collins, 2003; Usak et al., 2009; Caciki, Aricak & Ilgaz, 2011; Ali & Awan, 2014). This blur in literature warrants the need to further look into the relationship between these two variables.

Hypotheses

The null hypotheses of the study are:

1. The overall mean scores of the attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology and effort in learning Biology of the class exposed to CBI are not significantly higher from those of the class taught using CIA.
2. The mean score in Bioenergetics Achievement Test of the class exposed to CBI is not significantly higher from that of the class taught using CIA.
3. Sex does not significantly moderate the effects of instructional approach on:
    a. Students' attitude towards Biology; and
    b. Students' achievement in bioenergetics test
4. Learning style does not significantly moderate the effects of instructional approach on:
    a. Students' attitude towards Biology; and
    b. Students' achievement in bioenergetics test
5. The overall scores of students' attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology and effort

in learning Biology are not significantly related to their bioenergetics achievement test scores.

The research hypotheses of the study are:

1. The overall mean scores of the attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology and effort in learning Biology of the class exposed to CBI are significantly higher than those of the class taught using CIA.
2. The mean score in Bioenergetics Achievement Test of the class exposed to CBI is significantly higher than that of the class taught using CIA.
3. Sex significantly moderates the effects of instructional approach on:
    a. students' attitude towards Biology; and
    b. students' achievement in bioenergetics test
4. Learning style significantly moderates the effects of instructional approach on:
    a. students' attitude towards Biology; and
    b. students' achievement in bioenergetics test
5. The overall scores of students' attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology and effort in learning Biology are significantly related to their bioenergetics achievement test scores.

Definition of Terms

Achievement in Bioenergetics. According to the Encarta dictionary, 'achievement' is something that somebody has succeeded in doing, usually with efforts.

In this study it is operationalized as the student's score in a 35-item misconception-based Bioenergetics Achievement Test.

Attitude towards Biology. It is defined as an affective concept which are the feelings, beliefs and values held by an individual about an object that may be enterprise of science, school science, the impact of science on society or scientists themselves (Osborne, Simon & Collins, 2003). In this study, it refers to the student's overall score in a 51-item Attitude Towards Biology Scale (ATBS) which is composed of seven components as follows:

Importance of Biology. It refers to the significance, value and relevance (Encarta, 2009) of biology as perceived by the students. It is operationalized in this study as the average score of a student in 10 statements of ATBS.

Interest in biology lessons. It indicates the students' feeling of curiosity or concern about Biology that makes their attention turn toward it (Encarta, 2009). The term is used in this study to refer to the average reversed score obtained by a student in eight negative statements depicting disinterest in biology lessons.

Perceptions of the biology teacher. It refers to the students' impression, an attitude or understanding based on what is observed or thought (Encarta, 2009), of their biology teacher. It is contextualized in this study as the student's average score in eight statements of ATBS.

Keenness to learn Biology. It indicates the student's enthusiasm, eagerness and willingness (Encarta, 2009) to learn biology. As used in this study, it refers to the average score of students in eight statements of ATBS.

Enjoyment of Biology. It refers to the students' pleasurable experience of biology (Encarta, 2009). It is used in this study to refer to the student's average score in eight statements of the ATBS.

Anxiety towards Biology. It is the student's feeling of worry, nervousness or agitation (Encarta, 2009) about the subject. This is operationalized as the student's average reversed score in five statements of the ATBS.

Effort in learning Biology. It refers to the mental or physical energy exerted (Encarta, 2009) by a student in order to learn Biology. In this study, it is operationalized as the student's average score in four statements of the ATBS.

Consensus-based instruction. It refers to the democratizing approach to biology instruction that upholds the conscious agreement of everyone in all instructional decisions that are normally done by the teacher alone which has two levels – whole class consensus and consensus within groups in the context of a lesson.

Conventional instruction approach. It refers to the prevailing approach used in college instruction which is generally teacher-directed and teacher-centered and is characterized by lecture with slide presentation.

Learning style. It refers to the individual's preferred way of gathering, organizing, and thinking about information (Fleming, 2001). In this study, it refers to the students' preferred manner of obtaining new information such as listening, reading, iconic and direct experience (Canfield, 1988) defined as follows:

Listeners. They are learners who prefer lectures, tapes, speeches etc.

Readers. They are learners who enjoy examining written information, reading texts, pamphlets etc.

Iconics. They are learners who like to interpret illustrations, movies, slides, graphs, etc.

Direct experience learners. They are learners who desire hands-on or performance situations such as shop, field trips, practice exercises etc.

Chapter 3

METHODOLOGY

This chapter is organized into six sections: (a) discussion of the research design (b) characterization of the samples, (c) protocols observed in the development, validation and reliability testing of the research instruments, (d) procedure on how consensus-based instruction was implemented in the classroom as compared to the comparison group, (e) data collection procedure, and (f) data analysis procedure.

Research Design

The non-equivalent pretest-posttest control group quasi-experimental design (Table 4) was employed because the respondents were from two intact classes in a natural school setting where random assignment was not possible, and the distraction of class structure was avoided to the minimum.

Table 4. Research Design

Group	Pretest	Treatment	Posttest
1	O_A, O_B, O_1, O_2, O_3	CBI	O_C, O_4, O_5
2	O_1, O_2, O_3	CIA	O_4, O_5

Where:

1 = Experimental Group

2 = Control Group

O_1 = Pretest - Canfield Learning Styles Inventory (CLSI)

O_2 = Pretest - Attitude Towards Biology Scale (ATBS)

O_3 = Pretest - Bioenergetics Achievement Test (BAT)

O_A = Pretest – Questionnaire on the Importance of Democratic Practices in the Classroom (QIDPC)

O_B = Learning Needs Analysis Protocol (LNAP)

O_4 = Posttest - ATBS

O_5 = Posttest - BAT

O_C = Posttest - QIDPC

Students in group 1 (CBI group) were pretested for O_A and O_B. Then both groups were pretested for O_1, O_2, and O_3. Immediately after the end of the implementation of the intervention, posttests (O_4 and O_5) were administered to both groups. However, only students in group 1 were posttested for O_C. The dependent variables in the study are the students' posttest scores in O_4 and O_5 with their pretest scores as covariates (O_2 and O_3). These posttest data were used in comparing CBI group from CIA group. On the other hand, O_A and O_C were used in determining change in students' perceptions in the experimental group about the importance of practicing democracy in the classroom, after being exposed to CBI.

The Sample

The subjects of the study are 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. Their schedules were arranged such that when bioenergetics would already be the topic to be discussed, the researcher would take over as class instructor. The classes were chosen based on the following criteria: same academic program, same classroom, comparable size to achieve the 30 actual samples needed for comparative analysis, and similar day yet comparable time schedule. Between the two, the class that employed consensus-based instruction 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 males from the CBI group who were all forced to become the representative samples for their group. Data from these actual samples were used for comparative analysis. Table 5 summarizes the sample selection while Table 6 presents the age structure of the actual samples by group and gender.

Table 5. Summary of Sample Selection

Group	Gender	Class Size	Nos. of students with absences and incomplete data	Nos. of Qualified Samples	Nos. of Actual Samples
CBI Group					
	Male	7	0	7	7
	Female	47	5	42	23
	Total	54	5	49	30
CIA Group					
	Male	19	11	8	7
	Female	45	19	26	23
	Total	64	30	34	30

Table 6. Age Structure of Actual Samples by Group and Gender

Group	Gender	Sample size (*n*)	Mean Age (in years as of last birthday)	
CBI Group				17.05
	Male	7	17.57	
	Female	23	16.96	
	Total	30	17.10	
CIA Group				
	Male	7	17.00	
	Female	23	17.00	
	Total	30	17.00	

Instruments

Learning Needs Analysis Protocol (LNAP). This is a self-administered protocol modified from Blinne (2013) which was used in assessing students' learning needs (Refer to Appendix G). 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: an instructor with a PhD in biology education, a campus director with a PhD in educational psychology and a master's in science education, and an associate professor with a PhD in educational management and also with a master's in science education. The instrument was revised as suggested. The non-revised protocol of this instrument was the one that was tried out in July 2015 of the first semester of School Year 2015-2016 in a biological science class at the College of Education in the same state university. Since the revision was mainly about providing options for respondents to choose, it was deemed unnecessary anymore to try-out again the instrument.

Questionnaire on the Importance of Democratic Practices in the Classroom (QIDPC). This is a 10-item researcher-made instrument administered for students in the CBI group which determined their perceptions about the importance of democratic practices in the classroom along a four-point Likert type scale, 1 as not important, 2 as slightly important, 3 as important, and 4 as very important (Refer to Appendix H). This instrument was submitted to the same experts who validated the LNAP. Their suggestions were incorporated in the revised form in consultation with the researcher's adviser. It was pilot-tested in a biological science class of 50 students last November 24, 2015 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, that is to check if all items within the questionnaire are measuring the same thing. The Chronbach'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 domains: (1) conditions for learning, (2) area of interest, (3) mode of learning, and (4) expectation for course grade (Refer to Appendix I). The first three domains are combined to create a learner typology that categorizes individuals into preferred learning styles which are further sub-categorized as either pure types or mixed types. For pure types, the typologies include social, independent, applied and conceptual learners. For the mixed types, the typologies are social/conceptual, independent/applied, independent/conceptual and neutral type. The domain on expectation for course grade is self-contained and scores on these four scales are combined to give an overall expectation score. Details about how the instrument is scored

Table 7. Structure of the Canfield Learning Styles Inventory

Learning Domains	Item Placement	Cronbach alpha (α) (Eide et al., 2001)
Conditions for Learning: Preferred situations or Context of Instruction		
Peer	1a, 6a, 11a, 16a, 21a, 26a	0.38 – 0.65
Organization	1b, 6b, 11b, 16b, 21b, 26b	0.32 – 0.61
Goal Setting	1c, 6c, 11c, 16c, 21c, 26c	0.53 – 0.66
Competition	1d, 6d, 11d, 16d, 21d, 26d	0.44 – 0.63
Instructor	2a, 7a, 12a, 17a, 22a, 27a	0.54 – 0.77
Detail	2b, 7b, 12b, 17b, 22b, 27b	0.70 – 0.77
Independence	2c, 7c, 12c, 17c, 22c, 27c	0.65 – 0.77
Authority	2d, 7d, 12d, 17d, 22d, 27d	0.58 – 0.71
Average		0.54 – 0.69
Area of Interest: Preferred Subject Matter or Objects of Study		
Numeric	3a, 8a, 13a, 18a, 23a, 28a	0.74 – 0.83
Qualitative	3b, 8b, 13b, 18b, 23b, 28b	0.80 – 0.84
Inanimate	3c, 8c, 13c, 18c, 23c, 28c	0.84 – 0.88
People	3d, 8d, 13d, 18d, 23d, 28d	0.77 – 0.81
Average		0.79 – 0.84
Mode of Learning: Preferred Manner of Obtaining New Information		
Listening	4a, 9a, 14a, 19a, 24a, 29a	0.72 – 0.84
Reading	4b, 9b, 14b, 19b, 24b, 29b	0.80 – 0.88
Iconic	4c, 9c, 14c, 19c, 24c, 29c	0.77 – 0-.87
Direct experience	4d, 9d, 14d, 19d, 24d, 29d	0.74 – 0.86
Average		0.78 – 0.86
Average for Instrument		0.67 – 0.77
Expectation for Course Grade: Level of Performance Anticipated		
Outstanding/Superior (A)	5a, 10a, 15a, 20a, 25a, 30a	Unreported
Above Average/Good (B)	5b, 10b, 15b, 20b, 25b, 30b	
Average/Satisfactory (C)	5c, 10c, 15c, 20c, 25c, 30c	
Below Ave./Unsatisfactory (D)	5d, 10d, 15d, 20d, 25d, 30d	
Total Expectation	Weighted sum of A-B-C and D expectations	

and interpreted were appended. Table 7 shows how the instrument is structured as well as the reported reliability coefficients of its subscales as normed from 531 university students in USA.

Attitude Towards Biology Scale (ATBS). This is a 51-item researcher-made instrument containing statements of students' feelings towards biology. Their degree of agreement to each statement was measured along a four-point Likert type scale, 1 as strongly disagree, 2 as disagree, 3 as agree, and 4 as strongly agree (Refer to Appendix J). Items were lifted from research literature which covered components of students' attitude towards science (which the researcher replaced with the word 'biology') such as specific feelings towards biology, motivation to achieve in biology, biology anxiety, attitude towards biology teacher, attitude towards biology curriculum, keennees to learn biology, enjoyment in biology learning, disinterest, teacher interaction, importance of biology, interest in biology lessons and understanding of biology processes. The original draft of the instrument had 66 items but was increased to 67 after it was submitted to the same experts who validated the LNAP and QIDPC instruments. Their suggestions in consultation with the research adviser were incorporated in the preparation of the instrument's second draft.

To extract the components of students' attitude towards biology, the revised scale was pilot-tested from November 24 - 26, 2015 among 365 freshmen students who had just taken biological science course during the preceding semester from the College of Education, and College of Arts and Sciences in the same university. This sample size overly satisfied the desired ratio to run an exploratory factor analysis - that is to have five observations per variable (Hair et al., 2010) which would have been 335 samples only for a scale of 67 items. The instrument was scored in favor of the affirmative, hence, students' ratings in negative statements were scored in reverse. When exploratory factor analysis was performed, preliminary data screening revealed a Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy value of 0.896, which is interpreted as a meritorious distribution of values, adequate to conduct the procedure (George & Mallery, 2010). Based from the computed significance value of the Bartlett's Test of Sphericity which is less than 0.05, the distribution was approximately multivariate normal and did not produce an identity matrix (factor analysis would be meaningless with an identity matrix). Thus, the data were acceptable to run the procedure.

Table 8. Structure and Reliability of the Attitude Towards Biology Scale

Factor	Label	Nos. of items	Item Placement	α
1	Importance of Biology	10	1, 2, 4, 7, 27 31, 39, 45, 46, 48	0.862
2	Interest in Biology Lessons	8	8*, 19*, 22*, 23* 30*, 38*, 42*, 44*	0.830
3	Perceptions of the Biology Teacher	8	21, 25, 35, 40 41, 43, 47, 51	0.846
4	Keenness to Learn Biology	8	10, 17, 18, 20 28, 29, 33, 36	0.817
5	Enjoyment of Biology	8	3, 5*, 6, 15 24, 26, 32, 37	0.820
6	Anxiety Towards Biology	5	9*, 11*, 14* 16*, 50*	0.764
7	Effort in Learning Biology	4	12, 13, 14, 49	0.790
Total		51		
Whole-Scale Reliability				0.922

* negative statement, scoring reversed

Using Principal Component Analysis as the extraction method and Varimax with Kaiser Normalization as the rotation method, 16 factors were extracted. Since the sample size exceeded 350, a factor loading of 0.30 and above was used as basis in selecting the items that clustered on a specific factor (Hair et al., 2010). But further analysis revealed that only nine out of the 16 factors have items that indicated some plausibility and rationale for clustering. Of these nine, only seven passed the second screening which was the reliability test for each factor ($\alpha > 0.7$). This gave rise to the final structure of the 51-item scale (Table 8) which generated a Cronbach's alpha value of 0.922 for the whole test, an excellent scale (George & Mallery, 2010). The factors were labelled as informed by literature and in consultation with the research adviser.

Bioenergetics Achievement Test (BAT). This is a 35-item researcher-made test that assessed students' learning from the topic bioenergetics (Refer to Appendix K). 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 bases of constructing the instrument. The 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 as indicated in Table 9. The first draft was submitted to four biology content experts from reputable universities in the country for content validation: an associate professor with a PhD in biochemistry, a professorial lecturer with a PhD in zoology, a researcher with a PhD in genetics, and an associate professor with a PhD in plant biology. They inspected the questions and encircled 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.

On January 7, 2016, 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 of the same university. From the results of the pilot test, a Chronbach's alpha value of 0.719 was generated establishing the acceptability and reliability of the instrument. Table 8 presents the specification of items for the developed bioenergetics achievement test.

Table 9. Table of Specification for the Bioenergetics Achievement Test

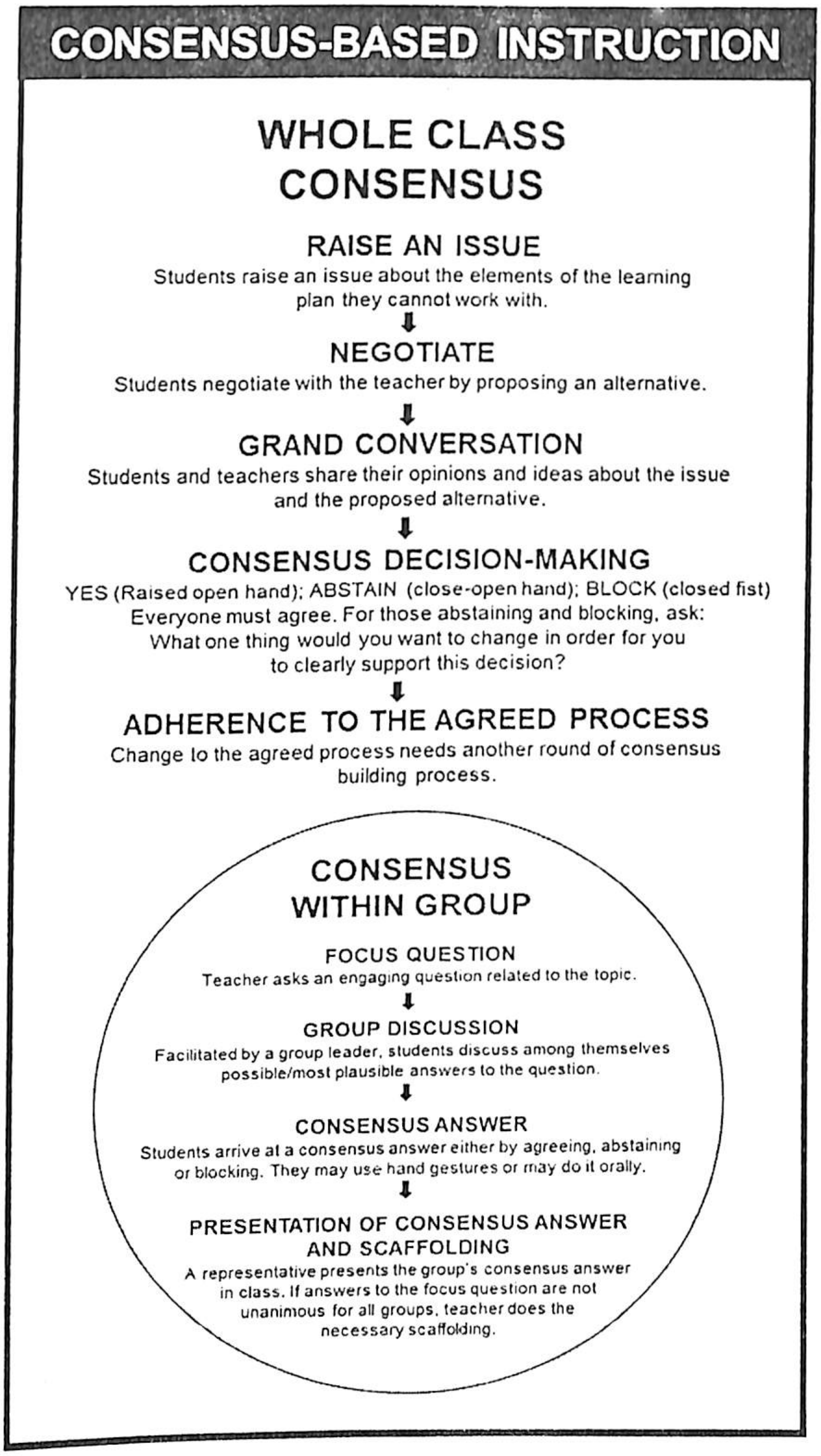
Science Cognitive Domain (TIMSS-based)	Topic/Item Placement			Total/ (%)
	Metabolism	Photosynthesis	Cellular Respiration	
Knowing				11 (31%)
Recall/Recognize		6, 7, 9	12, 13, 14	
Define	1			
Describe		8	19, 29	
Illustrate with examples	2			
Demonstrate knowledge of scientific instruments				
Applying				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	
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 to students.

Consensus-Based Instruction

The intervention is termed Consensus-Based Instruction (CBI). In CBI, authority and responsibility for making decisions about the learning plan (LP) are shared by the teacher with the whole class. In the context of this experiment, the approach began by introducing the CBI 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. Thereafter, the CBI process began working (Fig. 2).

In CBI, consensus was practiced in two levels – whole class consensus and consensus within a group. In 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, 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*; and a closed fist for *block*. 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.



CONSENSUS-BASED INSTRUCTION

WHOLE CLASS CONSENSUS

RAISE AN ISSUE
Students raise an issue about the elements of the learning plan they cannot work with.

NEGOTIATE
Students negotiate with the teacher by proposing an alternative.

GRAND CONVERSATION
Students and teachers share their opinions and ideas about the issue and the proposed alternative.

CONSENSUS DECISION-MAKING
YES (Raised open hand); ABSTAIN (close-open hand); BLOCK (closed fist)
Everyone must agree. For those abstaining and blocking, ask:
What one thing would you want to change in order for you to clearly support this decision?

ADHERENCE TO THE AGREED PROCESS
Change to the agreed process needs another round of consensus building process.

CONSENSUS WITHIN GROUP

FOCUS QUESTION
Teacher asks an engaging question related to the topic.

GROUP DISCUSSION
Facilitated by a group leader, students discuss among themselves possible/most plausible answers to the question.

CONSENSUS ANSWER
Students arrive at a consensus answer either by agreeing, abstaining or blocking. They may use hand gestures or may do it orally.

PRESENTATION OF CONSENSUS ANSWER AND SCAFFOLDING
A representative presents the group's consensus answer in class. If answers to the focus question are not unanimous for all groups, teacher does the necessary scaffolding.

Figure 2. Process Flow of the Consensus-Based Instruction Approach

The second feature of CBI 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 labelled '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.

Employing the CBI process, the following items and issues in the learning plan on bioenergetics were finally negotiated through consensus:

1. The use of *Taglish* rather than pure English as medium of instruction;
2. Students signing in the attendance sheet every meeting instead of the teacher checking it. They also negotiated that the one point deduction policy for every absence will be waived when they have a valid excuse;
3. Non-enforcement of the non-acceptance or a zero-grade for a requirement that is submitted late if there is a valid excuse;
4. Alphabetical seat plan;
5. Use of *stootsies*, a non-dictionary term suggested by a student that refers to scorecards which the teacher can easily dispose in appraising quality of students'

answers during recitation in which teacher would just give the appropriate scorecard that matches the quality of students' answers. The latter will just sign their names on the scorecard;

6. The inclusion of the following strategies in the learning plan: 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.

In the conventional instruction approach (CIA), 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 instructional delivery in the control group, CBI class was one meeting longer than the control. To address ethical issues such as depriving the students in the CIA of the possible advantages of CBI, 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 10 shows the instructional comparison between the two approaches.

Table 10. Comparison of Instructional Activities between CBI and CIA

Instructional Activities	Consensus-Based Instruction Group (CBI)	Conventional Instruction Group (CIA)
Pre-Instructional activities and acclimatization to video-recording device		
Pretest	Canfield Learning Style Inventory (CLSI) Attitude Towards Biology Scale (ATBS)	
	▪ Administration of the Questionnaire on the Importance of Democratic	▪ Getting to know each other/ Self-

Instructional Activities	Consensus-Based Instruction Group (CBI)	Conventional Instruction Group (CIA)
	Practices in Classroom (QIDPC)	introductions
▪ Orientation	▪ Introduction of the use of consensus-based instruction, 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: o Raise an issue o Negotiate o Grand conversation o Call for a consensus o Adhere to the agreed process ▪ Consensus within group o Focus question o Group discussion o Consensus answer o Presentation and scaffolding ▪ Administration of the Learning Needs Analysis Protocol 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 instruction: *Taglish* ▪ Checking of attendance: Students sign at the attendance sheet. ▪ If with valid excuse, student with absence will not be deducted points. ▪ If with valid excuse, students' requirement will still be accepted and not be graded zero. ▪ Alphabetical seat plan. ▪ Use of *stootsies*. ▪ 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 ▪ 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 slide presentation. ▪ Quizzes were also administered with slide presentation.

Instructional Activities	Consensus-Based Instruction Group (CBI)	Conventional Instruction Group (CIA)
▪ Implementation of the Learning Plan (Trial)	▪ Instruction was based on the agreed process with additional group consensus activities within group. ▪ Review of Cell Structures o *Trivia:* What is the largest known cell? o *Video clip with worksheet*: Overview of cell structures o *Consensus group activity (CGA) #1*: Make a consensus group decision about the Top 3 most important structures that are necessary for cell to survive. Support your decision with convincing reasons.	▪ Based on the teacher-prepared learning plan.
▪ Pretest	Bioenergetics Achievement Test (BAT)	
Instructional Activities		
▪ Implementation of the Learning Plan in Bioenergetics	▪ Metabolism o *Video clips:* metabolic pathway; feedback inhibition o *Trivia:* Do you know that spicy foods can boost your metabolic rate? o *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 enzymatic activity. ▪ Photosynthesis o *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? o *Video clips:* Light dependent and light independent reactions. o *Game:* Peel me, I peel you! o *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.)	▪ Based on the teacher-prepared learning plan.

Instructional Activities	Consensus-Based Instruction Group (CBI)	Conventional Instruction Group (CIA)
	▪ 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 cylcle 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?	
▪ Poster making (learning outcome)	▪ Evaluated based on criteria generated through whole class consensus.	▪ Based on criteria set by the teacher.
Post-Instructional Activity		
▪ Post-test	QIDPC, ATBS, BAT	ATBS & BAT only.

Data Collection Procedure

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 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, the following instruments were administered by the subject teacher to the students both in the CBI and CIA groups on December 14-16, 2015: CLSI and ATBS. Unfortunately, typhoon Nona devastated the province the next day. Classes were cancelled and preliminary data collection activities were aborted. On January 6, 2016, data collection resumed when both classes were already turned over by the subject teacher to the researcher for the experimental investigation which covered the topic on bioenergetics. In the CBI 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 recording device, orientation and familiarization were allotted before the respondents were pretested for BAT on January 18, 2016. Thereafter, lessons about metabolism, photosynthesis and cellular respiration were discussed to both groups, following the agreed process with consensus group activities in the CBI group, and the prevailing method in the CIA group. On February 10, 2016, the QIDPC, ATBS, and BAT were administered as posttests to the CBI group while the CIA group only answered the ATBS and BAT.

Data Analysis Procedure

Descriptive statistics such as the mean, standard deviation, minimum and maximum scores were used in the ATBS and BAT scores to present preliminary information.

The One-Way Analysis of Covariance (ANCOVA I) was run to test whether significant differences in students' posttest mean scores in ATB scale and BAT exist between the CBI and CIA groups. Likewise, a Two-Way ANCOVA (ANCOVA II) was employed in investigating the interaction effects between instructional approach and sex, and between instructional approach and learning styles on students' posttest mean scores in ATB scale and BAT. Pretest values for their corresponding posttest mean scores in

ATB scale and 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. Instead of ANCOVA I, *t*-test for independent samples was used in testing the significant difference in posttest scores in BAT between CIA and CBI, because the pretest scores were the same for both groups.

Multiple Linear Regression Analysis was applied to students' posttest mean scores in BAT with their global and subset posttest scores in ATBS as predictors taken singly. This is to determine whether students' attitude towards biology could significantly predict scores in bioenergetics achievement test. Tests of hypotheses were all done at the 0.05 level.

In addition to these quantitative statistical analyses, students' perceptions in the CBI group about the importance of democratic practices in the classroom before and after they were exposed to the intervention were analyzed using *t*-test for paired samples in order to provide support to some findings of the study. Supporting qualitative evidences were then gleaned from observation notes, data sheets, questionnaires, recorded videos and interviews.

Scoring system for instruments. Students' learning styles were assessed using the scoring system suggested by Canfield and Knight (1983). However, to meet the sample size for comparative analysis, students' dominant preference for learning or acquiring new information such as listening, reading, iconic and direct experience, was used as the classificatory variable instead of the learning typologies which yielded several types and were dominated by the neutral learners. In scoring the ATBS, negative statements were scored in reverse. Then, the component and overall mean scores were generated.

Chapter 4

RESULTS AND DISCUSSION

This chapter presents and analyzes the data gathered. This is organized into five sections corresponding to the research problems as follows: (1) comparison of students' attitude towards Biology across instructional approach, (2) comparison of students' achievement in bioenergetics test across instructional approach, (3) moderating effects of sex on students' attitude towards Biology and their achievement in bioenergetics test, (4) moderating effects of learning styles on students' attitude towards Biology and their achievement in bioenergetics test, and (5) relationship between students' attitude towards Biology and their achievement in bioenergetics test.

Comparison of Students' Attitude Towards Biology Across Instructional Approach

Students' pretest and posttest mean scores in the administered ATBS were compared across instructional approaches. It can be seen from Table 11 that students in the CBI group have higher overall pretest mean scores in ATBS (2.91) as well as in the four components of the scale: TEACH1 (3.00), KEEN1 (2.78), ANXIETY1 (2.97) and EFFORT1 (3.31). Whereas, students from the CIA group scored higher than the CBI group in the following components: IMPT1 (3.29), INT1 (3.02), and ENJOY1 (3.06). However, after the intervention, all the components and the overall posttest mean scores of the students from the CBI group were observed to be higher than the conventional group (Table 11).

Table 11. Comparison of Pretest and Posttest Mean Scores in Attitude Towards Biology Across Instructional Approach

Attitude Towards Biology	Pretest Score			
	CBI Group (n=30)		CIA Group (n=30)	
	Mean	SD	Mean	SD
Importance of Biology (IMPT1)	3.17	0.39	3.29	0.20
Interest in Biology Lessons (INT1)	3.01	0.57	3.02	0.43
Perceptions of the Biology Teacher (TEACH1)	3.00	0.27	2.86	0.28
Keenness to Learn Biology (KEEN1)	2.78	0.33	2.71	0.28
Enjoyment of Biology (ENJOY1)	2.94	0.35	3.06	0.39
Anxiety Towards Biology (ANXIETY1)	2.97	0.58	2.86	0.46
Effort in Learning Biology (EFFORT1)	3.31	0.43	3.30	0.39
Overall Pretest Mean Score (PREATB)	2.91	0.27	2.87	0.18
	Posttest Score			
Importance of Biology (IMPT2)	3.35	0.32	3.19	0.42
Interest in Biology Lessons (INT2)	3.21	0.40	3.10	0.54
Perceptions of the Biology Teacher (TEACH2)	3.08	0.31	2.79	0.31
Keenness to Learn Biology (KEEN2)	2.81	0.28	2.64	0.28
Enjoyment of Biology (ENJOY2)	3.07	0.28	2.88	0.41
Anxiety Towards Biology (ANXIETY2)	3.02	0.41	2.88	0.41
Effort in Learning Biology (EFFORT2)	3.23	0.36	3.13	0.57
Overall Posttest Mean Score (POSTATB)	2.98	0.19	2.83	0.29

A one-way between-group analysis of covariance (ANCOVA) was employed to test if the observed differences in the overall and components' posttest mean scores in the ATB scale between the CBI and CIA groups are significant. Pretest values for their corresponding posttest mean scores 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. Presented and discussed in the succeeding paragraphs are the results of ANCOVA organized based on the overall and individual components of students' attitude towards Biology.

Importance of Biology. To test the main effect of the instructional approach (TREATMENT) on students' attitude towards the importance of Biology, ANCOVA table (Table 12) generated an *F* value of 2.821 with a corresponding *p* value of 0.099

leading to the non-rejection of the null hypothesis. Thus, after adjusting for the pretest mean scores, there was no significant difference between the CBI and CIA groups on posttest mean scores as regard to students' attitude towards the importance of Biology.

Table 12. Tests of Between-Subjects Effects for Students' Attitude on Importance of Biology

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
IMPT2	Corrected Model	.416[a]	2	.208	1.483	.235
	Intercept	4.509	1	4.509	32.175	.000
	CV: IMPT1	.066	1	.066	.472	.495
	TREATMENT	.395	1	.395	2.821	.099
	Error	7.988	57	.140		
	Total	650.108	60			
	Corrected Total	8.404	59			

a. R Squared = .049 (Adjusted R Squared = .016)

The non-significance of the mean difference in this component of attitude towards Biology is probably brought about by a 0.10 point decline in posttest mean in the CIA group (from 3.29 to 3.19) and a 0.18 point increase in posttest mean in the CBI group (from 3.17 to 3.35). This opposing trend could have counterbalanced the mean difference between the two groups but was not sufficient enough at attributing such variation to the instructional approach used in Biology. The teacher also made it a point to integrate the relevance and usefulness of learning the topics in their daily lives in both groups whenever applicable. Likewise, both groups could have an inherent appreciation of the importance of Biology, regardless of the instructional approaches used because many problems and challenges the world faces today are biology-related such as medical advancements, environmental degradation, climate change, GMOs and the like. These are usually featured in mass media to which both groups could have been exposed. Moreover, today's age is also named by scientists as the century of Biology. This supports the argument that generally students tend to develop positive attitude towards science in the context of the society (Ebenezer & Zoller, 1993; Sundberg, Dini & Li, 1994; Breakwell & Beardsell, 1992).

Interest in biology lessons. It has been hypothesized that CBI can improve students' interest in biology lessons. Descriptive data show that there is an increasing trend in interest in biology lessons for both groups (CBI = from 3.01 to 3.21; CIA = from 3.02 to 3.10), with those in the CBI demonstrating higher increase (0.20). However, ANCOVA (Table 13) reveals that the generated *F* value of 1.101 has a corresponding *p* value that is above 0.05. Thus, the null hypothesis was not rejected. Therefore, after adjusting for the pretest mean scores, there was no significant difference between the CBI and CIA groups on posttest mean scores.

Table 13. Tests of Between-Subjects Effects for Students' Interest in Biology Lessons

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
INT2	Corrected Model	2.516[a]	2	1.258	6.741	.002
	Intercept	6.202	1	6.202	33.226	.000
	CV:INT1	2.327	1	2.327	12.467	.001
	TREATMENT	.206	1	.206	1.101	.298
	Error	10.640	57	.187		
	Total	610.082	60			
	Corrected Total	13.156	59			

a. R Squared = .191 (Adjusted R Squared = .163)

While the use of consensus process has been reported in literature to create engaged students (Moreno-Lopez, 2005) to a higher level (Sartor & Young Brown, 2004), this engagement was not translated in this investigation into a higher interest in biology lessons than those taught in the conventional way. Probably, interest in biology lessons are triggered by other factors other than CBI. For example, one of the students in the CBI group reflected upon the important role of the teacher in making the topic less boring (emphasis supplied):

> Bioenergetics is not a boring topic because our teacher makes some activities that make us happy. Example of this is the experiment time, trivia, games and participation/ recitation with corresponding points. In that way I consider that bioenergetics is a very interesting lesson.

In the above student's reflection, it can be deduced that what makes bioenergetics an interesting lesson is because of the activities done by the teacher. These activities however were the results of the whole-class consensus decision about the negotiated learning plan. But from the perspective of this student, interest in biology lesson was mediated by the teacher. Moreover, both groups were exposed to slide presentation using a LED TV and used similar module on bioenergetics, thus arousing students' interest and probably evening out the effect of instructional approach.

Perception of the biology teacher. Descriptive data (Table 11) show that there is a decline in the students' perception of their biology teacher in the CIA group (from 2.86 to 2.79) and an increase in perception in the CBI group (from 3.00 to 3.08). Results of ANCOVA (Table 14) uncovered significant difference between the two groups on posttest mean scores in terms of students' perceptions of their biology teacher ($F = 9.164$, $p=0.004$). This leads to the rejection of the null hypothesis. Students in the CBI group hold more positive perception of their biology teacher than those in the CIA group.

Table 14. Tests of Between-Subjects Effects for Students' Perceptions of their Biology Teacher

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
TEACH2	Corrected Model	1.637[a]	2	.819	8.821	.000
	Intercept	2.079	1	2.079	22.404	.000
	CV: TEACH1	.402	1	.402	4.328	.042
	TREATMENT	.850	1	.850	9.164	.004
	Error	5.290	57	.093		
	Total	522.548	60			
	Corrected Total	6.927	59			

a. R Squared = .236 (Adjusted R Squared = .210)

This finding is consistent with the claims of Sartor and Young Brown (2004), the pioneering proponents of using consensus in the classroom, that consensus requires and creates a paradigm shift in a teacher's relationship with his or her students and in students' relationship with each other. They believe that through consensus, teachers can gain a broader understanding of their students' needs. abilities and concerns which they can consider in teaching. The result also strengthens the position of Hendley et al. (1995) that one of the most common reasons given by students for liking or disliking the subject were teacher-related comments. Perhaps, the democratic and consensual manner of identifying learning needs and difficulties and addressing them based on the agreed process in the CBI group created a feeling of trust, thereby developing a better perception of the teacher. The issue on student's trust on the teacher was emphasized by Sartor and Young Brown (2004) as an essential requisite for consensus in the classroom to work. The following accounts from students who experienced the CBI approach point to the positive perception of their teacher's competence, pedagogical skills and motivating skills.

> *Magaling magturo ang aming* teacher *talagang malinaw para maunawaan.* (Our teacher is good in teaching, truly clear so that it will be understood.)
>
> Bioenergetics lesson is very enjoyable, fun, challenging, and interesting not only of its different topics but also the way our teacher teaches us.
>
> Enjoy *dahil magaling at masaya ang aming guro. Hindi sya* boring *magturo.* (Enjoy because our teacher is good and lively. He is not boring.)
>
> I'm really amazed at the way our teacher teaches and how he makes our bioenergetics class so much enjoying.
>
> Our teacher encourages me to learn more about biology for more understanding and it was amazing and interesting… By using consensus, our teacher gives us chance to express our ideas, thoughts and feelings.

> Using consensus, our teacher gives us a chance to express the ideas we want to share with others and he encourages us to speak and show our talent in facing many people *nang walang pag-aalinlangan* (without reservation).

Keenness to learn Biology. The descriptive data in Table 11 shows a decline in posttest mean score to those in the CIA group (from 2.71 to 2.64) and an increase to those in the CBI group (from 2.78 to 2.81) in their keenness to learn Biology. Results of ANCOVA as shown in Table 15 shows that the *p* (0.039) associated with the generated *F* (4.455) is less than 0.05. Thus, the null hypothesis was rejected. After adjusting for the pretest scores, there was a significant difference between the CBI and CIA groups on posttest mean scores as regards students' keenness to learn Biology.

Table 15. Tests of Between-Subjects Effects for Students' Keenness to Learn Biology

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
KEEN2	Corrected Model	.782[a]	2	.391	5.415	.007
	Intercept	2.924	1	2.924	40.488	.000
	CV: KEEN1	.371	1	.371	5.130	.027
	TREATMENT	.322	1	.322	4.455	.039
	Error	4.117	57	.072		
	Total	449.837	60			
	Corrected Total	4.899	59			

a. R Squared = .160 (Adjusted R Squared = .130)

Students' keenness or eagerness to learn Biology is significantly higher in the CBI group than in the CIA group. When students know that what has been agreed is implemented and when they feel comfortable at speaking up on different issues that may affect their learning, it was observed that they show eagerness in learning more about the topic by having regular study schedule, doing home works and reviewing lessons. Consistent with this finding were the observations of Mitchell et al. (2009) and Blinne (2013) who reported that involving students in the consensus process allows them the creativity to work together to fulfill their own learning goals within a group dynamic.

This effect was also corroborated by the accounts of Sartor and Young Brown (2004) who observed that students in the consensus classroom were developing personal authority and responsibility of their own learning. Mitchell et al. (2009) further reported that the consensus process improves students' ability to apply learning to new contexts. Some of the students' reflections expressing their keenness to learn more about Biology are presented as follows:

> Attending biology class is fun and interesting. I have learned a lot from it, even though it's hard for me to understand it at first. I have tried my best to answer all questions that were given in exams. I'm looking forward for my next topic and hoping to learn more and more.
>
> *...nadagdagan pa yung dating mga kaalaman ko.* And I really enjoy the topics *na tinuro sa amin... Yung* feeling *na gusto mo laging mag-*experiment *ng iba't-ibang bagay.* (...my previous knowledge was enhanced. And I really enjoy the topics taught to us... That feeling when you always want to experiment with a lot of things.)

Enjoyment of Biology. Based from the reports made in literature, the use of consensus is expected to heighten students' engagement and full-participation thus fostering a lively learning community (Sartor & Young Brown, 2004). Descriptive data from Table 11 show a decline in enjoyment of Biology (from 3.06 to 2.88) in the CIA group against an increase in enjoyment in the CBI group (from 2.94 to 3.07). ANCOVA results (Table 16) yielded an F value of 5.538 with the corresponding p value (0.022) that is less than 0.05, thus, rejecting the null hypothesis. After adjusting for the pretest scores, this result significantly differentiated the CBI group from the CIA group on the posttest mean scores concerning students' enjoyment of Biology.

Table 16. Tests of Between-Subjects Effects for Students' Enjoyment of Biology

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
ENJOY2	Corrected Model	.831[a]	2	.415	3.541	.036
	Intercept	4.910	1	4.910	41.858	.000
	CV: ENJOY1	.304	1	.304	2.595	.113
	TREATMENT	.650	1	.650	5.538	.022
	Error	6.686	57	.117		
	Total	537.365	60			
	Corrected Total	7.517	59			

a. R Squared = .111 (Adjusted R Squared = .079)

This finding supports the claim of Sartor and Young Brown (2004) cited earlier about the benefit of using consensus in the classroom adding that the open and inclusive discussion of consensus can enhance everyone's awareness of the variety of issues and concerns in the classroom. This also confirms Blinne's (2013) observations in her attempt at democratizing learning whence students get excited if course content is reflective of their interests and is connected to their daily lives. Likewise, the result is a proof that achieving optimal engagement is not difficult when learners have something to say in the most basic structure of a course. This also supports the observation of Mitchell et al. (2009) about the apparent satisfaction of students when their individual needs and interests are incorporated in their learning. It also confirms the proposition that the learning environment provided by CBI as one that gives students opportunities to take control of their learning and enhance their role for personal autonomy contributes to the improvement of students' engagement (Wallace, 1996; Osborne & Collins, 2000).

From the reflective comments of the students in the CBI group, they mainly point out that the consensus group activities, decision-making activities that everyone can support, teacher's adherence to the negotiated elements of the learning plan, the democratizing process of consensus, the opportunity for self-expression, student-teacher interactions, as among those that gave them sense of enjoyment. All these are embedded in the following students' utterances:

> Using consensus in class is good because everyone understands each other and we're free to decide about anything. It's fun and great because everyone can show their feeling about the decisions. I prefer it than others like making decision with everyone and also with our teacher. We're comfortable in making decision. I also learned everything using consensus.
>
> It is a very good idea because we can share our ideas to our group even if we are not sharing it 100% to the class.
>
> *Lahat kami na nandito ay nagkakaintindihan,* sometimes *yung iba* disagree *at yung iba* agree *pero sa huli nagkakaayusan naman.* I'm happy when we have an activity and experiment. I enjoy. (All of us here are in agreement, sometimes others disagree and some others agree but in the end we were able to settle our differences.)
>
> Using consensus in making decision is a good idea. *Yun bang nagkakasundo lahat at nagco*cooperate. I'm so happy for that. (That when all agreed and cooperated.)
>
> *Lahat kami ay nagkakaisa para sa isang desisyon. Masaya kami dahil naipapahayag namin ang aming nais sabihin sa ibang desisyon.* (All of us unite for a single decision. We are happy because we can express what we want to say in other decision.)
>
> *Nakaka-*enjoy *po talaga at marami kaming natutunan. Para kasing mas madali kapag ganun yung* set-up *ng isang klase. Hindi boring at the same time natututo pa.* (It was really enjoyable and we learned a lot. It seems easier if the class is set-up that way. It is not boring at the same time, we are learning.)
>
> *Masaya dahil lahat ng* students *ay nagkakaisa sa mga aktibidad.* (Happy, because all students are united in doing the activities.)
>
> My experience in consensus is happy and fun *dahil binibigyan ng pagkakataon ang bawat isa kung ano ang kanilang desisyon.* (My experience in consensus is happy and fun because everyone is given an opportunity to speak if what is their decision.)
>
> Enjoy when we have our group activity *kasi dito kami nagkakasundo at nagsha-*share *ng* thoughts. (Enjoy when we have our group activity because it is here where we agreed with one another and share our thoughts.)
>
> I enjoy learning bioenergetics together with our teacher and classmates especially if it involves activities like games and trivia.

Anxiety towards Biology. Descriptive data in Table 11 show an increase in posttest mean score both in the CBI group (from 2.97 to 3.02) and the CIA group (from 2.86 to 2.88) in students' anxiety towards Biology. In the instrument, all the statement indicators of anxiety are expressed in the negative, thus an increase in score is interpreted as having less anxious feelings about Biology. Reflected in Table 17 is the result of ANCOVA showing that the *p* value (0.247) associated with the *F* value (1.370) is above 0.05. Thus, the null hypothesis was not rejected. After adjusting for the pretest scores, this result indicates non-significant difference between the two groups on posttest mean scores regarding students' anxiety towards Biology.

It has been reported in literature that the consensus process can mitigate the effect of threats and stress among learners (Sartor & Young Brown, 2004). In this investigation, this suggested effect, however, did not distinguish CBI from CIA. Nevertheless, the researcher observed that in the CIA group, there were occasional blank stares and yawns probably brought about by the strict use of English as a medium of instruction. A loss of interest in attending classes was also observed evidenced by several unexcused absences incurred by students in the CIA group (47 times) than in the CBI group (7 times). In CIA, the frequency of absences ranged from one to four times. These were committed by 21 students, 8 males and 13 females. In CBI, on the other hand, frequency of absences

Table 17. Tests of Between-Subjects Effects for Students' Anxiety Towards Biology

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
ANXIETY2	Corrected Model	2.377[a]	2	1.188	6.474	.003
	Intercept	6.573	1	6.573	35.811	.000
	CV: ANXIETY1	1.960	1	1.960	10.679	.002
	TREATMENT	.252	1	.252	1.370	.247
	Error	10.463	57	.184		
	Total	530.280	60			
	Corrected Total	12.839	59			

a. R Squared = .185 (Adjusted R Squared = .157)

ranged from one to three times which was recorded only to be incurred by five female students. One of the probable reasons why the two groups did not differ in this aspect of comparison is that those students who were frequently absent in the class taught the conventional way were removed from the qualified sampling frame and thus their data were excluded in the analysis, and thus were not reflected in the findings. When this concern was validated with the subject teacher, she mentioned that such degree of truancy was not apparent in the class taught using CIA prior to the experiment. While attributing truancy to instructional approach is less conclusive, the researcher suspects that it was probably brought about by the teacher-centered policies and many autocratic decisions implemented in the CIA class. Interestingly, MacDougall (2013) mentioned that behavior problems like the one presented erstwhile are minimized when students engage in productive dialogue with guidance and structure provided by the teacher.

Effort in learning Biology. Noticeably, the descriptive data presented in Table 11 show the decline in effort in learning Biology from pretest to posttest both in the CBI (from 3.31 to 3.23) and CIA groups (from 3.30 to 3.13), with the latter decreasing more (0.17). When ANCOVA was run, the associated *p* value (0.428) to the generated *F* (0.637) is above 0.05 (Table 18). The null hypothesis was not rejected. After adjusting for pretest scores, there was no significant difference between the CBI and CIA groups on posttest mean scores in terms of students' effort in learning Biology.

This finding only shows that improving students' efforts in learning Biology is not a function of instructional approach but possibly of other factors such as motivation, self-drive, and the like. Bioenergetics is a challenging topic and given the same set of modules, assignments and slide presentation materials, students from both groups might have exerted comparable efforts in doing their best in learning Biology.

Table 18. Tests of Between-Subjects Effects for Students' Effort in Learning Biology

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
EFFORT2	Corrected Model	.278^a	2	.139	.609	.548
	Intercept	7.010	1	7.010	30.715	.000
	CV: EFFORT1	.128	1	.128	.560	.457
	TREATMENT	.145	1	.145	.637	.428
	Error	13.010	57	.228		
	Total	618.125	60			
	Corrected Total	13.288	59			

a. R Squared = .021 (Adjusted R Squared = -.013)

Overall attitude towards Biology. For the overall score of students in ATBS, the descriptive data in Table 11 indicate an increase in posttest score in the CBI group (from 2.91 to 2.98) and a decrease in the CIA group (from 2.87 to 2.83). After adjusting for the pretest scores, ANCOVA showed a significant difference between the two groups in terms of their overall posttest mean scores on attitude towards Biology ($F = 5.187, p =$ 0.027) as depicted in Table 19. The null hypothesis was rejected.

Table 19. Tests of Between-Subjects Effects for Students' Overall Attitude Towards Biology

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
POSTATB	Corrected Model	.529^a	2	.264	4.613	.014
	Intercept	1.762	1	1.762	30.749	.000
	CV: PREATB	.185	1	.185	3.233	.077
	TREATMENT	.297	1	.297	5.187	.027
	Error	3.267	57	.057		
	Total	510.370	60			
	Corrected Total	3.796	59			

a. R Squared = .139 (Adjusted R Squared = .109)

This finding is very significant because to the researcher's best knowledge, this is the first time in literature that the consensus process has been empirically tested, since most reports about its benefits originated only from the investigators' self-contained classrooms. Too, this is the first time that students' attitude in Biology have become the point of comparison in testing the effects of consensus against the conventional approach.

In the literature, the importance of developing positive attitude towards science is an uncontested goal of science education. Osborne, Simon and Collins (2003) believe that these positive attitude could result in the public engagement with science which they argue is the *sine qua non* of the public appreciation of science. In the context of this investigation, the use of CBI is a strategic response to reports in literature (Brown, 1976; Myers & Fouts, 1992; Wallace, 1996; Osborne & Collins, 2000) about the kind of classroom environment that can develop positive attitude in science in general, and in Biology in particular such as high level of involvement, very high level of personal support, strong positive relationship with classmates, the use of variety of teaching strategies, and unusual learning activities. These ideals of a learning environment are actually the major features of the CBI approach. In addition, the variety of teaching strategies and learning activities in CBI are products of the consensual decisions of the students and teachers – decisions that everyone in the class can support and work with. On top of the cognitive demands required to learn science content, the use of CBI provides students an opportunity for a productive student-to-student dialogue. With the findings of this experiment, CBI can be proposed as a workable and sustainable solution to remediate the international trend on students' declining attitude towards science. The reflection of a student below is a compelling proof on the adoption of CBI.

> Based on what we experienced in our bioenergetics class using consensus, I can easily say that this is very effective. It tightened our relationship as classmates and it strengthened our unity. Using consensus can improve and help everyone express their thoughts and ideas freely and learn how to negotiate and interact with others.

The above accounts is a reflection of what Harnett (2012) claimed about the value of consensus, that it embodies inclusiveness, cooperation, collaboration, maximizing agreement, relationship building and respect for all viewpoints.

Comparison of Students' Achievement in Bioenergetics Test Across Instructional Approach

Both the CBI and CIA groups incidentally had equal pretest mean score in BAT (10.40). But after the intervention, those in the CBI group obtained higher posttest mean score (15.40) than those in the CIA group (15.27).

Table 20. Comparison of Posttest Mean Scores in Bioenergetics Achievement Across Instructional Approach

Instructional Approach in Biology	Posttest BAT Score (POSTBAT)	
	Mean	SD
CBI (n = 30)	15.40	4.37
CIA (n=30)	15.27	4.69

A *t-test* for independent samples was conducted to compare the effectiveness of the two instructional approaches in improving students' achievement in bioenergetics test. Levene's test revealed that the two groups have equal variances ($F = 0.275$, $p = 0.602$). It was found out that there was no significant difference between the two instructional approaches on posttest mean scores in bioenergetics achievement test ($t = 0.114$, df = 58, $p = 0.910$) as shown in Table 21. Thus, the null hypothesis was not rejected.

Table 21. *t*-test Analysis for Independent Samples on Students' Achievement in Bioenergetics Test across Instructional Approaches

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

The effect of using consensus on academic performance or scores in standardized tests is one of the major challenges against consensus. As of yet, there was no empirical investigation from which results of the current study can be compared. Although the posttest BAT mean scores of students in the CBI group was 0.13 higher than the CIA group, it was not enough to establish that the difference was significant.

The use of gained scores for analysis neither established the difference (CBI = 4.87, CIA = 4.97) but when the gained scores were categorized in a five-point interval, interesting results were gleaned as shown in Table 22.

Table 22. Gained Scores in BAT across Instructional Groups

BAT Gained Score	Instructional Approach		Total
	CBI	CIA	
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	

The range of scores gained by the students exposed to CBI was 18 (from -2 to 15), while those in the CIA was 16 (from -4 to 11). It is also noticeable that the CBI group has two students whose scores did not increase or possibly decreased in the posttest as compared to CIA which has 6. Interestingly, there were five students from the CBI group whose gained scores were above 10 points as compared to one in the CIA. These descriptive data are indicative of the positive effects of CBI on students' achievement, despite revelations of non-significance from statistical test.

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 in the data as reflected in Table 23.

Table 23. Comparison Between CBI and CIA on Frequency of Items with Gained Scores across BAT Components

BAT Components	Frequency of BAT Items with Gained Score			Total
	Favoring CBI	Favoring CIA	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

In terms of the topics covered, CBI group obtained higher gained score in 10 out of 16 items (62.5%) 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 CIA group.

As to the cognitive domains measured by the test items, CBI group outperformed the CIA group in 7 out of 10 items (70%) at the domain of reasoning. The finding 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 intelligences 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 CBI 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 CIA group because the current investigation did not impose such negative environment and experience to that group.

Most likely, the absence of statistical significance could be possibly explained by the insufficient dosage of intervention due to the short duration of the experiment. Also, despite keeping high degree of control in the implementation of the experiment to keep the two groups equally matched, there was an instance, however, when the pacing of lesson was ahead by two days in the conventional group. This was due to the time-consuming administration of learning needs protocol and generation of whole class consensus on the negotiated elements of the learning plan in the CBI group. Nevertheless, the administration of pretest and posttest was conducted on the same date for both groups.

Despite this result, students showed preference in favor of CBI than CIA as indicated by the following informal spot interviews with students:

> *Kapag ginamitan ng consensus, nagkakasundo at nagkakaayos kung ano man yung dapat na gawin namin sa aming grupo.* (If consensus has been used, we agreed and resolved our differences in whatever it is that our group wants to do.)
>
> *Yung estudyante minsan, natatakot sya dun sa* teacher. *Dapat magkasundo yung estudyante at* teacher, *para matuto yung estudyante.* (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.)
>
> *Nung una talaga,* hate *ko yung* biology *kasi sabi ko ano ang makukuha ko rito, parang nakakatamad, nakaka*boring, *nakakaantook. Pero yung nag*consensus *na parang* enjoy *s'ya na ang dami mong natututunan.* (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.)
>
> *Noong una ay natakot kami, pero yung nagco*consensus *na ay doon lang namin nalaman na malupit pala. Masaya.* (At first, we were scared, but when we started doing consensus, it was only then when we realized that it was great. Happy.)
>
> *Pinakagusto ko yung naggo*group *tapos ganito yung gusto ko, ganito yung gusto nya, hanggang magkasundo sa sagot.* (What I liked most was when we were grouped, this is what I want, this is what s/he wants, until we agreed on an answer.)

Moreover, in the CBI 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 24) show that there is a significant difference between their pretest (3.23) and posttest mean scores (3.40) on the QIDPC, $t = -3.009, p=0.005$.

Table 24. Paired Samples Statistics for Students' Perceptions on the Importance of Democratic Practices in Classroom

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

This 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, in developing criteria of how their work will be evaluated, etc.

CBI 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 in 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 in 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 investigation, to be successful at implementing CBI, 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 CBI. 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 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 literature.

In the context of consensus within groups, teachers can be successful in this aspect of CBI 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 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 CBI a feasible instructional approach.

Moderating Effects of Sex on Students' Attitude Towards Biology and Achievement in Bioenergetics Test

Moderating effects of sex on students' attitude towards Biology. The possibility that sex or interaction between sex and instructional approach may affect students' attitude towards Biology was investigated. Report in literature that males have more positive attitude towards school science than those of the females was explored.

Table 25 presents some information on the gender distribution and students' pretest and posttest mean scores in ATB scale between the CBI and CIA groups.

Table 25. Descriptive Statistics for Students' Attitude Towards Biology (Instructional Approach by Sex)

Dependent Variable	Treatment	Sex	*n*	Pretest		Posttest	
				Mean	SD	Mean	SD
IMPT	CBI	Male	7	3.30	0.34	3.46	0.35
		Female	23	3.14	0.40	3.31	0.31
		Total	30	3.17	0.39	3.35	0.32
	CIA	Male	7	3.23	0.24	3.20	0.42
		Female	23	3.31	0.20	3.19	0.43
		Total	30	3.29	0.20	3.19	0.42
	Total	Male	14	3.26	0.28	3.33	0.39
		Female	46	3.22	0.32	3.25	0.38
		Total	60	3.23	0.31	3.27	0.38
INT	CBI	Male	7	3.06	0.73	3.43	0.41
		Female	23	2.99	0.54	3.14	0.38
		Total	30	3.01	0.57	3.21	0.40
	CIA	Male	7	3.04	0.36	3.32	0.52
		Female	23	3.01	0.46	3.03	0.53
		Total	30	3.02	0.43	3.10	0.54
	Total	Male	14	3.05	0.55	3.38	0.45
		Female	46	3.00	0.49	3.09	0.46
		Total	60	3.01	0.50	3.15	0.47
TEACH	CBI	Male	7	3.11	0.24	3.22	0.25
		Female	23	2.97	0.27	3.03	0.32
		Total	30	3.00	0.27	3.08	0.31
	CIA	Male	7	2.81	0.39	2.89	0.37
		Female	23	2.88	0.24	2.76	0.29
		Total	30	2.86	0.28	2.79	0.31
	Total	Male	14	2.96	0.35	3.06	0.35
		Female	46	2.92	0.26	2.89	0.34
		Total	60	2.93	0.28	2.93	0.34
KEEN	CBI	Male	7	2.93	0.32	2.88	0.25
		Female	23	2.74	0.33	2.78	0.29
		Total	30	2.78	0.33	2.81	0.28
	CIA	Male	7	2.67	0.24	2.74	0.34

Dependent Variable	Treatment	Sex	*n*	Pretest		Posttest	
				Mean	SD	Mean	SD
		Female	23	2.72	0.30	2.61	0.25
		Total	30	2.71	0.28	2.64	0.28
	Total	Male	14	2.80	0.31	2.81	0.30
		Female	46	2.73	0.31	2.70	0.28
		Total	60	2.75	0.31	2.72	0.29
ENJOY	CBI	Male	7	3.07	0.12	3.09	0.32
		Female	23	2.90	0.39	3.06	0.27
		Total	30	2.94	0.35	3.07	0.28
	CIA	Male	7	3.18	0.44	2.88	0.42
		Female	23	3.02	0.37	2.88	0.41
		Total	30	3.06	0.39	2.88	0.41
	Total	Male	14	3.13	0.31	2.98	0.38
		Female	46	2.96	0.38	2.98	0.36
		Total	60	3.00	0.37	2.97	0.36
ANXIETY	CBI	Male	7	3.00	0.59	3.20	0.40
		Female	23	2.96	0.59	2.97	0.41
		Total	30	2.97	0.58	3.02	0.41
	CIA	Male	7	3.09	0.20	2.86	0.60
		Female	23	2.80	0.50	2.85	0.49
		Total	30	2.86	0.46	2.85	0.51
	Total	Male	14	3.04	0.42	3.03	0.52
		Female	46	2.88	0.54	2.91	0.45
		Total	60	2.92	0.52	2.94	0.47
EFFORT	CBI	Male	7	3.43	0.40	3.46	0.44
		Female	23	3.27	0.45	3.15	0.31
		Total	30	3.31	0.43	3.23	0.36
	CIA	Male	7	2.96	0.27	3.00	0.29
		Female	23	3.40	0.37	3.16	0.63
		Total	30	3.30	0.39	3.13	0.57
	Total	Male	14	3.20	0.41	3.23	0.43
		Female	46	3.33	0.41	3.16	0.49
		Total	60	3.30	0.41	3.18	0.47
ATB	CBI	Male	7	2.97	0.13	3.11	0.19
		Female	23	2.90	0.30	2.94	0.18
		Total	30	2.91	0.27	2.98	0.19
	CIA	Male	7	2.89	0.15	2.92	0.25
		Female	23	2.87	0.20	2.80	0.30
		Total	30	2.87	0.18	2.83	0.29
	Total	Male	14	2.93	0.14	3.01	0.24
		Female	46	2.88	0.25	2.87	0.25
		Total	60	2.89	0.23	2.91	0.25

It is noticeable that after the intervention, except on the subscale enjoyment of Biology where posttest mean score was equal for both gender (2.98), males scored higher than females in the following measures of attitude towards Biology: importance of Biology (3.33>3.25), interest in biology lessons (3.38>3.09), perception of biology teacher (3.06>2.89), keenness to learn Biology (2.81>2.70), anxiety towards Biology (3.03>2.91), effort in learning Biology (2.23>3.16), and the overall score for attitude towards Biology (3.01>2.87).

Within the instructional groups, the above trend was also observable. In the CBI class, males scored higher than females in all posttest measures of attitude towards Biology. However, in the CIA group, except for students' enjoyment in Biology where males and females obtained equal score (2.88) and effort in learning Biology where females scored higher than males (3.16>3.00), similar trend was evident.

A between-groups ANCOVA was conducted to assess the effectiveness of the two instructional approaches in Biology in improving attitude towards Biology of male and female students (Table 26). Pretest values for their corresponding posttest mean scores in ATBS 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.

Table 26. Tests of Between-Subjects Effects for Components and Overall Students' Attitude Towards Biology (Instructional Approach by Sex)

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
IMPT2	Corrected Model	.506[a]	4	.126	.880	.482
	Intercept	4.565	1	4.565	31.789	.000
	CV: IMPT1	.044	1	.044	.305	.583
	TREATMENT	.396	1	.396	2.757	.103
	SEX	.059	1	.059	.409	.525
	TREATMENT* SEX	.032	1	.032	.222	.639
	Error	7.898	55	.144		
	Total	650.108	60			
	Corrected Total	8.404	59			
INT2	Corrected Model	3.314[b]	4	.828	4.630	.003
	Intercept	6.711	1	6.711	37.501	.000
	CV: INT1	2.217	1	2.217	12.387	.001
	TREATMENT	.133	1	.133	.744	.392
	SEX	.796	1	.796	4.449	.039
	TREATMENT* SEX	.001	1	.001	.007	.936

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
	Error	9.843	55	.179		
	Total	610.082	60			
	Corrected Total	13.156	59			
TEACH2	Corrected Model	1.882[c]	4	.471	5.131	.001
	Intercept	2.146	1	2.146	23.402	.000
	CV: TEACH1	.358	1	.358	3.898	.053
	TREATMENT	.598	1	.598	6.517	.013
	SEX	.245	1	.245	2.674	.108
	TREATMENT SEX	7.684E-7	1	7.684E-7	.000	.998
	Error	5.044	55	.092		
	Total	522.548	60			
	Corrected Total	6.927	59			
KEEN2	Corrected Model	.895[d]	4	.224	3.075	.023
	Intercept	2.826	1	2.826	38.824	.000
	CV: KEEN1	.356	1	.356	4.894	.031
	TREATMENT	.152	1	.152	2.084	.154
	SEX	.086	1	.086	1.185	.281
	TREATMENT* SEX	.025	1	.025	.347	.558
	Error	4.004	55	.073		
	Total	449.837	60			
	Corrected Total	4.899	59			
ENJOY2	Corrected Model	.836[e]	4	.209	1.721	.158
	Intercept	4.511	1	4.511	37.134	.000
	CV: ENJOY1	.304	1	.304	2.501	.120
	TREATMENT	.509	1	.509	4.191	.045
	SEX	.003	1	.003	.024	.878
	TREATMENT* SEX	.003	1	.003	.022	.882
	Error	6.681	55	.121		
	Total	537.365	60			
	Corrected Total	7.517	59			
ANXIETY2	Corrected Model	2.687[f]	4	.672	3.640	.011
	Intercept	6.116	1	6.116	33.133	.000
	CV: ANXIETY1	1.975	1	1.975	10.699	.002
	TREATMENT	.493	1	.493	2.670	.108
	SEX	.038	1	.038	.208	.650
	TREATMENT* SEX	.269	1	.269	1.459	.232
	Error	10.152	55	.185		
	Total	530.280	60			
	Corrected Total	12.839	59			
EFFORT2	Corrected Model	.842[g]	4	.211	.931	.453
	Intercept	7.331	1	7.331	32.399	.000
	CV: EFFORT1	.027	1	.027	.119	.732
	TREATMENT	.489	1	.489	2.163	.147
	SEX	.071	1	.071	.313	.578
	TREATMENT* SEX	.475	1	.475	2.101	.153
	Error	12.445	55	.226		
	Total	618.125	60			
	Corrected Total	13.288	59			
POSTATB	Corrected Model	.713[h]	4	.178	3.178	.020
	Intercept	1.884	1	1.884	33.612	.000
	CV: PREATB	.153	1	.153	2.727	.104
	TREATMENT	.245	1	.245	4.378	.041

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
	SEX	.180	1	.180	3.217	.078
	TREATMENT* SEX	.004	1	.004	.064	.801
	Error	3.083	55	.056		
	Total	510.370	60			
	Corrected Total	3.796	59			

a. R Squared = .060 (Adjusted R Squared = -.008)
b. R Squared = .252 (Adjusted R Squared = .197)
c. R Squared = .272 (Adjusted R Squared = .219)
d. R Squared = .183 (Adjusted R Squared = .123)
e. R Squared = .111 (Adjusted R Squared = .047)
f. R Squared = .209 (Adjusted R Squared = .152)
g. R Squared = .063 (Adjusted R Squared = -.005)
h. R Squared = .188 (Adjusted R Squared = .129)

After adjusting for the pretest mean scores in each of the posttest attitudinal scores, no significant interaction effects were found between instructional approach and sex in terms of the following dependent variables: importance of Biology ($F = 0.222, p = 0.639$); interest in Biology ($F = 0.007, p = 0.936$); perception of biology teacher ($F = 0.000, p = 0.998$); keenness to learn Biology ($F = 0.347, p = 0.558$); enjoyment of Biology, ($F = 0.022, p = 0.882$); anxiety towards Biology ($F = 1.459, p = 0.232$); effort in learning Biology, ($F = 2.101, p = 0.153$); and overall attitude towards Biology ($F = 0.064, p = 0.801$).

Generally, there was no significant sex effect seen on students' attitude towards Biology except on students' interest in Biology ($F = 4.449, p = 0.039$) where males (3.38) tend to exhibit more positive attitude than females (3.09). This general trend seen among the samples supports the findings of Talisayon, de Guzman and Balbin (2006) that attitude of Filipino students towards science does not significantly differentiate between boys and girls. However, a body of literature also supports that significant sex differences exist between males and females' attitude towards science, with the former exhibiting more positive attitude (Harvey & Edwards, 1980; Kahle & Lakes, 1983; Erickson &

Erickson, 1984; Smail & Kelly, 1984; Johnson, 1987; Robertson, 1987; Becker, 1989; Breakwell & Breadsell, 1992; Weinburgh, 1995; Hendley et al., 1996; Jovanovic & King, 1998.) In this study, such difference was only observed on students' interest in Biology.

Factoring in the influence of sex, the effect of instructional approach, on the other hand, was found to be significant only in the following attitudinal measures: students' perceptions of their biology teacher ($F = 6.517, p = 0.013$); enjoyment of Biology ($F = 4.191, p = 0.045$); and overall attitude towards Biology ($F = 4.378, p = 0.041$). Interestingly, the effect of instructional approach on keenness in learning Biology became insignificant ($F = 2.084, p = 0.154$) when sex was factored in as a moderator variable. This only established the finding that indeed, the effects of instructional approach is independent of sex.

In a nutshell, these results suggest that the attitudinal response of the males and females to the two instructional approaches did not significantly differ, establishing CBI as a promising gender-fair approach to biology instruction consistent with the call for reexamination of pedagogical strategies that are not gender-biased (SWE-AWE-CASEE, 2009).

Moderating effects of sex on students' achievement in bioenergetics test. The likelihood that sex or interaction between sex and instructional approach may affect students' achievement in bioenergetics test was also investigated. Reports in literature are conflicting about the effect of sex on achievement in science, particularly in Biology.

Table 27 presents some information on the sex distribution and students' pretest and posttest mean scores in BAT between the CBI and CIA groups.

Table 27. Descriptive Statistics for Students' Achievement in Bioenergetics Test (Instructional Approach by Sex)

Treatment	Sex	*n*	Pretest		Posttest	
			Mean	SD	Mean	SD
CBI	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
CIA	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

It is evident that in the class exposed to CBI, males obtained higher posttest mean score (16.86) than females (14.96). 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 sex-by-instructional approach interaction exists, the two way ANCOVA was employed (Table 28). 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 ($F= 0.026, p = 0.873$). Neither of the main effects were statistically significant, treatment: $F = 0.000, p = 0.985$; and sex: $F = 2.081, p = 0.155$, confirming reports of previous studies about the non-significant difference of male and female performance in Biology (Lauer et al., 2013; Ajewole, 1991; Catsambis, 1995; Greenfield, 1996).

Table 28. Tests of Between-Subjects Effects for Achievement in Bioenergetics Test (Instructional Approach by Sex)

Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	242.985[a]	4	60.746	3.523	.012
Intercept	315.469	1	315.469	18.296	.000
CV: PREBAT	174.832	1	174.832	10.139	.002
TREATMENT	.006	1	.006	.000	.985
SEX	35.881	1	35.881	2.081	.155
TREATMENT* SEX	.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)

However, evidence from this study contradict 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. Females are almost three times more than males, thus offsetting the significance of mean difference (2.45).

Moderating Effects of Learning Styles on Students' Attitude Towards Biology and Achievement in Bioenergetics Test

Moderating effects of learning styles on students' attitude towards Biology. Based from the conflicting results of learning styles research, the possibility that learning styles or interaction between learning styles and instructional approach may affect students' attitude towards Biology was investigated.

Table 29 presents some information on the learning styles distribution and students' pretest and posttest mean scores in ATBS between the CBI and CIA groups. It is noticeable that after the intervention, four patterns were observed on the attitude of students grouped by learning styles (preferred mode of learning). Listeners obtained highest posttest mean score (3.03) over readers (2.99) and iconics (2.79) on anxiety towards Biology. For interest in Biology and effort in learning Biology, readers obtained the highest posttest mean score (3.21, 3.19) over listeners (3.14, 3.17) and iconics (3.11, 3.16), respectively. For students' keenness to learn Biology, enjoyment of Biology, and overall attitude towards Biology, readers obtained the highest posttest mean score (2.80, 3.05, 2.94) over iconics (2.68, 2.94, 2.89) and listeners (2.67, 2.91, 2.88), respectively. For students' attitude towards the importance of Biology and their perceptions of their biology teacher, iconics obtained the highest posttest mean (3.35, 3.00) score over readers (3.28, 2.95) and listeners (3.17, 2.83), respectively. However, this trend varies within instructional groups.

Table 29. Descriptive Statistics for Students' Attitude Towards Biology (Instructional Approach by Learning Style)

Dependent Variable	Treatment	Learning Style	*n*	Pretest		Posttest	
				Mean	SD	Mean	SD
IMPT	CBI	Listening	8	2.91	0.47	3.28	0.35
		Reading	12	3.22	0.30	3.36	0.35
		Iconic	10	3.34	0.32	3.39	0.28
		Total	30	3.17	0.39	3.35	0.32
	CIA	Listening	10	3.19	0.22	3.09	0.30
		Reading	10	3.27	0.18	3.18	0.25
		Iconic	10	3.41	0.17	3.31	0.62
		Total	30	3.29	0.20	3.19	0.42
	Total	Listening	18	3.06	0.37	3.17	0.33
		Reading	22	3.24	0.25	3.28	0.31
		Iconic	20	3.38	0.25	3.35	0.47
		Total	60	3.23	0.31	3.27	0.38
INT	CBI	Listening	8	2.91	0.78	3.14	0.41
		Reading	12	3.11	0.34	3.28	0.38
		Iconic	10	2.96	0.64	3.18	0.44
		Total	30	3.01	0.57	3.21	0.40
	CIA	Listening	10	3.17	0.31	3.13	0.44
		Reading	10	2.87	0.50	3.11	0.50
		Iconic	10	3.03	0.45	3.05	0.69
		Total	30	3.02	0.43	3.10	0.54
	Total	Listening	18	3.05	0.57	3.14	0.41
		Reading	22	3.00	0.43	3.21	0.44
		Iconic	20	3.00	0.54	3.11	0.57
		Total	60	3.01	0.50	3.15	0.47

Dependent Variable	Treatment	Learning Style	*n*	Pretest		Posttest	
				Mean	SD	Mean	SD
TEACH	CBI	Listening	8	2.94	0.28	2.93	0.20
		Reading	12	3.00	0.25	3.09	0.32
		Iconic	10	3.05	0.31	3.18	0.36
		Total	30	3.00	0.27	3.08	0.31
	CIA	Listening	10	2.74	0.31	2.76	0.25
		Reading	10	2.91	0.19	2.79	0.32
		Iconic	10	2.94	0.30	2.82	0.38
		Total	30	2.86	0.28	2.79	0.31
	Total	Listening	18	2.83	0.31	2.83	0.24
		Reading	22	2.96	0.22	2.95	0.35
		Iconic	20	3.00	0.30	3.00	0.40
		Total	60	2.93	0.28	2.93	0.34
KEEN	CBI	Listening	8	2.71	0.33	2.73	0.31
		Reading	12	2.85	0.32	2.89	0.25
		Iconic	10	2.77	0.37	2.77	0.29
		Total	30	2.78	0.33	2.81	0.28
	CIA	Listening	10	2.69	0.27	2.62	0.19
		Reading	10	2.76	0.33	2.70	0.39
		Iconic	10	2.68	0.27	2.60	0.22
		Total	30	2.71	0.28	2.64	0.28
	Total	Listening	18	2.70	0.29	2.67	0.25
		Reading	22	2.81	0.32	2.80	0.33
		Iconic	20	2.72	0.32	2.68	0.26
		Total	60	2.75	0.31	2.72	0.29
ENJOY	CBI	Listening	8	2.79	0.39	2.93	0.24
		Reading	12	2.97	0.40	3.22	0.24
		Iconic	10	3.03	0.23	2.99	0.27
		Total	30	2.94	0.35	3.07	0.28
	CIA	Listening	10	2.95	0.30	2.89	0.35
		Reading	10	3.00	0.21	2.85	0.33
		Iconic	10	3.23	0.55	2.89	0.55
		Total	30	3.06	0.39	2.88	0.41
	Total	Listening	18	2.88	0.34	2.91	0.30
		Reading	22	2.99	0.32	3.05	0.33
		Iconic	20	3.13	0.42	2.94	0.42
		Total	60	3.00	0.37	2.97	0.36
ANXIETY	CBI	Listening	8	2.92	0.72	3.05	0.45
		Reading	12	3.17	0.44	3.03	0.41
		Iconic	10	2.76	0.59	2.98	0.43
		Total	30	2.97	0.58	3.02	0.41
	CIA	Listening	10	2.97	0.41	3.02	0.32
		Reading	10	2.64	0.40	2.94	0.41
		Iconic	10	2.98	0.51	2.60	0.67
		Total	30	2.86	0.46	2.85	0.51
	Total	Listening	18	2.95	0.55	3.03	0.37
		Reading	22	2.93	0.49	2.99	0.40
		Iconic	20	2.87	0.55	2.79	0.58
		Total	60	2.92	0.52	2.94	0.47
EFFORT	CBI	Listening	8	3.03	0.54	3.19	0.26
		Reading	12	3.31	0.34	3.25	0.37
		Iconic	10	3.53	0.34	3.23	0.45
		Total	30	3.31	0.43	3.23	0.36

Dependent Variable	Treatment	Learning Style	*n*	Pretest		Posttest	
				Mean	SD	Mean	SD
	CIA	Listening	10	3.34	0.34	3.15	0.54
		Reading	10	3.33	0.26	3.13	0.53
		Iconic	10	3.23	0.55	3.10	0.68
		Total	30	3.30	0.39	3.13	0.57
	Total	Listening	18	3.20	0.45	3.17	0.43
		Reading	22	3.31	0.30	3.19	0.44
		Iconic	20	3.38	0.47	3.16	0.56
		Total	60	3.30	0.41	3.18	0.47
ATB	CBI	Listening	8	2.80	0.38	2.96	0.19
		Reading	12	2.99	0.27	3.02	0.18
		Iconic	10	2.92	0.12	2.96	0.21
		Total	30	2.91	0.27	2.98	0.19
	CIA	Listening	10	2.90	0.17	2.82	0.26
		Reading	10	2.82	0.11	2.85	0.22
		Iconic	10	2.90	0.25	2.82	0.39
		Total	30	2.87	0.18	2.83	0.29
	Total	Listening	18	2.86	0.28	2.88	0.24
		Reading	22	2.91	0.22	2.94	0.22
		Iconic	20	2.91	0.19	2.89	0.31
		Total	60	2.89	0.23	2.91	0.25

A between-groups ANCOVA was conducted to assess the effectiveness of CBI and CIA in improving attitude towards Biology of students with different learning styles such as listening, reading and iconic (Table 30). Pretest values for their corresponding posttest mean scores in ATBS 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.

Table 30. Tests of Between-Subjects Effects for Components and Overall Students' Attitude Towards Biology (Instructional Approach by Learning Style)

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
IMPT2	Corrected Model	.659^a	6	.110	.752	.611
	Intercept	4.292	1	4.292	29.375	.000
	CV: IMPT1	.004	1	.004	.026	.873
	TREATMENT	.318	1	.318	2.177	.146
	LS	.192	2	.096	.656	.523
	TREATMENT*LS	.035	2	.018	.121	.886
	Error	7.745	53	.146		

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
	Total	650.108	60			
	Corrected Total	8.404	59			
INT2	Corrected Model	2.631[b]	6	.438	2.208	.056
	Intercept	5.825	1	5.825	29.331	.000
	CV: INT1	2.300	1	2.300	11.580	.001
	TREATMENT	.189	1	.189	.952	.334
	LS	.102	2	.051	.256	.775
	TREATMENT*LS	.016	2	.008	.041	.960
	Error	10.526	53	.199		
	Total	610.082	60			
	Corrected Total	13.156	59			
TEACH2	Corrected Model	1.864[c]	6	.311	3.252	.009
	Intercept	2.073	1	2.073	21.703	.000
	CV: TEACH1	.316	1	.316	3.313	.074
	TREATMENT	.796	1	.796	8.333	.006
	LS	.117	2	.058	.611	.547
	TREATMENT*LS	.120	2	.060	.631	.536
	Error	5.063	53	.096		
	Total	522.548	60			
	Corrected Total	6.927	59			
KEEN2	Corrected Model	.911[d]	6	.152	2.018	.079
	Intercept	3.036	1	3.036	40.352	.000
	CV: KEEN1	.300	1	.300	3.987	.051
	TREATMENT	.291	1	.291	3.867	.055
	LS	.122	2	.061	.812	.450
	TREATMENT*LS	.006	2	.003	.041	.960
	Error	3.988	53	.075		
	Total	449.837	60			
	Corrected Total	4.899	59			
ENJOY2	Corrected Model	1.303[e]	6	.217	1.851	.107
	Intercept	4.537	1	4.537	38.695	.000
	CV: ENJOY1	.258	1	.258	2.203	.144
	TREATMENT	.530	1	.530	4.522	.038
	LS	.185	2	.093	.790	.459
	TREATMENT*LS	.266	2	.133	1.135	.329
	Error	6.215	53	.117		
	Total	537.365	60			
	Corrected Total	7.517	59			
ANXIETY2	Corrected Model	3.793[f]	6	.632	3.703	.004
	Intercept	4.979	1	4.979	29.171	.000
	CV: ANXIETY1	2.356	1	2.356	13.802	.000
	TREATMENT	.256	1	.256	1.500	.226
	LS	.519	2	.260	1.521	.228
	TREATMENT*LS	.879	2	.439	2.574	.086
	Error	9.047	53	.171		
	Total	530.280	60			
	Corrected Total	12.839	59			
EFFORT2	Corrected Model	.299[g]	6	.050	.203	.974
	Intercept	6.197	1	6.197	25.288	.000
	CV: EFFORT2	.117	1	.117	.479	.492
	TREATMENT	.138	1	.138	.562	.457
	LS	.012	2	.006	.024	.976

Dependent Variable	Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
	TREATMENT*LS	.008	2	.004	.015	.985
	Error	12.989	53	.245		
	Total	618.125	60			
	Corrected Total	13.288	59			
POSTATB	Corrected Model	.554^a	6	.092	1.511	.193
	Intercept	1.629	1	1.629	26.631	.000
	CV: PREATB	.181	1	.181	2.951	.092
	TREATMENT	.290	1	.290	4.748	.034
	LS	.022	2	.011	.176	.839
	TREATMENT*LS	.004	2	.002	.034	.967
	Error	3.241	53	.061		
	Total	510.370	60			
	Corrected Total	3.796	59			

a. R Squared = .078 (Adjusted R Squared = -.026)
b. R Squared = .200 (Adjusted R Squared = .109)
c. R Squared = .269 (Adjusted R Squared = .186)
d. R Squared = .186 (Adjusted R Squared = .094)
e. R Squared = .173 (Adjusted R Squared = .080)
f. R Squared = .295 (Adjusted R Squared = .216)
g. R Squared = .022 (Adjusted R Squared = -.088)
h. R Squared = .146 (Adjusted R Squared = .049)

After adjusting for the pretest mean scores, no significant interaction effects between instructional approach and learning styles were observed in all eight measures (all p's > 0.05). Attitudinal measures also did not significantly differ across learning styles (all p's > 0.05).

Considering students' learning styles, the effect of instructional approach, on the other hand, was found to be significant only in the following attitudinal measures: students' perceptions of their biology teacher ($F = 8.333$, $p = 0.006$); enjoyment of Biology, ($F = 4.522$, $p = 0.038$); and overall attitude towards biology, ($F = 4.748$, $p = 0.034$). Interestingly, the effect of instructional approach on keenness in learning Biology became insignificant ($F = 3.867$, $p = 0.055$) when learning styles was factored in as a moderator variable. This only means that the observed effect of instructional approach is independent of students' learning styles.

These results suggest that the attitudinal response of the listeners, readers and iconics to the two instructional approaches did not significantly differ from each other. CBI therefore is an inclusive approach capable of addressing the learning needs and learning styles of the students, without bias against students' learning styles particularly on their preferred mode of obtaining new information. This supports the suggestion that rather than matching teaching style to individual student learning style which is pedagogically impractical, it is better to employ different teaching styles to allow students to learn in many different ways (Vaughn & Baker, 2001) because students have the potential of accommodating all teaching approaches (Zhang, Sternberg & Tan, 2013).

Moderating effects of learning styles on students' achievement in bioenergetics test. The likelihood that learning styles or interaction between learning styles and instructional approach may affect students' achievement in bioenergetics test was also investigated. Reports in literature are conflicting about the effect of learning styles on achievement in science, particularly in Biology.

Table 31 presents some information on the learning styles distribution and students' pretest and posttest mean scores in BAT between the CBI and CIA groups.

Table 31. Descriptive Statistics for Students' Achievement in Bioenergetics Test (Instructional Approach by Learning Style)

Treatment	Learning Style	*n*	Pretest		Posttest	
			Mean	SD	Mean	SD
CBI	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
CIA	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

Treatment	Learning Style	*n*	Pretest		Posttest	
			Mean	SD	Mean	SD
	Iconic	20	11.30	3.21	16.90	4.95
	Total	60	10.40	2.80	15.33	4.49

It is evident that in the class exposed to CBI, iconics obtained the highest posttest mean score (16.10) over readers (15.42) and listeners (14.50). In the CIA 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.

To determine if this observed difference among learning styles is significant and whether a learning styles-by-instructional approach interaction exists, the two way ANCOVA was employed (Table 32). 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.

Table 32. Tests of Between-Subjects Effects for Achievement in Bioenergetics Test (Instructional Approach by Learning Style)

Source	Type of III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	247.146[a]	6	41.191	2.312	.047
Intercept	297.276	1	297.276	16.687	.000
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)

After adjusting for pretest scores, there was no significant interaction effect (F= 0.246, p = 0.783). Neither of the main effects were statistically significant, treatment: F = 0.010, p = 0.921; and learning styles: F = 0.962, p = 0.389. This finding 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 CBI is a non-discriminatory approach to biology instruction that is equally comparable with the conventional method.

However, this result did not capture the learning typologies that were intended to be generated as described in the CLSI due to sample size issue. The learning style utilized instead was only the students' preferred way or mode of obtaining new information, one of the features only of CLSI. Yet, this classificatory measure is thought to be reflective of students' preference for learning.

Relationship Between Attitude Towards Biology and Achievement in Bioenergetics

There is a blur in the relationship between attitude and achievement in biology. To test their nature of association, a multiple linear regression using the stepwise method was employed on students' data after the intervention. The posttest mean score in BAT was the dependent variable and the posttest attitudinal measures taken singly were the independent variables as follows: importance of Biology (IMPT2), interest in Biology (INT2), perception of the biology teacher (TEACH2), keenness to learn Biology (KEEN2), enjoyment of Biology (ENJOY2), anxiety towards Biology (ANXIETY2), effort in learning Biology (EFFORT2), and overall attitude towards Biology (POSTATB).

The subsequent table (Table 33) revealed that of all the independent variables tested, interest in Biology significantly predicted students' posttest mean score in BAT explaining about 11.4 percent of the variance ($\beta = 0.337$, $R^2 = 0.114$). The regression model is significant ($p = 0.008$), giving the following prediction equation for achievement:

Predicted BAT Score = 5.205 + 3.211(INT2 Score)

This means that in every unit increase in students' interest towards Biology, a corresponding 3.211 increase occurs proportionately in their achievement in BAT.

Table 33. Multiple Regression Analysis on Students' Achievement in Bioenergetics as Predicted by their Attitude Towards Biology

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.205	3.751		1.388	.171
	INT2	3.211	1.176	0.337	2.730	.008

Dependent Variable: POSTBAT
$R^2 = 0.114$

In this study, achievement in bioenergetics test was assigned as the dependent variable, based on the premise that attitude precedes behavior (Osborne et al., 2003) and best milk comes from contented cows (Fraser, 1982). This result is consistent with the findings of Usak et al. (2009), Caciki, Aricak amd Ilgaz (2011), and Ali and Awan (2014) who also found out small yet significant associations between attitude towards and achievement in Biology. The fact that only one component of attitude towards Biology was found to be a significant predictor of achievement, with small variance to explain, keeps the argument up between the nature of relationship between the two variables.

However, further multiple regression analysis using gained scores within the instructional groups was explored. In the CBI group, when the same model was run using the stepwise method, no significant predictor came out. When achievement was disaggregated into topics and cognitive domains only one model yielded significant findings as shown in Table 34.

Table 34. Multiple Regression Analysis on CBI's Gained Scores in Metabolism part of BAT as Predicted by Gained Scores in Attitude Towards Biology

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.560	.349		4.472	.000
	GAINTEACH	-2.573	1.121	-.398	-2.296	.029

Dependent Variable: GAINMET

$R^2 = 0.158$

CBI students' gained score in their perception of their biology teacher (GAINTEACH) significantly predicts their gained score in the metabolism (GAINMET) part of BAT ($t = -2.296$, $p = 0.029$). But the relationship is negative ($\beta = -0.398$) accounting for 15.8 percent of the variance in GAINMET. This could mean that for every unit increase in GAINTEACH, there is a corresponding 0.398 unit decrease in the GAINMET.

This finding does not corroborate with what most researchers on attitude-achievement hypothesis claim that the best milk comes from the most contented cows. Attitude did not precede behavior in this case. Chances are in the CBI group, many students developed positive attitude towards their teacher, but these attitude were not translated into an increase in performance in GAINMET, in fact a significant drop in performance was statistically supported. In the same way those students whose attitude are not really high could possibly have higher score in GAINMET. This supports the argument of Osborne, Simon and Collins (2003) that learners can achieve highly in science without necessarily holding positive attitude towards it. For the CIA group, no significant regression model was produced using the same set of predictor and criterion variables, across topics and cognitive domains.

To understand better the nature of the relationship between the two variables considered, further multiple regression analysis was done within sex groups, with GAINBAT as the criterion variable and the component and overall gained scores of ATB as predictors. Results of analysis are shown in Table 35.

Within the male group, gained scores in BAT were found to be significantly predicted by the students' overall gain in ATB score ($\beta = 0.541$, $t = 2.228$, $p = 0.046$), explaining 29.3 percent of variance in the former. This amount of explained variance is way over and above those reported in literature with significant multiple coefficient of determination (R^2) values ranging from 2.5 to 6.76 percent only (Usak et al, 2009; Caciki, Aricak & Ilgaz, 2011; Ali & Awan, 2014). This means that the relationship between attitude towards Biology and achievement in bioenergetics is strongly evident in males than the females, where overall gained score in ATB was not a significant predictor.

Table 35. Multiple Regression Analysis on Gained Scores in BAT as Predicted by Component and Overall Gained Scores in ATB

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
Males						
1	(Constant)	4.006	1.135		3.528	0.004
	GAINATB	14.219	6.381	0.541	2.228	0.046
Dependent Variable: GAINBAT; $R^2 = 0.293$						
Females						
1	(Constant)	4.926	0.602		8.184	0.000
	GAINKEEN	3.441	1.706	0.291	2.017	0.050
Dependent Variable: GAINBAT; $R^2 = 0.085$						

Within the female group, the only significant predictor of BAT gained scores is their keenness to learn Biology ($\beta = 0.291$, $t = 2.017$, p=0.050) which accounts for 8.5 percent of the variance in BAT gained score. It is apparent in literature that relationship between attitude and achievement is scantily investigated within sex groups.

Re-conceptualized Framework

Based from the findings of the study, the CBI framework was re-conceptualized as shown in Figure 3. In the original framework, CBI was assumed to affect students' attitude towards Biology and their achievement in bioenergetics test. In the revised framework, it can be seen that CBI only bears significant effect on students' attitude and not on their achievement. Especially, its effects are pronounced only among students' perceptions of their biology teacher, their keenness to learn Biology, their enjoyment of Biology and their overall attitude towards Biology. No significant CBI effects were seen on other components like students' interest in Biology, their perceptions on importance of Biology, their anxiety towards Biology, and their effort in learning Biology. In the previous framework, learning styles and sex were thought to moderate the effects of CBI on both students' attitude towards Biology and their achievement in bioenergetics test. But these suppositions were not supported by the findings of the current investigation, thus they were omitted. However, sex has been established to be acting as a variable independent of instructional approach, and not a moderator, as previously thought of. Specifically, sex effect has been observed on students' interest in Biology, which interestingly, is the only component of students' attitude towards Biology that can substantially predict their achievement in bioenergetics test. But the finding is not true within instructional groups, where none of the overall and component gained scores both

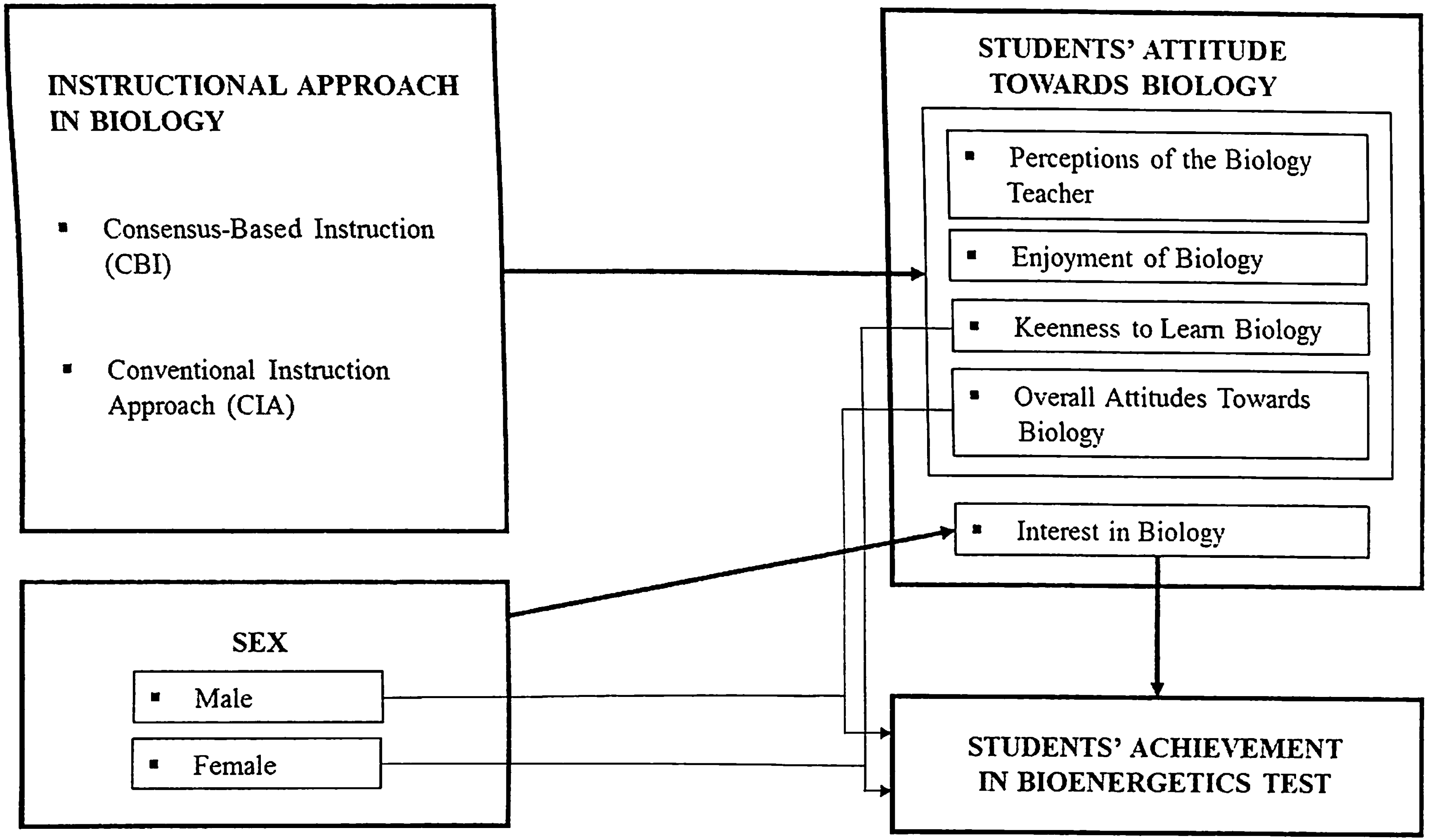


Figure 3. Consensus-Based Instruction Re-conceptualized Framework

in the CBI and CIA groups significantly predicted their achievement in BAT. Within sex groups, however, significant relationship between the overall attitude of males towards Biology and their achievement in bioenergetics has been supported by the data generated from this experiment, as indicated by the thin lines. Likewise, females' keenness to learn Biology significantly predicts as well their achievement in bioenergetics.

Chapter 5

SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of the study, the highlights of findings, as well as the conclusions and the recommendations deduced from the study's findings.

Summary

This study aimed to determine the effects of consensus-based instruction (CBI) on attitude towards Biology and achievement in bioenergetics among college students enrolled in the biological science class at the College of Business and Accountancy in a state university in the MIMAROPA Region during the second semester of School Year 2015-2016. Specifically, this study sought to answer the following questions:

1. Are the overall mean scores in attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher, keenness to learn Biology, enjoyment of Biology, anxiety towards Biology and effort in learning Biology of the class exposed to CBI higher than those of the class taught using conventional instruction approach (CIA)?
2. Is the mean score in the Bioenergetics Achievement Test of the class exposed to CBI higher than that of the class taught using CIA?
3. Does sex moderate the effects of instructional approach on:
    a. Students' attitude towards Biology; and
    b. Students' achievement in bioenergetics test?
4. Does learning style moderate the effects of instructional approach on:
    a. Students' attitude towards Biology; and

b. Students' achievement in bioenergetics test?

5. Are the overall scores of students' attitude towards Biology and its components such as importance of Biology, interest in biology lessons, perceptions of the biology teacher. keenness to learn Biology. enjoyment of Biology, anxiety towards Biology and effort in learning Biology related to their bioenergetics achievement test scores?

Covering the unit in bioenergetics, two NatSci 102 (Biological science) classes were chosen and compared using the non-equivalent pretest-posttest control group quasi-experimental design. One group was taught using conventional instruction approach (CIA) while the other group used the CBI approach. In CBI, students were given the chance to raise an issue in the learning plan, negotiate, propose an alternative, participate in a 'grand conversation', decide using consensus, and adhere to the agreed implementation process. Within groups, students in the CBI class were also tasked to arrive at a consensus answer on a teacher-prepared focus question related to the day's lesson. The following research instruments were utilized: Canfield Learning Style Inventory (CLSI), Learning Needs Analysis Protocol (LNAP), Questionnaire on the Importance of Democratic Practices in Classroom (QIDPC), Attitude Towards Biology Scale (ATBS) and Bioenergetics Achievement Test (BAT). All instruments were researcher-made and expert-validated except for the standardized CLSI. Based on the results of pilot tests and reliability analyses, all instruments were acceptable for use. CLSI was administered to both groups prior to the experiment, LNAP was accomplished only by the CBI group prior to the experiment, QIDPC was administered only to the CBI group prior to and after the experiment, while ATBS and BAT were administered to both groups before and after the experiment. Quantitative data collection methods were supplemented by video-recorded class sessions, researcher's journal and informal interviews to students. Thirty students per group were randomly chosen for comparative analysis after those with incomplete data and absences were excluded from the sampling frame. Descriptive statistics were used in profiling the respondents. Using pretest scores as covariates, ANCOVA was used in comparing differences in posttest mean scores between CBI and CIA groups in terms of students' attitude in Biology and their achievement in the bioenergetics test. It was also utilized in testing the moderating effects of sex and learning styles on the above mentioned dependent variables. In comparing both groups in terms of BAT achievement, *t*-test for independent samples was employed. In the CBI group, the change in students' perception about the importance of democratic practices in classroom before and after the intervention was compared using the *t*-test for paired samples. Multiple regression analysis was used in determining the relationship between students' attitude towards Biology and their achievement in the bioenergetics test.

Findings

The summary of findings of the study is presented below vis-à-vis the research problems asked:

1. As to the students' attitude towards the importance of Biology, the posttest mean score of the CBI group was 3.35 compared to the CIA group which was 3.19. After adjusting for the pretest mean scores, there was no significant difference between the CBI and CIA groups ($F = 2.821, p = 0.099$). The null hypothesis was not rejected.

In terms of students' interest in biology lessons, CBI group obtained a posttest mean score of 3.21 as compared to CIA group which was 3.10. After adjusting for the pretest mean scores, there was no significant difference between the two groups ($F = 1.101, p = 0.05$). The null hypothesis was not rejected.

As regards students' perception about their biology teacher, the posttest mean score of the CBI group was 3.08 while the CIA group was 2.79. After removing the effect of the pretest score, ANCOVA uncovered significant difference between the two groups ($F = 9.164, p = 0.004$). The null hypothesis was rejected in favor of the alternative. Therefore, students in the CBI group hold more positive perception of their biology teacher than those in the CIA group. Many of them reported positive perceptions of their teacher's competence, pedagogical skills and motivating skills.

With regard to students' keenness to learn Biology, those in the CBI group obtained a posttest mean score of 2.81 while those in the CIA group was 2.64. After adjusting for the pretest scores, it was found out that a significant difference exists between the two groups ($F = 4.455, p = 0.039$). The null hypothesis was rejected in favor of the alternative. Consequently, students in the CBI group are keener to learn Biology than those in the conventional group.

As to students' enjoyment of Biology, the posttest mean score of the CBI group was 3.07 as compared to 2.88 of the CIA group. After the influence of pretest scores was adjusted, ANCOVA results significantly differentiated the two groups ($F = 5.538, p = 0.022$). The null hypothesis was rejected. Thus, students in the CBI group enjoyed Biology more than those in the CIA group. They mainly point out that the consensus group activities. decision-making activities that everyone can support, teacher's adherence to the negotiated elements of the learning plan, the democratizing process of consensus, the opportunity for self-expression, student-teacher interactions, as among those that gave them sense of enjoyment.

In terms of students anxiety towards Biology, students in the CBI group scored a posttest mean of 3.02 while in the CIA group was 2.88. After adjusting for the pretest score, ANCOVA found out that there is no significant difference between the two groups ($F = 1.370, p = 0.247$). The null hypothesis was not rejected.

With regard to their effort in learning Biology, the posttest mean score obtained by the students in the CBI group was 3.23 while those in the CIA group was 3.13. After adjusting for pretest scores, ANCOVA revealed that there was no significant difference between the two groups ($F = 0.637, p = 0.428$). The null hypothesis was not rejected.

For the students' overall attitude towards Biology, those in the CBI group attained a posttest mean score of 2.98 while those in the conventional group was 2.83. After adjusting for the pretest scores, ANCOVA showed a significant difference between the two groups ($F = 5.187, p = 0.027$). The null hypothesis was rejected. Thus, students in the CBI group demonstrated more positive attitude in Biology than those in the conventional group.

2. The posttest mean score in BAT of the class exposed to CBI was 15.40 while that of the class taught using CIA was 15.27. Levene's test revealed that the two

groups have equal variances (F = 0.275, p = 0.602). It was found out that there was no significant difference between the two instructional approaches on posttest mean scores in bioenergetics achievement test (t = 0.114, df = 58, p = 0.910). The null hypothesis was not rejected. However, descriptive and qualitative data show some interesting support on the use of CBI.

3. As to the interaction effects of sex with instructional approach on students' attitude towards Biology, the following were the highlights of the findings:
   a. Concerning the influence of sex on students' attitude towards Biology, males had higher posttest means than females in the following: importance of Biology (3.33>3.25), interest in biology lessons (3.38>3.09), perception of biology teacher (3.06>2.89), keenness to learn Biology (2.81>2.70), anxiety towards Biology (3.03>2.91), effort in learning Biology (2.23>3.16), and the overall score for attitude towards Biology (3.01>2.87). The students' enjoyment of biology posttest mean score was equal for both males and females (2.98).

      Within the instructional groups, males in the CBI class scored higher than females in all posttest measures of attitude towards Biology. However, in the CIA group, except for students' enjoyment in Biology where males and females obtained equal mean score (2.88) and effort in learning Biology where females scored higher than males (3.16>3.00), a similar trend was evident.

      After adjusting for the pretest mean scores in each of the posttest attitudinal scores, ANCOVA found no significant interaction effects between instructional approach and gender in terms of the following dependent variables: importance of Biology ($F = 0.222, p = 0.639$); interest in Biology ($F = 0.007, p = 0.936$); perception of biology teacher ($F = 0.000, p = 0.998$); keenness to learn Biology ($F = 0.347, p = 0.558$); enjoyment of Biology ($F = 0.022, p = 0.882$); anxiety towards Biology ($F = 1.459, p = 0.232$); effort in learning Biology ($F = 2.101, p = 0.153$); and overall attitude towards Biology ($F = 0.064, p = 0.801$).

Generally, there was no significant sex effect seen on students' attitude towards biology except on students' interest in Biology ($F = 4.449, p= 0.039$) where males (3.38) tend to exhibit more positive attitude than females (3.09). Factoring in the influence of sex, the effect of instructional approach, on the other hand, was found to be significant only in the following attitudinal measures: students' perceptions of their biology teacher ($F = 6.517, p = 0.013$); enjoyment of Biology ($F = 4.191, p= 0.045$); and overall attitude towards Biology, ($F = 4.378, p = 0.041$).

b. With regard to the interaction effect of sex and instructional approach on students' achievement in the bioenergetics test, males obtained a higher posttest mean score (16.86) than females (14.96) in the class exposed to CBI. The same observation can be found in the CIA 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. After adjusting for pretest scores, ANCOVA bared that there was no significant interaction effect between sex and instructional approach ($F= 0.026, p = 0.873$). Neither of the main effects was statistically significant, treatment ($F = 0.000$, $p = 0.985$) and sex ($F = 2.081$, $p = 0.155$).

4. As to the interaction effects of learning styles with instructional approach on students' attitude towards Biology, the following were the highlights of the findings:

    a. With regard to the interaction effect of gender and instructional approach on students' attitude towards Biology, four patterns were observed in students' posttest mean score on ATBS when grouped by learning styles. Listeners obtained highest posttest mean score (3.03) over readers (2.99) and iconics (2.79) on anxiety towards Biology. For interest in biology and effort in learning Biology, readers obtained the highest posttest mean score (3.21, 3.19) over listeners (3.14, 3.17) and iconics (3.11, 3.16), respectively. For students' keenness to learn Biology, enjoyment of Biology, and overall attitude towards Biology, readers obtained the highest posttest mean score (2.80, 3.05, 2.94) over iconics (2.68, 2.94, 2.89) and listeners (2.67, 2.91, 2.88), respectively. For students' attitude towards the importance of Biology and their perceptions of their Biology teacher, iconics obtained the highest posttest mean (3.35, 3.00) score over readers (3.28, 2.95) and listeners (3.17, 2.83), respectively.

        After adjusting for the pretest mean scores, ANCOVA showed no significant interaction effects between instructional approach and learning styles in all eight measures (all p's > 0.05). Attitudinal measures also did not significantly differ across learning styles (all p's > 0.05).

Considering students' learning styles, the effect of instructional approach was found to be significant only in the following attitudinal measures: students' perceptions of their biology teacher ($F = 8.333$, $p = 0.006$); enjoyment of Biology, ($F = 4.522$, $p = 0.038$); and overall attitude towards Biology, ($F = 4.748$, $p = 0.034$).

b. As regards the interaction effect of learning style and instructional approach on students' achievement in bioenergetics test, iconics obtained the highest BAT posttest mean score (16.10) over readers (15.42) and listeners (14.50) in the class exposed to CBI. In CIA 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 in BAT was 16.90, whereas for the 18 listeners and 22 readers, it was 14.56 and 14.55, respectively.

After adjusting for pretest scores, there was no significant interaction effect observed between learning style and instructional approach, ($F = 0.246$, $p = 0.783$). Neither of the main effects was statistically significant, treatment ($F = 0.010$, $p = 0.921$) and learning styles ($F = 0.962$, $p = 0.389$).

5. The Multiple Regression Analysis revealed that of the component and overall posttest mean scores of students' attitude towards Biology, only interest in Biology significantly predicted students' posttest mean score in biology achievement test explaining about 11.4 percent of the variance ($R = 0.337$, $R^2 = 0.114$). The regression model is significant ($p=0.008$).

CBI students' gained score in their perception of their biology teacher (GAINTEACH) significantly predicts their gained score in the metabolism (GAINMET) part of BAT (t = -2.296, p = 0.029). But the relationship is negative (β = -0.398) accounting for 15.8 percent of the variance in GAINMET.

No relationships between components and overall gained scores in ATB and gained score in BAT were observed both within the CBI and CIA groups. However, within sex groups, males' overall gained scores in ATB significantly predict their gained scores in BAT (β = 0.541, t = 2.228, p = 0.046), explaining 29.3 percent of variance in the former. Within the female group, the only significant predictor of BAT gained scores is their keenness to learn Biology (β = 0.291, t = 2.017, p=0.050) which accounts for 8.5 percent of the variance in BAT gained score.

Conclusions

Based from the findings of the study, the following conclusions are drawn:

1. CBI is an effective instructional approach in improving students' overall attitude towards Biology, a *sine qua non* for public appreciation and engagement with science. In particular, the approach is effective in developing among students a positive perception of their biology teacher, improving their keenness to learn Biology and enhancing their enjoyment of the subject.
2. CBI is not effective in improving students' achievement in bioenergetics test but there are evidences supporting it as a comparable and feasible alternative approach that nurtures students' reasoning skills and can be added to biology teachers' repertoire of pedagogical approaches. CBI also helps students appreciate more the importance of practicing democratic processes in the classroom.

3. CBI is an approach that does not discriminate between sexes which engenders comparable responses between males and females as to their attitude towards Biology and achievement in the bioenergetics test. Although males exhibit greater interest in biology lessons, such is an independent observation and does not show any substantial interaction effect with CBI.
4. CBI addresses students' learning styles without bias. Listeners, readers and iconics equally accommodate the teaching strategies embedded in the approach and demonstrate comparable responses with regard to their attitude towards Biology and their achievement in bioenergetics test.
5. Students' interest in biology lessons is the only component of attitude towards Biology that significantly predicts achievement in bioenergetics test. Within sex groups, males' overall attitude towards Biology significantly predicts their achievement in bioenergetics while among females, it is keenness to learn Biology.

Recommendations

Based from the findings and conclusions of this study, the following recommendations are put forward:

1. For teachers, teacher trainers and educators, they may consider the use of CBI in their respective biology classes if they want to experience the benefits reported in literature and those that have been empirically revealed in this investigation. They can start by modelling from the consensus building procedures developed from this study, either whole class, within groups, or both. They can also use the developed primer in helping students understand consensus in comparison with

other decision-making rules and processes. It is also important that they have to assess first the learning needs of the students, allow tolerable amount of time for students to ponder on these needs and pay sincere attention to their suggestions and concerns. The Learning Needs Analysis Protocol used in this study can help them do this efficiently. In starting with consensus activity within groups, using carefully chosen and relevant video-based experiments which can be downloaded from the internet will be a good start. They can blend this with predict-observe-explain strategy, but predicted outcomes must be decided consensually. This can be done by pausing the video right before the results of the experiment are shown. In generating consensus decisions, the class can come up with creative techniques aside from doing it orally and through hand gestures. They may also consider adding other consensus practices reviewed in this study or they may design their own way of doing consensus based on their own style and own flavor within the students' context. It is also recommended that they do their own reading or attend a crash course, seminar or training about postmodernism, constructivism, and democratic education in order to have a strong grounding on the philosophical and theoretical bases of this emerging pedagogical approach.

2. For curriculum developers and textbook writers, they may add consensus-based instruction as an approach that teachers can try to narrow the gap between the intended and the achieved curriculum. If possible, curriculum developers and textbook writers may make use of the opportunity of attending students' conventions and conferences when they would have the chance to interview students about their interests and needs, and reflect them in the curriculum they

are developing or textbooks they are writing. In this way, curriculum standards will be contextualized to the learners' needs. Among textbook writers, the benefits of consensus can be integrated to their book writing by adding a section about carefully thought-of consensus-group activities, similar to the ones used in this study, for every lesson or every after the end of the unit. In this way, students will have the privilege of experiencing a quality social interaction where their own voices matter.

3. For the University officials particularly those who are in-charge of instruction, the idea of consensus as an approach gives students the voice in the teaching-learning transactions like negotiating the course syllabus without sacrificing the standards can be considered as a topic for one in-service training just so the approach can be deliberated at the academic level. The literature reviewed and the empirical results generated from this investigation can be presented as evidences for consideration and a springboard for considering it as among the researchable areas in the agenda for quality instruction.
4. Since this investigation covers only one unit, the sufficiency of the dosage of intervention cannot be ascertained. Thus, a similar semester-long experiment in college or in senior high school or a yearlong investigation in junior high school is recommended, using the same instruments as necessary.
5. To truly establish the interaction of learning styles with CBI, other learning style inventories that comprehensively typify the learners can be used.

6. BAT items can still be polished to improve its reliability coefficient by studying or revising those test items that would increase the Cronbach' alpha when they are deleted.
7. In order to capture consensus-based instruction within groups, it is recommended that during consensus group activities, the videographer should focus only on one group, so that the group processes such as the grand conversation and consensus building can be better examined and analyzed.
8. The following are recommended for future research:
    a. The effects of consensus-based instruction on students' 21st century skills like decision-making skills, among others;
    b. The effects of consensus-based instruction on teachers' technological pedagogical content knowledge and students' attending behavior;
    c. The effects of video-based consensus activity on students' academic performance;
    d. Comparative effects of consensus, democratic and autocratic approaches in improving students' self-concept and performance in authentic assessments in Biology; and
    e. Qualitative investigation on the kind and characteristics of teachers who perform better in CBI.

LITERATURE CITED

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour.* Englewood Cliffs, NJ: Prentice Hall.

Alexander, P. A. (1996). The past, the present and future of knowledge research: A reexamination of the role of knowledge in learning and instruction. *Educational Psychologist, 31*, 89–92.

Ali, M. S., & Awan, A. S. (2013). Attitude towards science and its relationship with students; achievement in science. *Interdisciplinary Journal of Contemporary Research in Business, 4*(10), 707-718.

Aragon, S. R., Johnson, S. D., & Shaik, N. (2002). The influence of learning preferences on student success in online versus face-to-face environments. *The American Journal of Distance Education, 16*(4), 227-243.

Balme, C., & Bennis, D. (2008). Democratic education in Israel. In M. Hern & E. C. Babaoglu (Eds. & Trans.), *Alternative education: Deschooling our lives* (191-205). Istanbul: Kalkedon Yayinlari.

Bankert, E. G., & Kozel, V. V. (2005). Transforming pedagogy in nursing education: A caring learning environment for adult students. *Nursing Education Perspectives, 26*(4), 227-229.

Barwashi, A. (2003). *Genre and the invention of the writer.* Logan: Utah State University Press.

Becker, B. J. (1989). Gender and science achievement: a re-analysis of studies from two meta-analyses. *Journal of Research in Science Teaching, 26,* 141-169.

Berquest, W. (1993). *The postmodern organization.* San Francisco: Jossey-Bass Publishers.

Bitran, M., Lafuente, M., Zuniga, D., Viviani, P., & Mena, B. (2004). The influence of psychological features and learning styles on the academic performance of medical students. *Revista Medica de Chile, 132*(9), 1127-1136.

Blalock, C. L., Lichtenstein, M. J., Owen, S., Pruski, L., Marshall, C., & Toepperwein, M. (2008). In pursuit of validity: A comprehensive review of science attitude instruments 1935 – 2005. *International Journal of Science Education, 30*(7), 961-977.

Blinne, K. C. (2013). Start with the syllabus. HELPing learners learn through class content collaboration. *College Teaching, 61,* 41-43.

Breakwell, G. M., & Beardsell, S. (1992). Gender, parental and peer influences upon science attitudes and activities. *Public Understanding of Science, 1,* 183-197.

Breckler, J., Joun, D., & Ngo, H. (2009). Learning styles of physiology students interested in the health professions. *Adv Physiol Educ, 33*(1), 30-36.

Briggs, B., & Reid, L. (2001). True consensus, false consensus. *Communities, Winter(*113), 43-47.

Brown, S. (1976). *Attitude goals in secondary school science.* Stirling: University of Stirling.

Bruffee, K. A. (1993). *Collaborative learning: Higher education, interdependence, and the authority of knowledge.* Baltimore, MD: John Hopkins University Press.

Buboltz, W., Wilkinson, L., Thomas, A., & Jenkins, S. (2001). Learner styles and potential relations to distance education. In J. C. Price et al. (Eds), *Proceedings of society for information technology and teacher education international conference 2001, Chesapeake, VA* (144-148). Norfolk, VA: AACE.

Butcher, J. (2002). Comments on Freeman Marvin's essay, "Consensus is primary to group facilitation." *Group Facilitation,* 4, 62-63.

Butcher, J. (2002). Consensus depends on the situation. *Group Facilitation,* 4, 58-60.

Caciki, Y., Aricak, O. T., & Ilgaz, G. (2011). Can attitudes toward biology course and learning strategies simultaneously predict achievement in biology? *Eurasian Journal of Educational Research, 45,* 31-48.

Cakiroglu, U. (2014). Analyzing the effect of learning styles and study habits of distance learners on learning performances: a case of an introductory programming course. *The International Review of Research in Open and Distance Learning, 15*(4), 161-182.

Campbell, C. (2013). Issues and challenges in learning science. In. C. Campbell & I. Robottom (Eds.), *Learning science beyond the classroom (13-23).* Penang, Malaysia: SEAMEO RECSAM.

Canfield, A. A. (1988). *Canfield learning styles inventory (LSI) manual.* Los Angeles, CA: Western Psychological Services.

Canfield, A. A., & Knight, W. (1983). *Learning styles inventory.* Los Angeles, CA: Western Psychological Services.

Capra, F. (1996). *The web of life.* New York: Anchor Press.

Cassidy, S. (2004). Learning styles: an overview of theories, models and measures. *Educational Psychology, 24*(4), 219-244.

Cheng, Y. J., & Yang, K. Y. (1995). The development and validation of attitudes towards biology scale. *Chinese Journal of Science Education, 3*(2), 189-212.

Childress, M. D. (2001). The relationship between learning style and achievement in a one-way video, two-way audio preservice teacher education computer literacy course. *International Journal of Educational Telecommnications, 7*(1), 57-71.

Chou, H., & Wang, T. (2000). The influence of learning style and training method on self-efficacy and learning performance in WWW homepage design training. *International Journal of Information Management, 20,* 455-472.

Christian, D. L. (2012). Busting the myth that consensus-with-unanimity is good for communities, Part I. *Communities, Summer*(155), 42-49.

Cimer, A. (2012). What makes biology learning difficult and effective: students' views. *Educational Research and Reviews, 7*(3), 61-71.

Clark, A. (2006). Changing classroom practice to include the project approach. *Early Childhood Research & Practice, 8*(2).

Cobb, P., Yackel, E., & Wood, T. (1991). Curriculum and teacher development: psychological and anthropological perspectives. In E. Fennema & S. J. Lamon (Eds.), *Integrating research on teaching and learning mathematics* (pp. 92-131). Albany, NY: State University of New York Press.

Cobern, W. W. (1995). Constructivism for science teachers. *Science Education International, 6*(3), 8-12.

Coffield, F., Moseley, D., Hall, E., & Ecclestone, K. (2004). *Learning styles and pedagogy in post-16 learning: A systematic and critical review*. London: Learning and Skills Research Center.

Conradt, L., & Roper, T. J. (2003). Group decision-making in animals. *Trends in Ecology & Evolution, 20,* 449-456.

Consensus (n.d.). In *Merriam-Webster Online Dictionary*. Retrieved from http://www.merriam-webster.com/dictionary/consensus

Cowan, D. V. (1960). Constitution-making for a democracy: an alternative to apartheid. *Optima Supplement.*

Cross, K. P. (1999). *Learning is about making connections.* Mission Viejo, CA: League for Innovation in the Community College.

Cunningham, P. A. (2014). Exploring the efficacy of consensus-based decision-making: a pilot study of the Cloughjordan Ecovillage, Ireland. *International Journal of Housing, 7*(2), 233-253.

Curry, L. (1981). Learning styles in continuing medical education. *CMA Journal, 124*(1), 535-536.

Danielwicz, J., & Elbow, P. (2009). A unilateral grading contract to improve learning and teaching. *CCC, 61*(2), 244-267.

Dart, B. C., Burnett, P. C., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000). Students' conceptions of learning, the classroom environment, and approaches to learning. *The Journal of Educational Research, 93*(4), 262-270.

Dearing, R. (1996). *Review of qualifications for 16-19 year olds.* London: Schools Curriculum and Assessment Authority.

DeStephen, R., & Hirokawa, R. Y. (1988). Small group consensus: Stability of group support of the decision, task process, and group relationships. *Small Group Behavior, 19,* 227-239.

Dewey, J. (1938). *Experience and education.* New York: Collier Macmillan Publishers.

Didcoct, B., & DeLapa, P. (2000). 12 myths of consensus. *Communities, Winter*(109), 50-52.

Doll, W. (1993). *A post-modern perspective on curriculum.* New York: Teachers College Press.

Dunn, R., & Dunn, K. (1978). *Teaching students through their individual learning styles: A practical approach.* Reston, VA: Reston Publishing.

Dziuban, C., Moskal, P., & Hartman, J. (2005). *Higher education blended learning, and the generations: Knowledge is power: No more. Elements of quality online education: Engaging communities.* Needham, MA: Sloan Center for Online Education.

Ebenezer, J. V., & Zoller, U. (1993). Grade 10 students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching, 30,* 175-186.

Eggen, P. & Kauchak, D. (1999). *Educational Psychology: Windows on Classrooms (4th ed.).* Prentice Hall.

Eide, B. J., Geiger, M. A., & Schwartz, B. N. (2001). The Canfield learning style inventory: an assessment of its usefulness in accounting education research. *Issues in Accounting Education, 16*(3), 341-365.

Eide, B. J., Geiger, M. A., & Schwartz, B. N. (2001). The Canfield Learning Style Inventory: an assessment of its usefulness in accounting education research. *Issues in Accounting Education, 16*(3), 341-365.

Erickson, G., & Erickson, L. (1984). Females and science achievement: evidence, explanations, and implications. *Science Education, 68,* 63-89.

European Commission (2007). *Science Education NOW: A renewed pedagogy for the future of Europe*. Retrieved from http://www.eirma.org/documents/ EU/report-rocard-on-science-education.pdf

Fasset, D. L., & Warren, J. T. (2007). *Critical communication pedagogy.* Thousand Oaks: Sage.

Fearing, A., & Riley, M. (2005). Graduate students' perceptions of online teaching and relationship to preferred learning styles. *Medsurg Nursing, 14*(6), 383-389.

Felder, R. M., & Silverman, L. K. (1988). Learning styles and teaching styles in engineering education. *Engineering Education 78*(7), 674-681.

Felder, R. M., & Soloman, B. A. (1997). Index of learning styles. Retrieved from http://www.ncsu.edu/felder-public/ILSpage.html

Fensham, P. (2004). *Engagement with science: An international issue that goes beyond knowledge.* Paper presented at the SMEC Conference. Retrieved from www.dcu.ie/smec/plenary/Fensham,%20Peter.pdf

Fernandez, C., & Yoshida, M. (2004). *Lesson study: A Japanese approach to improving mathematics teaching and learning.* Mahwah, NJ: Lawrence Erlbaum Associates.

Fink, A., Kosecoff, J., Chassin, M., & Brook, R. H. (1984). Consensus methods: characteristics and guidelines for us. *American Journal of Public Health, 74*(9), 979-983.

Fleming, N. D. (2001). *Teaching and learning styles: VARK strategies.* Christchurch, New Zealand: Author.

Foley, I. (1999). Teacher learning style preferences, student learning style preferences and student reading achievement (Doctoral dissertation). Available from ProQuest dissertation and theses databases (UMI No. 9929271).

Fosnot, C. T. (1996). "Constructivism: a psychological theory of learning." In *Constructivism: Theory, Perspectives and Practice*, ed. C. T. Fosnot, 8–33. New York: Teachers College Press.

Francis, M. C., Mulder, T. C., & Stark, J. S. (1995). *Intentional learning: A process for learning to learn in the accounting curriculum.* Sarasota, FL: American Accounting Association.

Franks, P. E. (1987). Consensus in the social sciences: a debate. *Navors. Bull., 17*(7), 43-46.

Fraser, B. J. (1981). *TOSRA, test of science-related attitudes, handbook.* Victoria: The Australian Council for Educational Research Limited.

Fraser, B. J. (1982). How strongly are attitude and achievement related? *School Science Review, 63,* 557-559.

Freeman, M. (2002). Consensus is primary to group facilitation. *Group Facilitation, Spring*(4), 56-58.

Freire, P. (1998). *Pedagogy of freedom: Ethics, democracy, and civic courage.* Lanham: Rowman & Littlefield Publishers, Inc.

Gang, P. (1989). *Rethinking education.* Vermont: Dagaz Press.

Gardner, H. (1993). *Multiple intelligences: The theory into practice.* New York: Basic Books.

Gardner, P. L. (1975). Attitudes to science. *Studies in Science Education, 2,* 1-41.

Gastil, J. (1993). *Democracy in small groups: Participation, decision making, and communication.* Philadelphia: New Society.

George, D. & Mallery, P. (2000). SPSS for windows step by step: A simple guide and reference 9.0 update. Massachusetts: Allyn & Bacon Pearson Education Company.

George, R. (2006). A cross-domain analysis of change in students' attitudes toward science and attitudes about the utility of science. *International Journal of Science Education, 28*(6), 571-589.

Gergen, K. J. (1982). *Toward transformation in social knowledge.* New York: Springer-Verlag.

Gibbs, J. (1994). *Tribes. A new way of learning together.* Santa Rosa, California: Center Source Publications.

Glasman, L. R., & Albaraccin, D. (2006). Forming attitudes that predict future behaviour: A meta-analysis of the attitude-behavior relation. *Psychological Bulletin, 132*(5), 778-822.

Gojkov, G., & Vrsac, M. P. (2012). Postmodern pedagogy. *Journal Plus Education, 14*(2), 9-39.

Gregorc, A. F., & Butler, K. A. (1984). Learning is a matter of style. *VocEd, 59*(3), 27-29.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis, 7th edition.* New Jersey: Pearson Prentice Hall.

Harding, J. (1983). *Switched off: the science education of girls.* New York: Longman.

Hartnett, T. (2012). Thinking flexibly about consensus. *Communities, Winter* (157), 62-63.

Harvey, T. J., & Edwards, P. (1980). Children's expectations and realizations of science. *British Journal of Educational Psychology, 50,* 74-76.

Hendley, D., Parkinson, J., Stables, A., & Tanner, H. (1995). Gender differences in pupil attitudes to the national curriculum foundation subjects of English, mathematics, science and technology in Key Stage 3 in South wales. *Educational Studies, 21,* 85-97.

Hooks, B. (1994). *Teaching to transgress: Education as the practice of freedom.* New York and London: Routledge.

Hsu, C. H. C. (1999). Learning styles of hospitality students: Nature or nurture? *Hospitality Management, 18,* 17-30.

Hudd, S. S. (2003). Syllabus under construction: involving students in the creation of class assignments. *Teaching Sociology, 31*(2), 195-202.

Imam, O. A., Mastura, M. A., Jamil, H., & Ismail, Z. (2014). Reading comprehension skills and performance in science among high school students in the Philippines. *Asia Pacific Journal of Educators and Education, 29,* 81-94.

Inoue, N. (2010). Zen and the art of *neriage*: facilitating consensus building in mathematics inquiry lessons through lesson study. *Journal of Mathematics Teacher Education, 14,* 5-23.

Johnson, D. W., & Johnson, F. P. (1997). *Joining together: Group theory and group skill* (6th ed.). Boston: Allyn and Bacon.

Johnson, S. (1987). Gender differences in science: parallels in interest, experience and performance. *International Journal of Science Education, 9,* 467-481.

Jovanovic, J., & King, S. S. (1998). Boys and girls in the performance-based science classroom: who's doing the performing? *American Educational Research Journal, 35,* 477-496.

Jung, C. G. (1970). *Analytical psychology, theory and practice, the Tavistock lectures.* New York: Vintage Books.

Kahle, J. B., & Lakes, M. K. (1983). The myth of equality in science classrooms. *Journal of Research in Science Teaching, 20,* 131-140.

Keefe, J., & Ferrel, B. (1990). Developing a defensible learning style paradigm. *Educational Leadership, 48*(2), 57-61.

Kennedy, P. (1993). *Preparing for the 21st century.* New York: Random House.

Khanal, L., Shah, S., & Koirala, S. (2014). Exploration of preferred learning styles in medical education using VARK model. *Russian Open Medical Journal, 3*(305), 1-8.

King, A. J., Douglas, C. M. S., Huchard, E., Isaac, N. J. B., & Cowlishaw, G. (2008). Dominance and affiliation mediate despotism in a social primate. *Current Biology, 18,* 1833-1838.

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: enhancing experiential learning in higher education. *Academy of Management Learning and Education, 4*(2), 193-212.

Korkmaz, H. E., & Gumuseli, A. I. (2013). Development of democratic education environment scale. *International Online Journal of Educational Sciences, 5*(1), 82-98.

Kumar, L. R., & Chacko, T. V. (2012). Using appreciative inquiry to help students identify strategies to overcome handicaps of their learning styles. *Educ Health (Abingdon), 25*(3), 160-164.

Larkin, T., & Budny, D. (2005). Learning styles in the classroom: approaches to enhance student motivation and learning. Paper presented at ITHET 6th Annual International Conference, pp F4D1 – F4D8. Doi: 10.1109/ITHET. 2005. 1560310.

Laszlo, E. (1972). *The systems view of the world.* New York: Braziller.

Laycock, M., & Stephenson, J. (1994). Learning contracts: scope and rationale. In M. Laycock, & J. Stephenson (Eds.). *Using learning contracts in higher education (17-25).* London: Kogan Page Ltd.

Lee Jones, C. (1981). The politics of consensus. *The Journal of Academic Librarianship, 7*(2), 156-160.

Li, Y. S., Chen, H. M., Yang, B. H., & Liu, C. F. (2011). An exploratory study of the relationship between age and learning styles among students in different nursing programs in Taiwan. *Nurse Education Today, 31*(1), 18-23.

Limon, M. (2001). On the cognitive conflict as an instructional strategy for conceptual change : a critical appraisal. *Learning and Instruction, 11*, 357–380. Retrieved from www.elsevier.com/locate/learninstruc

Liu, C. H., & Matthews, R. (2005). Vygotsky ' s philosophy : Constructivism and its criticisms examined. *International Education Journal, 6*(3), 386–399. Retrieved from http://files.eric.ed.gov/fulltext/EJ854992.pdf

Lujan, H. L., & Di Carlo, S. E. (2006). First-year medical students prefer multiple learning styles. *Adv Physiol Educ, 30*(1), 160-164.

Lyons, T. (2005). Different countries, same science classes: Students' experiences of school science in their own words. *International Journal of Science Education, 28*(6), 591–614.

Macbeth, J., Schratz, M., Meuret, D., Jakobsen, L. (2000). *Self-evaluation in European schools: A story of change.* London: Routledge.

MacDougall G. (2013). Student-to-student collaboration and coming to consensus. *Science Scope,* 59-63.

Macy, J. (1991). *Mutual causality in Buddhism and General Systems Theory: The dharma of natural systems.* Buffalo, NY: SUNY Press.

Mansbridge, J. J. (1983). *Beyond adversary democracy.* Chicago: University of Chicago Press.

Marcy, V. (2001). Learning styles: How the VARK learning style inventory can be used to improve student learning. *J Assoc Physician Assist Programs, 12*(2), 1-5.

Martin, M. O., Mullis, I. V. S., & Foy, P. (2008). *TIMSS 2007 International science report: Findings from IEA's trends in international mathematics and science study at the fourth and eighth grades.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Maushak, N., Chen, H., Martin, L., Shaw, B., & Unfred, D. (2001). Distance education: looking beyond the no significant difference. *The Quarterly Review of Distance Education, 2*(2), 119-140.

Mayer, R. E. (1996). History of instructional psychology. In E., De Corte and F. E. Weinert (Eds) *International Encyclopaedia of Developmental and Instructional Psychology,* pp. 29-33. Pergamon Press.

McAllister, M. (2010). Solution focused nursing: A fitting model for mental health nurses working in a public health paradigm. *Contemporary Nurse, 34*(2), 149-157.

McInerney, D. M. & McInerney, V. (2002). *Educational Psychology: Constructing Learning* (3rd ed.). Prentice Hall.

McKeachie, W. J., Pintrinch, P. R., Lin, Y., & Smith, D. A. (1986). *Teaching and learning in the college classroom: A review of the research literature.* Ann Arbor: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.

McLeod, G. (2003). "Learning Theory and Instructional Design." *Learning Matters, 2,* 35–53. Retrieved from http://www/courses/durhamtech.edu/tlc/Resources/Learning_Matters.htm

Mitchell, S., Foulger, T. S., Wetzel, K., & Rathkey, C. (2009). The negotiated project approach: project-based learning without leaving the standards behind. *Early Childhood Education Journal, 36,* 339-346.

Moayyeri, H. (2015). The impact of undergraduate students' learning preferences (VARK model) on their language achievement. *Journal of Language Teaching and Research, 6*(1), 132-139.

Moreno-Lopez, I. (2005). Sharing power with students: the critical language classroom. *Radical Pedagogy, 7*(2).

Morrison, K. A. (2009). Making teacher education more democratic. *Educational Horizons, 87*(2), 102-115.

Moscovici, S., & Doise, W. (1994). *Conflict and consensus: A general theory of collective decisions.* London: Sage Publications.

Myers, R. E., & Fouts, J. T. (1992). A cluster analysis of high school science classroom environments and attitudes toward science. *Journal of Research in Science Teaching, 29,* 929-937.

Nielsen, M. E., & Miller, C. E. (1992). Expectations regarding the use of various group decision rules. *Journal of Social Behavior and Personality, 7,* 43-58.

Nielsen, M. E., & Miller, C. E. (1997). The transmission of norms regarding group decision rules. *Personality and Social Psychology Bulletin, 23,* 516-525.

Nolting, P. (2002). *Winning at math: your guide to learning mathematics through successful study skills.* Bradenton, FL: Academic Success Press.

Norwich, B., & Duncan, J. (1990). Attitudes, subjective norm, perceived preventive factors, intentions and learning science: testing a modified theory of reasoned action. *British Journal of Educational Psychology, 60,* 312-321.

Okoye, N. S., & Okecha, R. E. (2008). The interaction of logical reasoning ability and socio-economic status on achievement in genetics among secondary school students in Nigeria. *College Student Journal, 42*(2), 617-624.

Oliver, J. S., & Simpson, R. D. (1988). Influences of attitude toward science, achievement motivation, and science self-concept on achievement in science: a longitudinal study. *Science Education, 72,* 143-155.

Olson, J. F., Martin, M. O., & Mullis, I. V. S. (2008). *TIMSS 2007 Technical Report.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Ong, E. T., & Yeo, C. E. (2012). The effectiveness of jigsaw-II cooperative learning method on student chemistry achievement, interest, interaction level and attitudes. In N. M. Z. Ahmad & R. P. Devadason (Eds.), *Transforming school science education in the 21st century (241-252).* Penang, Malaysia: SEAMEO RECSAM.

Ormerod, M. B., & Duckworth, D. (1975). *Pupils' attitudes to science.* Slough: NFER.

Osborne, J. F., & Collins, S. (2000). *Pupils' and parents' views of the school science curriculum.* London: King's College, London.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049 – 1079, DOI: 10.1080/0950069032000032199

Osman, K., & Kaur, S. J. (2014). Evaluating biology achievement scores in an ICT integrated PBL environment. *Eurasia Journal of Mathematics, Science & Technology Education, 10*(3), 185-194.

Oxford, R., Ehrman, L. M., & Lavine, R. Z. (1991). Style wars: teacher-student style conflicts in the language classroom. In Magnan, S. S. (Ed.), *Challenges in the 1990s for college foreign language programs.* Boston, MA: Heinle & Heinle.

Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. *Psychological Science in the Public Interest, 9*(3), 105-119.

Pearce, J. C. (1992). *Evolution's end: claiming the potential of our intelligence.* New York: HarperCollins Publishers.

Pearce, J. C. (2002). *The crack in the cosmic egg: new constructs of mind and reality.* South Paris, ME: Park Street Press.

Peterson, R., & Eeds, M. (1990). *Grand conversations: Literature groups in action.* New York: Scholastic Project Approach.

Phillips, D. C. (1995). The good, the bad, and the ugly: the many faces of constructivism. *Educational Researcher, 24* (7), 5-12.

Phoenix, D. A. (2000). Looking towards reform – the student focus. *Journal of Biology Education, 34*(4), 171.

Prokop, P., Prokop, M., & Tunnicliffe, S. D. (2007). Is biology boring? Student attitudes towards biology. *Journal of Biology Education, 42*(1), 36-39.

Prokop, P., Tuncer, G., & Chuda, J. (2007). Slovakian students' attitudes towards biology. *Eurasia Journal of Mathematics, Science and Technology Education, 3*(4), 287-295.

Pyritz, L. W., King, A. J., Sueur, C., & Fichtel, C. (2011). Reaching a consensus: Terminology and concepts used in coordination and decision-making research. *International Journal of Primatology, 32,* 1268-1278. DOI 10.1007/s10764-011-9524-9.

Ramsden, J. M. (1998). Mission impossible? Can anything be done about attitudes to science? *International Journal of Science Education, 20*(2), 125-137.

Robertson, I. J. (1987). Girls and boys and practical science. *International Journal of Science Education, 9,* 505-518.

Russell, J., & Hollander, S. (1975). A biology attitude scale. *The American Biology Teacher, 37*(5), 270-273.

Sager, K. L., & Gastil, J. (1999). Reaching consensus on consensus: A study on the relationships between individual decision-making styles and use of the consensus decision rule. *Communication Quarterly, 47*(1), 67-79.

Sager, K. L., & Gastil, J. (2006). The origins and consequences of consensus decision making: a test of the Social Consensus Model. *Southern Communication Journal, 71*(1), 1-24.

Salta, K., & Tzougraki, C. (2004). Attitudes toward chemistry among 11th grade students in high schools in Greece. *Science Education, 88*(4), 535-547.

Sartor, L., & Sutherland, K. (1992). The consensus classroom. *Education Digest, 57,* 47-50.

Sartor, L., & Young Brown, M. (2004). *Consensus in the classroom: fostering a lively learning community.* Mt. Shasta, CA: Psychosynthesis Press.

Savvas, M., El-Kot, G., & Sadler-Smith, E. (2001). Comparative study of cognitive styles in Egypt, Greece, Hong Kong and the UK. *International Journal of Training and Development, 5*(1), 64-73.

Schutt, R. (2001). *Notes on consensus decision-making.* [PDF document]. Retrieved from http://www.vernalproject.org/papers/process/ConsensNotes.pdf

Schwartzman, H. B. (1989). *The meetings: Gatherings in organizations and communities.* New York: Plenum Press.

Schwarz, R. (1994). *The skilled facilitator.* New York, NY: Jossey-Bass.

Shah, Z. A., & Mahmood, N. (2011). Developing a scale to measure attitude towards science learning among school students. *Bulletin of Education and Research, 33*(1), 71-81.

Shimizu, Y. (1999). Aspects of mathematics instruction in Japan: Focusing on teachers' roles. *Journal of Mathematics Teacher Education, 2,* 107-116.

Shor, I., & Pari, C. (2000). *Education is politics: Critical teaching across differences, postsecondary.* Portsmouth: Boynton/Cook.

Simpson, R. D., & Oliver, J. S. (1990). A summary of the major influences on attitude toward and achievement in science among adolescent students. *Science Education, 69,* 511-526.

Sirin, A., & Guzel, A. (2006). The relationship between learning styles and problem solving skills among college students. *Educational Sciences: Theory and Practice, 6*(1), 255-264.

Slavin, R. E. (2000). *Educational Psychology: Theory and Practice.* Boston: Allyn and Bacon.

Smail, B., & Kelly, A. (1984). Sex differences in science and technology among 11 year old schoolchildren: II – affective. *Research in Science and Technology Education, 2,* 87-106.

Smith, P. L., & Ragan, T. J. (1999). *Instructional design (2nd ed.).* USA: John Wiley & Sons, Inc.

Smithers, A., & Robinson, P. (1998). *The growth of mixed A-levels.* Manchester: Department of Education, University of Manchester.

Spengler, O. (1959). *The decline of the West.* London: George Allen & Unwin Ltd. (One volume ed. First published 1918 (Vol. 1); 1922 (Vol. 2).

Stark, R., & Gray, D. (1999). Gender preferences in learning science. *International Journal of Science Education, 21*(6), 633-643.

Stellwagen, J. B. (2001). A challenge to the learning style advocates. *The Clearing House, 74*(5), 265-268.

Sueur, C. & Petit, O. (2008b). Organization of group members at departure is driven by social structure in *Macaca. International Journal of Primatology, 29,* 1085-1098.

Sueur, C., & Petit, O. (2008a). Shared or unshared consensus decision in macaques? *Behavioural Processes, 78,* 84-92.

Sun, K. T., Lin, Y. C., & Yu, C. J. (2008). A study on learning effect among different learning styles in a Web-based lab of science for elementary school students. *Computers & Education, 50*(4), 1411-1422.

Sundberg, M. D., Dini, M. L., & Li, E. (1994). Decreasing course content improves student comprehension of science and attitudes towards science in freshman biology. *Journal of Research in Science Teaching, 31,* 679-693.

Talisayon V. M., de Guzman F.S., & Balbin C.R. (2006). Science-related attitudes and interests of students. Paper presented at the XII IOSTE Symposium: Science and Technology Education in the service of Humankind, Penang, Malaysia. http://roseproject.no/network/countries/philippines/phl-talisayon-ioste2006.pdf

Tanner, K., & Allen, D. (2005). Approaches to biology teaching and learning: understanding the wrong answers – teaching toward conceptual change. *Cell Biology Education, 4,* 112-117.

Tekkaya, C., Ozkan, O., & Sungur, S. (2001). Biology concepts perceived as difficult by Turkish high school students. *Journal of Education, 21,* 145-150.

Thomas, G. E. (1986). Cultivating the interest of women and minorities in high school mathematics and science. *Science Education, 73,* 243-249.

TIMSS (1999). Trends in mathematics and science achievement around the world. Retrieved from http://timss.bc.edu/timss1999.html

Turner, J. C., Meyer, D. K., Cox, K. E., Logan, C., DiCintio, M., & Thomas, C. T. (1998). Creating contexts for involvement in mathematics. *Journal of Educational Psychology, 90,* 730-745.

Tytler, R. (2007). *Re-imagining science education: Engaging students in science education for Australia's future.* Victoria, Australia: ACER Press.

UNESCO (2010). *Current challenges in basic science education.* Paris: Author.

Usak, M., Prokop, P., Ozden, M., Ozel, M., Bilen, K., & Erdogan, M. (2009). Turkish university students' attitudes towards biology: The effects of gender and enrolment in biology classes. *Journal of Baltic Science Education, 8*(2), 88-96.

Vaughn, L., & Baker, R. (2001). Teaching in the medical setting: balancing teaching styles, teaching styles and teaching methods. *Med Teach, 23*(6), 610-612.

Voigt, J. (1991). Negotiation of mathematical meaning in classroom processes: social interaction and learning mathematics. In L. P. Steffe, P. Nesher, P. Cobb, G. A. Goldin, & B. Greer (Eds.), *Theories of mathematical learning.* Mahwah, NJ: Lawrence Erlbaum Associates.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychology process.* Cambridge, MA: Harvard University Press.

Waghid, Y. (2014). *Pedagogy out of bounds: Untamed variations of democratic education.* Rotterdam, The Netherlands: Sense Publishers.

Walker, J. M. T. (2008). Looking at teacher practices through the lens of parenting style. *Journal of Experimental Education, 76,* 218-240.

Wandersee, J.H., Mintzes, J.J., and Novak, J.D. (1994). Research on alternative conceptions in science. In D. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning (177-210),* New York: Simon &Schuster Macmillan.

Weinburgh, M. (1995). Gender differences in student attitudes toward science: a meta-analyses of literature from 1970 to 1991. *Journal of Research in Science Teaching, 32,* 387-398.

Wertsch, J. V. (1992). L. S. Vygotsky and contemporary developmental psychology. *Developmental Psychology, 28* (4), 548-557.

Wilkinson, T., Boohan, M., & Stevenson, M. (2014). Does learning style influence academic performance in different forms of assessment? *Journal of Anatomy, 224,* 304-308.

Williams, R. (1976). *Keywords.* London: Fontana.

Wolk, S. (1998). *A democratic classroom.* Portsmouth: Heinemann.

Woolfolk, A. (2001). *Educational Psychology (8th ed.).* Allyn and Bacon.

Woolnough, B. (1994). *Effective science teaching.* Buckingham: Open University Press.

Wu, D. C. (2014). Learning styles and satisfaction in distance education. *Turkish Online Journal of Distance Education, 15*(4), 112-130.

Yilmaz, K. (2008). Constructivist Suggestions Constructivism: Its Theoretical Underpinnings, Variations, and Implications for Classroom Instruction. *Educational Horizons.* Retrieved from http://eric.ed.gov/?id=EJ798521

Yusuf, M. O., & Afolabi, A. O. (2010). Effects of computer assisted instruction (CAI) on secondary school students' performance in biology. *The Turkish Online Journal of Educational Technology, 9*(1), 62-69.

Zhang, L., Sternberg, R. J., & Fan, J. (2013). Revisiting the concept of 'style match'. *British Journal of Educational Psychology, 83,* 225-237.

APPENDICES

Appendix A

Letter of Permit to the Vice President for Academic Affairs

24 November 2015

DR. ELVIN F. GAAC
Vice President for Academic Affairs
This University

Sir:

Greetings of peace and prosperity!

I would like to seek permission to implement in the University my dissertation proposal entitled **Consensus-Based Instruction in Biology: Effects on Students' Attitudes and Achievement**. This is in partial fulfilment of the requirements for the degree, PhD in Education major in Biology Education from the University of the Philippines Open University, of which I am currently enrolled as a CHED-FDP II partial scholar. The intervention will be implemented within the context of the topic 'bioenergetics', a learning unit in the course NatSci 102 (Biological Science), which is offered this semester at the College of Business and Accountancy.

Rest assured that ethical measures will be observed in the course of data collection and other research activities (see attached).

May this request merit your approval. More power and may God bless you indeed!

Respectfully yours,

Researcher

Appendix B

Letter of Permit to the Dean

4 January 2016

DR. EMELYN F. MONTOYA
Dean, College of Business and Accountancy
This University

Madam:

Greetings of peace and prosperity!

Attached is my request approved by the Vice President for Academic Affairs to implement the proposed instructional intervention, which is my dissertation, among the students enrolled in the course Biological Science in your College. The intervention will cover the unit about Bioenergetics.

Rest assured that ethical measures will be observed in the course of data collection and other research activities

Thank you for your support. More power and may God bless you indeed!

Respectfully yours,

Appendix C

Profiles of Validators

- **For Content Validation of Bioenergetics Achievement Test (BAT)**
  - **Validator 1:** 54 years old; female; Associate Professor V at UPLB specializing in plant physiology, biochemistry and molecular biology; with 25 years of experience in the discipline; graduated PhD in Biochemistry from UPLB.
  - **Validator 2:** female; Professorial Lecturer at Institute of Biology UP-Diliman handling biology and animal developmental biology; with 30 years of experience in the discipline; graduated PhD in Zoology from UP Diliman.
  - **Validator 3:** 39 years old; female; University Researcher at IBS, CAS, UPLB with a PhD degree in genetics from UPLB with 18 years of experience in practicing her discipline.
  - **Validator 4:** 32 years old; female; Associate Professor at Saint Louis University in Baguio City with a PhD degree in plant biology from SLU; with 11 years of experience in practicing the discipline.

- **For Validation of Bioenergetics Achievement Test (BAT) Items based on TIMSS Taxonomy of Cognitive Domains**
  - **Validator 1:** 55 years old; female; MAED in Biology Education from UP Diliman; Science Education Specialist II at UP NISMED; with 31 years of practicing biology education.
  - **Validator 2:** Science education specialist from UP NISMED; requested to be incognito.

- **For Learning Needs Analysis Protocol (LNAP), Attitude Towards Biology Scale (ATBS) and Questionnaire on Importance of Democratic Practices in Classroom (QIDPC)**
  - **Validator 1:** 33 years old; male; PhD in Biology Education from UPOU; Instructor 1 at WVSU in La Paz, Iloilo City; 13 years of experience in biology education.
  - **Validator 2:** 41 years old; female; PhD in Educational Management from PNU-Taft with master's in science education; Associate Professor at DLSU in Lipa City, Batangas; 21 years of experience in science education.
  - **Validator 3:** 55 years old; female; PhD in Educational Psychology major in Quantitative analysis from DLSU-Taft with master's in science education from Marikina Institute of Science and Technology; Campus Director at Romblon State University in San Fernando Campus in Sibuyan island; 33 years of experience in science education.

Appendix D

Letter to Validators of Learning Needs Analysis Protocol (LNAP), estionnaire on Importance of Democratic Practices in Classroom (QIDPC) and Attitude Towards Biology Scale (ATBS)

October 2015

Dear Validator,

Greetings!

My name is EDDIE G. FETALVERO, a graduate student of the University of the Philippines Open University in the program PhD Educ (Biology Educ). I am currently on the stage of validating instruments for my dissertation paper which is about Consensus-Based Instruction. May I ask a fraction of your time to look into the appropriateness of the following instruments by accomplishing the validation form which can be accessed and done on-line: http://goo.gl/forms/vZ4lbq0blL

- LEARNING NEEDS ANALYSIS PROTOCOL
- IMPORTANCE OF DEMOCRATIC PRACTICES QUESTIONNAIRE
- ATTITUDE TOWARDS BIOLOGY SCALE

I will appreciate if you could accomplish the forms on or before October 23, 2015. Thank you so much for your time and effort. More power and may God bless you indeed!

Respectfully yours,

EDDIE G. FETALVERO

VALIDATION FORMS

Part 1. PROFILE OF VALIDATORS
Directions. Kindly fill up the information asked or tick the option that describes you.

* Required

1. **Name ***

2. **Sex ***
   Check all that apply.
   ☐ Male
   ☐ Female

3. **Age (In years as of last birthday) ***

4. **Current Designation/Position ***

5. **Institution ***

6. **Address of Institution**

7. **Number of Years of Experience in the Field of Science/Biology Education ***

8. **Specialization in PhD or EdD Degree ***

9. **Institution where PhD or EdD degree obtained**

Part 2. Learning Needs Analysis Protocol

This is a proposed protocol modified from Blinne (2013) that will be used in assessing students' learning needs through a teacher-facilitated class meeting and discussion.

PROPOSED LEARNING NEEDS ANALYSIS PROTOCOL

1. Content Areas of Greatest Interest to the Class
   a. Given the lessons to be discussed in bioenergetics, which area are you most interested at? Why?
2. Goals, Expectations and Learning Needs of the Class
   a. What is that primary goal that you want to achieve after studying bioenergetics?
   b. What are your expectation on the following:
      i. Topic
      ii. Teacher
      iii. Classmates
      iv. Teacher-Student Interactions
      v. Student-student interaction

   c. What are your limitations that you think might hinder you from learning the topic well?

   d.Do you want to change or add some topics to be learned related to the unit? Why?
3. Preferred Medium of Instruction
   a. What is the medium of instruction do you prefer? Why?

4.Preferred Learning Environment
   a.How would you want your classroom be structured? Why?

5. Preferred Teaching Approach
   a. How would you want the topics to be taught?
   b. What activities do you suggest aside from the ones provided in the syllabus?

10. **Are the questions included in the protocol relevant to determine the learning needs of the students?**

Mark only one oval.

○ Yes

○ No

○ Other: ____________________

11. **What you may suggest to improve the protocol?**

____

____

____

____

____

Part 3. Questionnaire for the Importance of Democratic Practices in Classroom

This is a 10-item researcher-made instrument which will determine students' perceptions about democratic practices in the classroom. Responses are categorized along a five-point Likert type scale: 5 = Very Important; 4 = Important; 3 = Moderately Important; 2 = Slightly Important; 1= Not Important.

The directions for respondents will be worded as these:
Each of the statements below signifies some processes that are happening in the classroom. This is not a test. You will not be scored. Please rate each process on the extent of how important this is for you. For each, you may encircle the following number codes with their corresponding descriptors:

5 = Very Important
4 = Important
3 = Moderately Important
2 = Slightly Important
1= Not Important.

12. **Kindly evaluate the appropriateness of the items with respect to democratic practices in classroom. ***
Mark only one oval per row.

	Relevant	Fairly Relevant	Irrelevant	Needs Revision
1. The responsibility to learn is shared between the teacher and the students.	○	○	○	○
2. Students participate in making decisions that affect their learning (i.e. class rules and sanctions, formulation of instructional methods and materials, evaluation elements etc.)	○	○	○	○
3. Students' voices, views and ideas are freely expressed and heard.	○	○	○	○
4. Topics reflect students' interests and are connected to their daily lives.	○	○	○	○
5. Teacher considers students' learning styles.	○	○	○	○
6. Teacher considers students' learning needs and difficulties.	○	○	○	○
7. Teacher involves students in designing class lessons and activities.	○	○	○	○
8. Teacher and students discuss instructional issues together and arrive at a decision that is acceptable to everyone.	○	○	○	○
9. Teacher provides opportunities for students to negotiate instruction and take control of their learning.	○	○	○	○
10.Democratic principles are practiced inside the classroom.	○	○	○	○

13. **From those items that you rated as needing revision, please specify the specific revision you want to be done. Please feel free also to comment in order to improve the items. You may also suggest items.**

Part 4. Items for Attitudes Towards Biology Scale

This is a 66-item researcher-made instrument containing items about the reported components of students' attitudes towards science (pooled from literature), which was replaced with the word "biology", such as specific feelings towards biology, motivation to achieve in biology, biology anxiety, attitude towards biology teacher, attitude towards biology curriculum, keennees to learn biology, enjoyment in biology learning, disinterest, teacher interaction, importance of biology, interest in biology lessons and understanding of biology processes. Students' responses to these items will be FACTOR ANALYZED (exploratory) to extract the COMPONENTS of their attitudes towards biology.

Responses are categorized along a five-point Likert type scale: 1 = strongly disagree; 2= disagree, 3= be undecided, 4 = agree, or 5= strongly agree.

The directions for the respondents will be worded as these:
Directions. Each of the statements below expresses a feeling toward biology. Please rate each statement on the extent to which you agree. For each, you may (1) strongly disagree, (2) disagree, (3) be undecided, (4) agree, or (5) strongly agree. There are no correct answers. This is not a test. You will not be scored. Just honestly encircle the number code as best you can.

14. **Kindly validate if the following items are relevant in measuring students' attitudes towards biology.**
Mark only one oval per row.

	Relevant	Fairly Relevant	Irrelevant	Needs Revision
1. I enjoy learning biology.	○	○	○	○
2. Biology is boring.	○	○	○	○
3. I really like biology.	○	○	○	○
4. Biology is fascinating and fun.	○	○	○	○
5. I have good feelings towards biology.	○	○	○	○
6. I would enjoy being a biologist.	○	○	○	○
7. Biology is a very interesting subject.	○	○	○	○
8. I do not like biology and it scares me to have to take it.	○	○	○	○
9. I am always under a terrible strain in a biology class.	○	○	○	○
10. Biology makes me feel secure and at the same time it is stimulating.	○	○	○	○
11. Biology makes me feel uncomfortable, restless, irritable and impatient.	○	○	○	○
12. When I hear the word 'biology,' I have a feeling of dislike.	○	○	○	○
13. I approach biology with a feeling of hesitation.	○	○	○	○
14. It makes me feel nervous to even think about doing an experiment in biology.	○	○	○	○
15. I feel at ease in biology and I like it very much.	○	○	○	○
16. I feel a definite positive reaction to biology because it is enjoyable.	○	○	○	○
17. I feel real pleasure in my biology class.	○	○	○	○
18. I like biology more than other subjects.	○	○	○	○
19. Biology lessons are difficult for me.	○	○	○	○
20. I would like to have biology lessons more often.	○	○	○	○
21. I hate biology lessons.	○	○	○	○
22. Biology is one of the easiest subjects for me.	○	○	○	○

15. **For Items 1-22, what are your suggestions for those you rated to be needing revisions?**

____

____

____

	Relevant	Fairly Relevant	Irrelevant	Needs Revision
23. Biology lessons become a source of boredom for me.	○	○	○	○
24. The lessons taught in biology are not interesting.	○	○	○	○
25. I cannot understand the biology lessons after class.	○	○	○	○
26. I do not have the interest to discuss biology topics after the school time.	○	○	○	○
27. I do not have the interest to complete my homework in biology.	○	○	○	○
28. Biology makes me feel as though I am lost in the jungle of terms.	○	○	○	○
29. My mind goes blank when I am studying biology.	○	○	○	○
30. Biology tests make me nervous.	○	○	○	○
31. I would not probably do well in courses related to biology.	○	○	○	○
32. I always try hard no matter how difficult the lesson in biology is.	○	○	○	○
33. When I fail in biology exam, I always try much harder.	○	○	○	○
34. I always try to do my best in biology.	○	○	○	○
35. I try hard to do well in biology.	○	○	○	○
36. My biology teacher encourages me to learn more about biology.	○	○	○	○
37. I enjoy talking to my biology teacher after class.	○	○	○	○
38. My biology teacher makes good plans for us.	○	○	○	○
39. Sometimes, my biology teacher makes me feel I am unintelligent.	○	○	○	○
40. My biology teacher expects me to get good grades.	○	○	○	○
41. Whenever I want to ask anything about biology, I consult my biology teacher.	○	○	○	○
42. I consult my biology teacher in any topic/s that I cannot understand during science class.	○	○	○	○
43. The important points emphasized by my teacher during class discussion helps me in learning biology.	○	○	○	○
44. We do a lot of fun activities in biology class.	○	○	○	○

17. **For items 23-44, what are your suggestions for those you rated to be needing revisions?**

	Relevant	Fairly Relevant	Irrelevant	Needs Revision
45. We learn important things in biology class.	○	○	○	○
46. We cover interesting topics in biology class.	○	○	○	○
47. I like our biology textbook/reference.	○	○	○	○
48. Biology knowledge is essential for understanding other courses and phenomena.	○	○	○	○
49. The progress of biology improves the quality of our lives.	○	○	○	○
50. Biology is our hope for solving many environmental problems.	○	○	○	○
51. Biology is not important in comparison with other courses.	○	○	○	○
52. Biology is important part of our lives.	○	○	○	○
53. Nobody needs biology knowledge.	○	○	○	○
54. Biology helps in the development of my conceptual skills.	○	○	○	○
55. I make many efforts to understand biology.	○	○	○	○
56. I find biological processes very interesting.	○	○	○	○
57. The work with living organisms in biology lessons is very interesting.	○	○	○	○
58. I follow a regular schedule to study biology at home.	○	○	○	○
59. I understand biology lessons taught in class by the teacher.	○	○	○	○
60. I can focus in biology lessons.	○	○	○	○
61. I review lessons in biology daily at home.	○	○	○	○
62. I complete first my home work in biology before doing other things.	○	○	○	○
63. During biology lectures, I can comprehend the important points.	○	○	○	○
64. I fully concentrate on the topic discussed in my biology class.	○	○	○	○
65. I can explain biology concepts in my own words.	○	○	○	○
66. I usually relate the previously learned lessons in biology with the new one.	○	○	○	○

19. For items 44-66 what are your suggestions for those you rated to be needing revisions?

Appendix E

Letter to Content Validators of the Achievement Test

4 October 2015

Dear Content Validator,

Greetings!

I am EDDIE G. FETALVERO, a graduate student of UP Open University taking up PhD in Education major in Biology Education. I am currently doing my dissertation about Consensus-Based Instruction and now on the process of validating my research instruments. One of the dependent variables of my study is student's achievement in bioenergetics, a unit included in the GE course NatSci 102. The target students who will be taking the test are the freshmen from the College of Business and Accountancy.

Your expertise will greatly help improve the instrument in order to yield valid and reliable results. Attached is the proposed test. Kindly inspect the questions and highlight those that are not clear and have some grammatical issues. After which, please check whether the questions are consistent with the topics indicated in the course syllabus. Most of the questions are based from students' misconceptions as reported in literature.

After your suggestions are incorporated, this test will be sent to science education experts to determine the cognitive level measured by the items according to the TIMSS framework for science cognitive domains.

I will appreciate if you could e-mail me back your inputs on or before October 18, 2015. More power and may God bless you indeed!

Respectfully yours,

PROPOSED ACHIEVEMENT TEST IN BIOENERGETICS

The topics to be covered and the objectives of the Unit for Bioenergetics in the Course Syllabus (based on the proposed K to 12 Grade 11 curriculum guide for Core Courses) are the following:

- Metabolism
- Photosynthesis
- Cellular Respiration

Objectives:
At the end of the unit, students are expected to:

- explain how cells carry out functions required for life.
- explain how photosynthetic organisms use light energy to combine carbon dioxide and water to form energy-rich compounds.
- trace the energy flow from the environment to the cells.
- describe how organisms obtain and utilize energy.
- recognize that organisms require energy to carry out functions required for life.
- make a poster that shows the complementary relationship of photosynthesis and cellular respiration.

PROFILE OF VALIDATOR

Before proceeding to the items, kindly provide some information about you. Thank you.

Name:	
Sex:	[ ] Male [ ] Female
Age (In years as of last birthday):	
Current position/designation:	
Institution:	
Field/s of Discipline:	
Nos. of years practicing the discipline:	
Specialization in PhD:	
Institution where PhD was obtained:	

TOPIC: METABOLISM (6 items). Correct answer is in red.

___1. Using a microscope, a student observes a small, green organelle in a plant cell. Which energy transformation most likely occurs within the observed organelle?

A. ATP to light
B. Light to chemical
C. Heat to electrical
D. Chemical to chemical

Is this item consistent with the topic metabolism? [ ] Yes [ ] No

Validator's Comment:

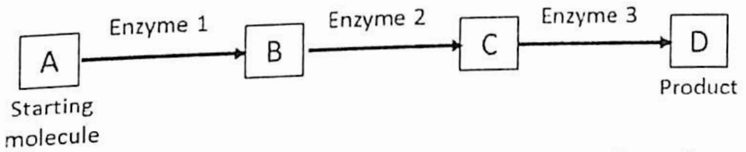
___2. Carbon dioxide and water are low energy molecules compared to the carbohydrate product formed when they are chemically combined under the aid of sunlight. What kind of reaction does this illustrate?

A. Endergonic reaction
B. Exergonic reaction
C. Oxidation reaction
D. Decomposition reaction

Is this item consistent with the topic metabolism? [ ] Yes [ ] No

Validator's Comment:

___3. Study this metabolic pathway.



Which of the following is NOT correct about the pathway?

A. A is the substrate for enzyme 1 and B is the product.
B. Enzyme 1 catalyzes substrate A to produce B.
C. Enzymes 2 can catalyze the substrates B, C, and D.
D. A is a reactant in the first reaction that forms the product B.

Is this item consistent with the topic metabolism? [ ] Yes [ ] No

Validator's Comment:

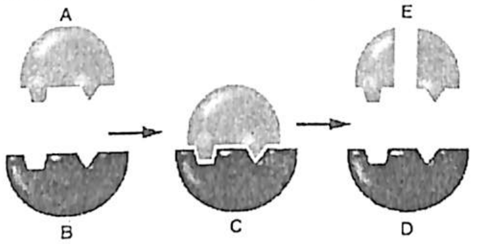
___4. For a bird, the energy to keep itself alive comes ultimately from

A. the worm it just ate.
B. the oxygen in the air.
C. the seeds it just ate.
D. the sun.

Is this item consistent with the topic metabolism? [ ] Yes [ ] No

Validator's Comment:

___5. The figure illustrates a chemical reaction catalyzed by an enzyme.

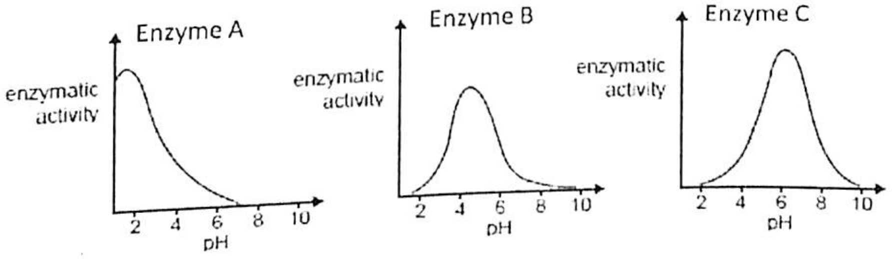


All of the following statements about the reaction are true EXCEPT
A. A is a substrate
B. B and D are enzymes
C. B catalyzes A and becomes E
D. D and E are products of the reaction

Is this item consistent with the topic metabolism? [ ] Yes [ ] No

Validator's Comment:

___6. Examine the following graphs showing the relationship between pH and enzymatic activity.



From these graphs, it is reasonable to infer that at a pH of 4
A. enzyme C would be inactive.
B. all the enzyme A will be denatured.
C. all the three enzymes would lack a functional active site.
D. enzyme B has the highest activity of the three enzymes.

Is this item consistent with the topic metabolism? [ ] Yes [ ] No

Validator's Comment:

TOPIC: PHOTOSYNTHESIS (13 items)

___1. Which of the following materials needed for photosynthesis is converted to food and contributes most to plant's mass?

A. Carbon dioxide
B. Sunlight
C. Water
D. Minerals

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___2. Which of the following does NOT occur during the Calvin cycle?

A. Carbon fixation
B. Oxidation of NADPH
C. Release of oxygen
D. Regeneration of the CO_2 acceptor

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___3. The oxygen released during photosynthesis comes from

A. Carbon dioxide
B. Water
C. NADPH
D. Glucose

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___4. The following are needed during the light-dependent phase of photosynthesis EXCEPT

A. light
B. water
C. chlorophyll
D. carbon dioxide

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___5. Which of the following processes is carried out more efficiently by a C_4 plant than by a C_3 plant?

A. Light absorption
B. Photolysis
C. Fixation of carbon dioxide
D. Transport of sugars

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

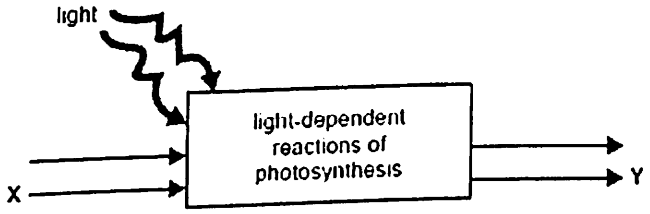
___6. Which of the following pairs of location and process related to photosynthesis is not correctly matched?

A. Thylakoid membrane: use of carbon dioxide
B. Thylakoid membrane: production of oxygen
C. Stroma: Calvin cycle
D. Stroma: production of sugar

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___7. The following diagram shows a simplified representation of the first stage of photosynthesis.



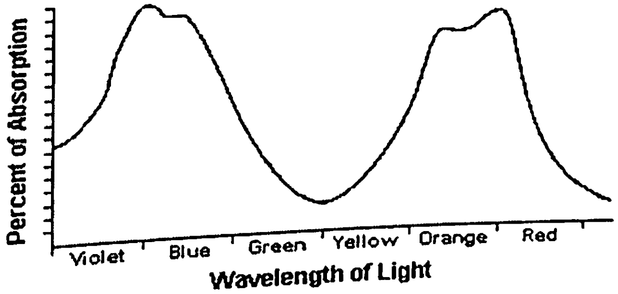
What does the input item X represent?

A. glucose
B. water
C. carbon dioxide
D. Either carbon dioxide or water

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___8.



The graph represents the absorption spectrum of chlorophyll. The graph indicates that the energy used in photosynthesis is most likely obtained from which regions of the spectrum?

A. Yellow and orange red
B. Violet blue and green
C. Orange red and violet blue
D. Green and yellow

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___9.

Which is the correct order by which light energy is absorbed by photosystems in the thylakoid membrane of the chloroplast?

1. Pigment molecules in the antenna complexes absorb energy from the incoming light.
2. One of the electrons in the pair of chlorophyll molecules becomes excited.
3. Electron is passed to an electron transport chain.
4. Energy is transferred to a reaction center consisting of a particular pair of chlorophyll molecules.

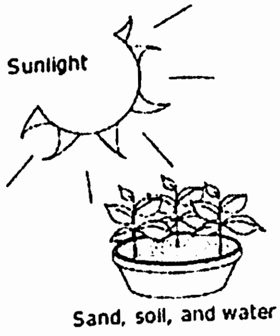
A. 1, 2, 3, 4
B. 1, 4, 2, 3
C. 1, 3, 4, 2
D. 1, 2, 4, 3

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

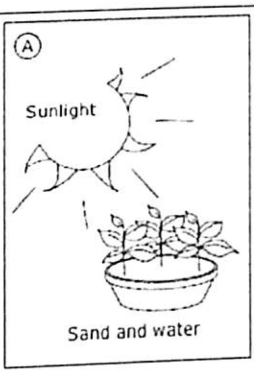
Validator's Comment:

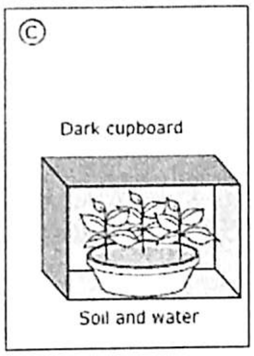
___10.

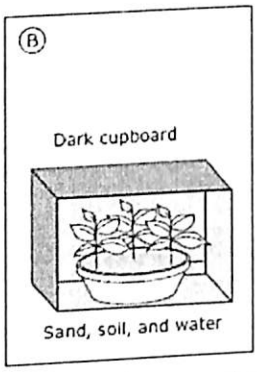
A girl has an idea that green plants need sunlight for healthy growth. In order to test her idea, she uses two pots of plants. She sets up one pot of plants as shown below.

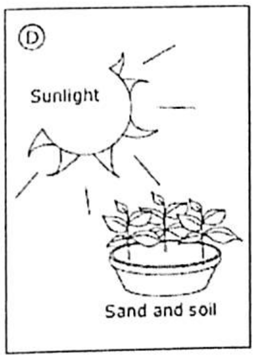


Which ONE of the following should she use for the second pot of plants? (B)









Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

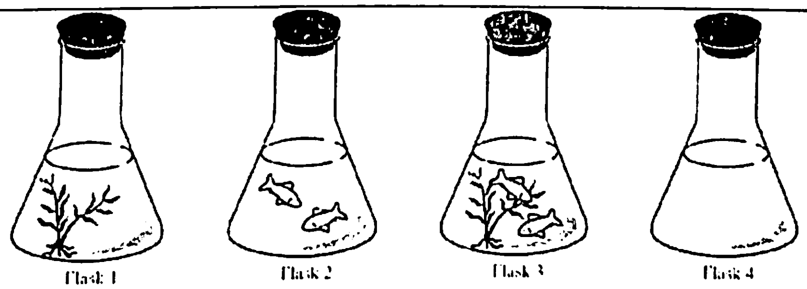
Validator's Comment:

___11. The box below shows a list of supplies that are available in the laboratory.

- Four flasks with stoppers
- Tap water
- Flasks
- Small aquarium plants
- Four small fish
- Bromothymol blue (a chemical indicator that changes color from blue to yellow as the level of carbon dioxide in a solution increases).

The class sets up an experiment with the four flasks as shown.

Flask 1: 100 mL water, 1 mL bromothymol blue, plant
Flask 2: 100 mL water, 1 mL bromothymol blue, 2 small fish
Flask 3: 100 mL water, 1 mL bromothymol blue, 2 small fish, plant
Flask 4: 100 mL water, 1 mL bromothymol blue



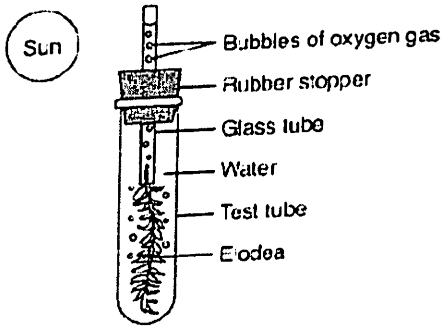
All four flasks are stoppered and placed under equal amount of sunlight. Which flasks will have yellow color after a few hours?

A. 1 only
B. 2 only
C. 1 and 3
D. 2 and 4

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___12. Yaya Dub placed a small water plant in bright sunlight for five hours as indicated by the set-up below. She observed bubbles of oxygen gas being released from the plant.



Since oxygen gas is being released, it can be inferred that the plant is

A. Producing glucose
B. Transpiring
C. Releasing energy from water
D. Respiring

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

___13. A student investigated the effect of temperature on the rate of photosynthesis in a water plant. The results are shown in the following table.

Temperature °C	Volume of oxygen released per cm^3 per 5 minutes
5	2
15	4
25	7
35	10
45	12

Which of the following statements accurately describes the relationship between temperature and rate of photosynthesis?

A. At 45°C, the water plant produced the most amount of oxygen.
B. As the temperature increases, the amount of carbon dioxide absorbed by the plant also increases.
C. As the temperature increases, the rate of photosynthetic activity becomes faster.
D. As the temperature increases, the amount of oxygen released by the water plant doubles.

Is this item consistent with the topic photosynthesis? [ ] Yes [ ] No

Validator's Comment:

TOPIC: CELLULAR RESPIRATION (16 items)

1. Cellular respiration releases energy by breaking down
   - A. food molecules
   - B. ATP
   - C. carbon dioxide
   - D. oxygen

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___2. The products of aerobic respiration in a mammalian cell are
   - A. water, ATP and oxygen
   - B. water, ATP and carbon dioxide
   - C. lactic acid and ATP
   - D. ethanol and ATP

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___3. Which of the following molecules passes high-energy electrons into the electron transport chain?
   - A. NADH and $FADH_2$
   - B. ATP and ADP
   - C. Citric acid
   - D. Acetyl-CoA

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___4. Glycolysis, a pathway that is common to both fermentation and aerobic respiration, begins with ___________ and ends with ___________.
   - A. glucose; pyruvate
   - B. glucose; acetyl CoA
   - C. glucose; carbon dioxide
   - D. glucose; ATP

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

____5. Which of the following statements is NOT correct about fermentation in animal cells?

A. It can provide a rapid burst of ATP when there is limited oxygen supply.
B. In our bodies, muscle cells more than other cells are likely to carry out fermentation.
C. Pyruvate can build up in muscles, changing the pH and causing the muscles to fatigue.
D. Only animal cells can carry out fermentation.

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

____6. In cellular respiration, which of the following processes does not match with its specific location?

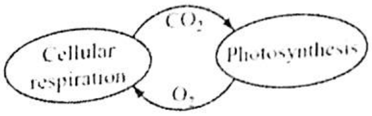
A. transition reaction: matrix of mitochondrion
B. electron transport chain: cristae of mitochondrion
C. Krebs cycle : intermembrane space of mitochondrion
D. Glycolysis: cytosol

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

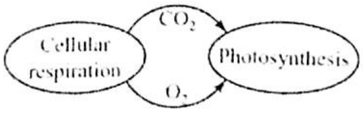
Validator's Comment:

____7. Which of the following diagrams accurately represents the use of gases in both cellular respiration and photosynthesis? (A)

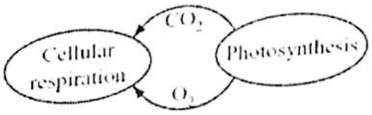
A.



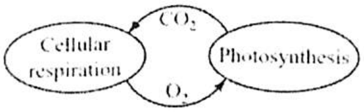
C.



B.



D.



Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___8. Which of the following products of Krebs cycle will diffuse out of the cell, enter the bloodstream, and be released from the lungs during aerobic cellular respiration?

A. Carbon dioxide
B. ATP
C. Oxygen
D. Electron carriers

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___9. The table shows the relationship of glucose molecules used to gas molecules released during cellular respiration.

Number of glucose molecules used during respiration	Number of gas molecules released during respiration
1	6
2	12
3	18
4	24

Which cellular process would result in a cell releasing 120 gas molecules?

A. The mitochondria converting 20 glucose molecules into carbon dioxide.
B. The chloroplasts converting 30 glucose molecules into carbon dioxide.
C. The mitochondria converting 30 glucose molecules into oxygen.
D. The chloroplasts converting 20 glucose molecules into oxygen.

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___10. Yeast, a common fungus, is economically important to the beverage industry because when placed in grape juice, it

A. releases sugars that react with alcohol in the juice
B. acts as an enzyme to break down juice into alcohol
C. ferments carbohydrates in the juice and releases alcohol
D. produces starch that bonds with juice sugars to form alcohol

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___11. When an animal has to survive without food for a long time, it will eventually break down proteins for energy. However, this process occurs only after exhausting the animal's reserves of

A. carbohydrates only
B. lipids only
C. both carbohydrates and lipids
D. carbon dioxide and water

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___12. Humans engage in cellular respiration. Which other living things engage in cellular respiration?

I. Snail
II. Bacteria
III. Rose plant
IV. Cow
V. Mushroom

A. IV only
B. I, II and III only
C. I, II, IV and V only
D. I, II, III, IV and V

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___13. The following are involved in the process of cellular respiration:

I. Energy
II. Carbohydrates
III. Carbon dioxide
IV. Water
V. Oxygen

Which one of the following combinations correctly represents their involvement in the above process?

A. II + III → I + IV + V
B. II + IV → I + III + V
C. I + II → III + IV + V
D. II + V → I + III + IV

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___14. During aerobic respiration, electrons travel downhill in which sequence?

A. Food → NADH/FADH$_2$ → electron transport chain → oxygen

B. Glucose → pyruvate → ATP → oxygen

C. Glucose → ATP → electron transport chain → NADH/FADH$_2$

D. Food → glycolysis → Krebs cycle → NADH/FADH$_2$ → ATP

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___15. A weightlifter is using heavy weights in short bursts for a competition. Because his muscle cells are not able to take in enough oxygen to make very much ATP, the weightlifter begins to get fatigue in his muscles. Which of the following processes is most likely going on in the muscles of the weightlifter as he competes in his event?

A. As the cells run out of oxygen, they switch to anaerobic respiration which allows the cell to make small amounts of ATP in the absence of oxygen.

B. As the cells run out of oxygen, they die off gradually and the weightlifter's muscles have fewer contracting muscle cells.

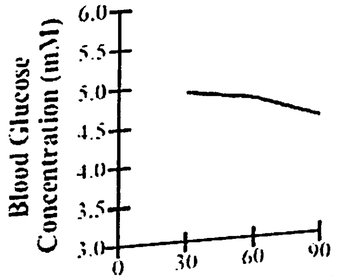
C. The cells will never run out of oxygen if the weightlifter is breathing

D. As the cells run out of oxygen, they will continue to make the same amount of ATP, since oxygen is not required to make ATP.

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

___16. The graph below shows the change in blood glucose level during prolonged exercise.



Which of the following statements explains the change in blood glucose level shown in the graph?

A. Glucose was broken down to produce ATP for energy

B. Glucose diffused from muscle cells into the bloodstream

C. Proteins combined with glucose to produce ADP for energy

D. Polysaccharides were made from glucose in metabolic pathways.

Is this item consistent with the topic cellular respiration? [ ] Yes [ ] No

Validator's Comment:

Appendix F

Letter to Validators of the Bioenergetics Achievement Test Items Based on TIMSS Taxonomy of Cognitive Domains

3 November 2015

Dear Item Validator,

Greetings!

I am [illegible] G. FETALVERO, a graduate student of UP Open University taking up PhD in Education major in Biology Education. I am currently [illegible] Co[illegible] in the process of validating [illegible] dissertation about [illegible]-Based Instruction and [illegible] study is [illegible] my research [illegible]. One of the dependent variables [illegible] students' achievement will be [illegible], a topic included in the GE courses [illegible]. The target students who will be taking the test are the freshmen from the College of Business and Accountancy.

You[illegible] help improve the instrument in order to yield valid and reliable results. Attached is the proposed test which has already [illegible] by experts from [illegible] for your [illegible] check whether the content validated [illegible] made [illegible] from URD and JPLB. [illegible] whether the initial appraisal by the researcher about the cognitive levels is correct [illegible] items according to [illegible] framework for science cognitive domain [illegible] free to [illegible] and highlight your comments and feedback. You may use the Track Changes function of the MS Word's Review Menu.

I will [illegible] your inputs on or before November 9, 2015. More power and may God bless you. [illegible]

Respectfully yours,

[illegible]vero
efetalvero@gmail.c
[illegible]t: 0919-9809098

SCIENCE COGNITIVE DOMAINS

KNOWING (35%)

- Covers science facts, procedures and concepts students need to know.
    - Recall or recognize appropriate science statements
    - Possess knowledge of vocabulary, facts, information, symbols and units
    - Select appropriate apparatus, equipment, measurement devices, and experimental operations to use in conducting investigations
    - Select illustrative examples in support of statement of facts or concepts.

1. Recall/ Recognize	Make or identify accurate statements about science facts, relationships, processes, and concepts; identify the characteristics or properties of specific organisms, materials and processes.
2. Define	Provide or identify definitions of scientific terms; recognize and use scientific vocabulary, symbols, abbreviations, units and scales in relevant contexts.
3. Describe	Describe organism, physical materials, and science processes that demonstrate knowledge of properties, structure, function and relationships.
4. Illustrate with examples	Support or clarify statements statement of facts or concepts with appropriate examples; identify or provide specific examples to illustrate knowledge of general concepts.
5. Demonstrate knowledge of scientific instruments	Demonstrate knowledge of how to use science apparatus, equipment, tools, measurement devices and scales.

APPLYING (35%)

- Focuses on the ability of the student to apply knowledge and conceptual understanding to a science problem
  - Require students to compare, contrast and classify
  - Interpret scientific information in light of a science concept or principle
  - Use and apply understanding of science concepts and principles to find a solution or develop an explanation.
  - Involve the direct application or demonstration of relationships, equations and formulas in contexts likely to be familiar in the teaching and learning of science concepts.

1. Compare/ Contrast/ Classify	Identify or describe similarities and differences between groups of organisms, materials, or processes; Distinguish, classify, or order individual objects, materials, organisms and processes, based on given characteristics and properties.
2. Use models	Use a diagram or model to demonstrate understanding of a science concept, structure, relationship, process or biological or physical system or cycle (i.e. food web, electric circuit, water cycle, solar system, atomic structure).
3. Relate	Relate knowledge of an underlying biological or physical concept to an observed or inferred property, behaviour, or use of objects, organisms or materials.
4. Interpret information	Interpret relevant textual, tabular, or graphical information in the light of a science concept or principle.
5. Find Solutions	Identify or use a science relationship, equation, or formula to find a qualitative or quantitative solution involving the direct application/demonstration of a concept.
6. Explain	Provide or identify an explanation for an observation or natural phenomenon, demonstrating understanding of the underlying science concept, principle, law or theory.

REASONING (30%)

- Goes beyond the solution of routine science problems to encompass unfamiliar situations, complex contexts and multi-step problems.
    - Engage in scientific reasoning to solve problems, develop explanations, draw conclusions, make decisions, and extend their knowledge to new situations.

1. Analyze	Analyze problems to determine the relevant relationships, concepts, and problem-solving steps; develop and explain problem-solving strategies.
2. Integrate/Synthesize	Provide solutions to problems that require consideration of a number of different factors or related concepts; make associations or connections between concepts in different areas of science; demonstrate understanding of unified concepts and themes across the domains of science; integrate mathematical concepts or procedures in the solutions to science problems.
3. Hypothesize/Predict	Combine knowledge of science concepts with information from experience or observation to formulate questions that can be answered by investigation; formulate hypotheses as testable assumptions using knowledge from observation and/or analysis of scientific information and conceptual understanding; make predictions about the effects of changes in biological or physical conditions in light of evidence and scientific understanding.
4. Design	Design or plan investigations appropriate for answering scientific questions or testing hypotheses; describe or recognize the characteristics of well-designed investigation in terms of variables to be measured and controlled and cause and effect relationships; make decisions about measurements or procedures to use in conducting investigations.
5. Draw Conclusions	Detect patterns in data, describe or summarize data trends, and interpolate or extrapolate from data or given information; make valid inferences on the basis of evidence and/or understanding of science concepts; draw appropriate conclusions that address questions or hypotheses, and demonstrate understanding of cause and effect.
6. Generalize	Make general conclusions that go beyond the experimental or given conditions, and apply conclusions to new situations; determine general formulas for expressing physical relationships.
7. Evaluate	Weigh advantages and disadvantages to make decisions about alternative processes, materials, and sources; consider scientific and social factors to evaluate the impact of science and technology on biological systems; evaluate alternative explanations and problem-solving strategies and solutions; evaluate results of investigations with respect to sufficiency of data to support conclusions.
8. Justify	Use evidence and scientific understanding to justify explanations and problem solutions; construct arguments to support the reasonableness of solutions to problems, conclusions from investigations, or scientific explanations.

PROPOSED ACHIEVEMENT TEST IN BIOENERGETICS

The topics to be covered and the objectives of the Unit for Bioenergetics in the Course Syllabus (based on the proposed K to 12 Grade 11 curriculum guide for Core Courses) are the following:

- Metabolism
- Photosynthesis
- Cellular Respiration

Objectives:
At the end of the unit, students are expected to:

- explain how cells carry out functions required for life.
- explain how photosynthetic organisms use light energy to combine carbon dioxide and water to form energy-rich compounds.
- trace the energy flow from the environment to the cells.
- describe how organisms obtain and utilize energy.
- recognize that organisms require energy to carry out functions required for life.
- make a poster that shows the complementary relationship of photosynthesis and cellular respiration.

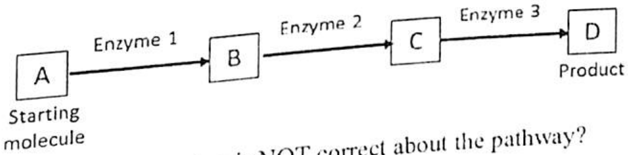
PROFILE OF VALIDATOR
Before proceeding to the items, kindly provide some information about you. Thank you.

Name:	
Sex:	[ ] Male [ ] Female
Age (In years as of last birthday):	
Current position/designation:	
Institution:	
Field/s of Discipline:	
Nos. of years practicing the discipline:	
Highest Educ'l Attainment (HEA):	
Institution where HEA was/is taken:	

TOPIC: METABOLISM (6 items). Correct answer is in red.

___1.	Using a microscope, a student observes a small, green organelle in a plant cell. Which energy transformation most likely occurs within the observed organelle? A. ATP to light B. Light to chemical C. Heat to electrical D. Chemical to chemical
DOMAIN:	**Knowing – Describe** Students describe the energy transformation process that demonstrates their knowledge of the structure and function of the chloroplast. *Common issue addressed:* Students usually do not relate photosynthesis with energy transformation.
Validator's Comment:	

___2.	Carbon dioxide and water are low energy molecules compared to the carbohydrate product formed when they are chemically combined under the aid of sunlight. What kind of reaction does this illustrate? A. Endergonic reaction B. Exergonic reaction C. Oxidation reaction D. Decomposition reaction
DOMAIN:	**Knowing – Illustrate with examples** Students identify concept of endergonic reaction based on the specific reaction between carbon dioxide and water to form carbohydrate. *Common issue addressed:* Students are confused between exergonic and endergonic reactions.
Validator's Comment:	

___3.	Study this metabolic pathway.  Which of the following is NOT correct about the pathway? A. B is acted upon by enzyme 2 to produce C. B. Enzyme 1 catalyzes A to produce B. C. Enzyme 2 catalyzes B, C, and D. D. C is catalyzed by enzyme 3 to produce D.
DOMAIN:	**Applying – Interpret Information** Students interpret relevant graphical information in the light of how a metabolic pathway works. *Common misconception:* The same enzyme can be used several times with different substrates in the pathway.
Validator's Comment:	

____4.

For a bird, the energy to keep itself alive comes ultimately from

A. the worm it just ate.

B. the oxygen in the air.

C. the seeds it just ate.

D. the sun.

DOMAIN: **Applying – Relate**

Students relate the laws of thermodynamics to sun as the ultimate energy source.

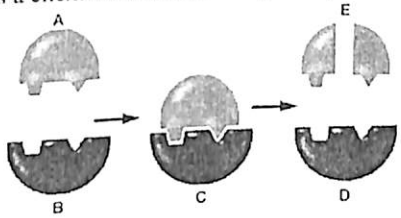
Common issue addressed:

Many students cannot relate far back to the sun the different forms of energy.

Validator's Comment:

____5.

The figure illustrates a chemical reaction catalyzed by an enzyme.



All of the following statements about the reaction are true EXCEPT

A. A is a substrate

B. B is an enzyme

C. B catalyzes A and becomes E

D. D and E are products of the reaction

DOMAIN: **Applying – Interpret Information**

Students interpret relevant graphical information in the light of how an enzyme works in a reaction.

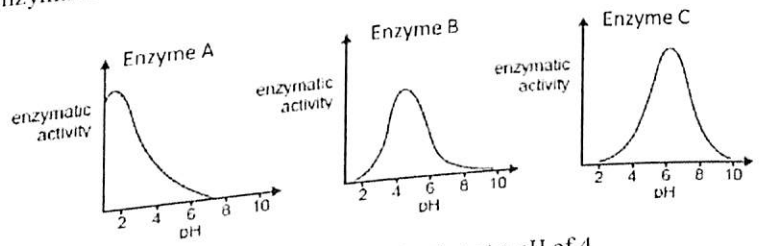
Common misconception:

Students incorrectly label the substrate and the product often using them interchangeably. They also consider enzyme as part of the products of the reaction.

Validator's Comment:

____6.

Examine the following graphs showing the relationship between pH and enzymatic activity.



From these graphs, it is reasonable to infer that at a pH of 4

A. enzyme C would be inactive.

B. enzyme A activity is reduced.

C. all the three enzymes would lack a functional active site.

D. enzyme B has the highest activity of the three enzymes.

DOMAIN: **Reasoning – Draw Conclusions**

Students describe data trends related to the effect of pH on enzymatic activity.

Common misconception:

Every enzyme has the same optimum pH

Validator's Comment:

TOPIC: PHOTOSYNTHESIS (13 items)

___1.	Which of the following materials needed for photosynthesis is converted to food and contributes most to plant's mass? A. Carbon dioxide B. Sunlight C. Water D. Minerals
DOMAIN:	**Knowing – Recognize** Students recognize a particular material for photosynthesis given its function. *Common misconception:* Gases such as CO_2 used in photosynthesis, have little or no mass, are unimportant, or cannot account for the mass gain of photosynthetic organisms. The sunlight is the food of the plants. The food of the plants is water and minerals from the soil.
Validator's Comment:	

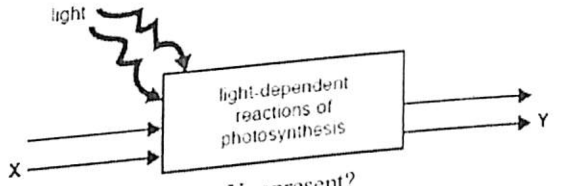
___2.	Which of the following does NOT occur during the Calvin cycle? A. Carbon fixation B. Oxidation of NADPH C. Release of oxygen D. Regeneration of the CO_2 acceptor
DOMAIN:	**Knowing – Describe** Students describe the Calvin Cycle process by identifying an event that is not associated with it. *Common misconception:* Oxygen is released from carbon dioxide fixed during Calvin Cycle.
Validator's Comment:	

___3.	The oxygen released during photosynthesis comes from A. Carbon dioxide B. Water C. NADPH D. Glucose
DOMAIN:	**Knowing – Recall** Students identify water molecule as source of oxygen in photosynthesis. *Common misconception:* Oxygen is released from carbon dioxide, a material for photosynthesis.
Validator's Comment:	

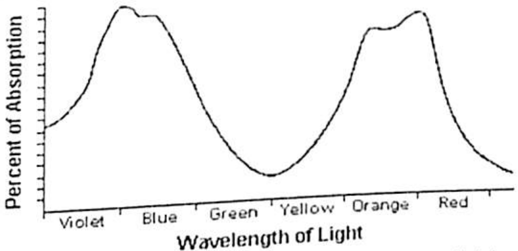
___4.	The following are needed during the light-dependent phase of photosynthesis EXCEPT A. light B. water C. chlorophyll D. carbon dioxide
DOMAIN:	**Knowing – Recognize** Students identify the material that is not needed in the light dependent phase of photosynthesis. *Common misconception:* Carbon dioxide is fixed during light dependent reaction.
Validator's Comment:	

___5.	Which of the following processes is carried out more efficiently by a C_4 plant than by a C_3 plant? A. Light absorption B. Photolysis C. Fixation of carbon dioxide D. Transport of sugars
DOMAIN:	**Applying - Contrast** Students identify a process by which C_3 and C_4 plants differ. *Common issue addressed:* Students distinguish C_4 plants only because of their ability to thrive in hot environments. They cannot relate yet spatial separation of carbon fixation to that.
Validator's Comment:	

___6.	Which of the following pairs of location and process related to photosynthesis is not correctly matched? A. Thylakoid membrane: use of carbon dioxide B. Thylakoid membrane: production of oxygen C. Stroma: Calvin cycle D. Stroma: production of sugar
DOMAIN:	**Applying – Classify/Distinguish** Students classify options based on their location and process related to photosynthesis. *Common Misconception:* They mistakenly point thylakoid space and membrane as site for Calvin Cycle and stroma as site for photolysis.
Validator's Comment:	

___7.	The following diagram shows a simplified representation of the light-dependent reaction of photosynthesis.  What does the input item X represent? A. glucose B. water C. carbon dioxide D. Either carbon dioxide or water
DOMAIN:	**Applying – Use Models** Students demonstrate understanding of science concept by using a diagram or model. *Common misconception:* Carbon dioxide and water are needed in light-dependent reaction.
Validator's Comment:	

8.



The graph represents the absorption spectrum of chlorophyll. The graph indicates that the energy used in photosynthesis is most likely obtained from which regions of the spectrum?

A. Yellow and orange red
B. Violet blue and green
C. Orange red and violet blue
D. Green and yellow

DOMAIN: **Applying – Interpret Information**

Student interpret graphical information based on light energy absorbance.

Common misconception:

Plants absorb green light that's why they are green. They also interpreted the graph wrongly.

Validator's Comment:

9.

Which is the correct order by which light energy is absorbed by photosystems in the thylakoid membrane of the chloroplast?

1. Pigment molecules in the antenna complexes absorb energy from the incoming light.
2. One of the electrons in the pair of chlorophyll molecules becomes excited.
3. Electron is passed to an electron transport chain.
4. Energy is transferred to a reaction center consisting of a particular pair of chlorophyll molecules.

A. 1, 2, 3, 4
B. 1, 4, 2, 3
C. 1, 3, 4, 2
D. 1, 2, 4, 3

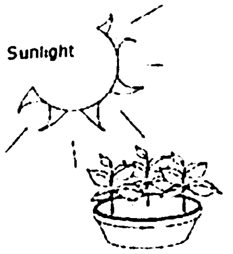
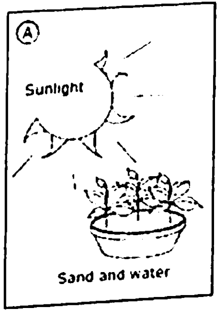
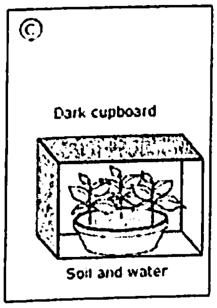
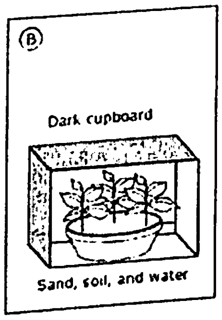
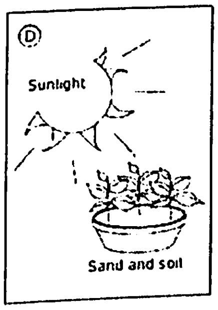
DOMAIN: **Applying – Classify/Order**

Students order events based on the process by which light energy is absorbed in photosystems.

Common issue addressed:

Students mix up the sequence.

Validator's Comment:

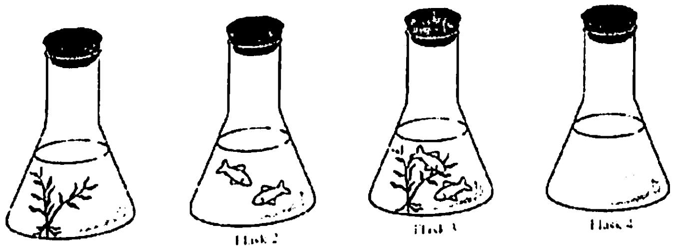
10.	A girl has an idea that green plants need sunlight for healthy growth. In order to test her idea, she uses two pots of plants. She sets up one pot of plants as shown below.  Sand, soil, and water Which ONE of the following should she use for the second pot of plants? (B)    
DOMAIN:	**Reasoning – Design** Students design investigation appropriate for testing hypothesis. *Common issue addressed:* Students have problems with controlling and manipulating variables. They think that photosynthesis can proceed in the absence of light because the Calvin cycle being called the 'dark reaction' of photosynthesis.
Validator's Comment:	

11. The box below shows a list of supplies that are available in the laboratory.

- Four flasks with stoppers
- Tap water
- Flasks
- Small aquarium plants
- Four small fish
- Bromothymol blue (a chemical indicator that changes color from blue to yellow as the level of carbon dioxide in a solution increases).

The class sets up an experiment with the four flasks as shown.

Flask 1: 100 mL water, 1 mL bromothymol blue, plant
Flask 2: 100 mL water, 1 mL bromothymol blue, 2 small fish
Flask 3: 100 mL water, 1 mL bromothymol blue, 2 small fish, plant
Flask 4: 100 mL water, 1 mL bromothymol blue

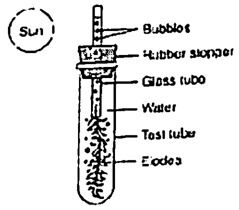


All four flasks are stoppered and placed under equal amount of sunlight. Which flasks will have yellow color after a few hours?

A. 1 only
B. 2 only
C. 1 and 3
D. 2 and 4

DOMAIN: **Reasoning – Hypothesize/Predict**
Students make prediction about the effects of changing variables in an experiment.
Common issue addressed:
Students are confused which gas is more abundant in each flask and how it will cause change in the color of the CO_2 indicator.

Validator's Comment:

___12.	Yaya Dub placed a small water plant in bright sunlight for five hours as indicated by the set-up below. She observed bubbles being released from the plant.  If these bubbles were oxygen gas, it can be inferred that the plant is A. Producing glucose B. Transpiring C. Releasing energy from water D. Respiring
DOMAIN:	**Reasoning - Evaluate** Students make general conclusion that go beyond the experimental condition. *Common misconception:* Photosynthesis is a type of respiration.
Validator's Comment:	

13.

A student investigated the effect of temperature on the rate of photosynthesis in a water plant. The results are shown in the following table.

Temperature °C	Volume of oxygen released per cm³ per 5 minutes
5	2
15	4
25	7
35	10
45	12

Which of the following statements accurately describes the relationship between temperature and rate of photosynthesis?

A. At 45°C, the water plant produced the most amount of oxygen.

B. As the temperature increases, the amount of carbon dioxide absorbed by the plant also increases.

C. As the temperature increases, the rate of photosynthetic activity becomes faster.

D. As the temperature increases, the amount of oxygen released by the water plant doubles.

DOMAIN:

Reasoning – Draw Conclusions

Students make valid inferences on the basis of evidence.

Common issue addressed:

Students do not usually relate temperature increase to rate of photosynthetic activity.

Validator's Comment:

TOPIC: CELLULAR RESPIRATION (16 items)

___1.	Cellular respiration releases energy by breaking down A. sugar from food B. ATP C. carbon dioxide D. oxygen
DOMAIN:	**Knowing – Recall/Recognize** Students make accurate statement about cellular respiration. *Common misconception:* Cellular respiration is the exchange of gas similar to the respiratory system.
Validator's Comment:	

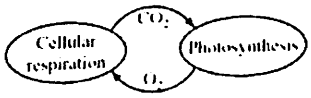
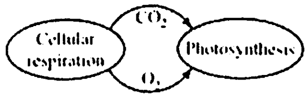
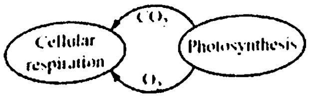
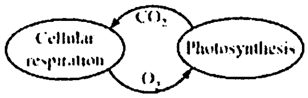
___2.	The products of aerobic respiration in a mammalian cell are A. water, ATP and oxygen B. water, ATP and carbon dioxide C. lactic acid and ATP D. ethanol and ATP
DOMAIN:	**Knowing – Recall/Recognize** Students identify science facts. *Common issue addressed:* Students consider lactate and ethanol.
Validator's Comment:	

___3.	Which of the following molecules passes high-energy electrons into the electron transport chain? A. NADH and $FADH_2$ B. ATP and ADP C. Citric acid D. Acetyl-CoA
DOMAIN:	**Knowing – Recall/Recognize** Students identify science facts. *Common misconception:* ATP and ADP are electron carriers because they are high energy molecules.
Validator's Comment:	

___4.	Glycolysis, a pathway that is common to both fermentation and aerobic respiration, begins with ___________ and ends with ___________. A. glucose; pyruvate B. glucose; acetyl CoA C. glucose; carbon dioxide D. glucose; ATP
DOMAIN:	**Knowing – Describe** Students describe the process of glycolysis by demonstrating knowledge of its end-products. *Common misconception:* ATP is the end-product of glycolysis.
Validator's Comment:	

5.	Which of the following statements is NOT correct about fermentation in animal cells? A. It can provide a rapid burst of ATP when there is limited oxygen supply. B. In our bodies, muscle cells more than other cells are likely to carry out fermentation. C. Pyruvate can build up in muscles, changing the pH and causing the muscles to fatigue. D. Only animal cells can carry out fermentation.
DOMAIN:	**Knowing – Describe** Students describe the process of fermentation by identifying which process s not related to it. *Common misconception:* Only animal cells can carry out fermentation.
Validator's Comment:	

6.	Which of the following processes in cellular respiration does NOT occur in the mitochondrion? A. transition reaction B. electron transport chain C. Krebs cycle D. Glycolysis
DOMAIN:	**Applying – Classify/Distinguish** Students classify options based on their location and process related to cellular respiration. *Common issue addressed:* Students usually mismatch the location and process.
Validator's Comment:	

7.	Which of the following diagrams accurately represents the use of gases in both cellular respiration and photosynthesis? (A) A.  C.  B.  D 
DOMAIN:	**Applying – Use Models** Students use a model to demonstrate understanding of a science concept. *Common misconception:* Photosynthesis is cellular respiration in plants. Photosynthesis gives off carbon dioxide for cells that undergo cellular respiration.
Validator's Comment:	

___ 8. Which of the following products of Krebs cycle will diffuse out of the cell, enter the bloodstream, and be released from the lungs during aerobic cellular respiration?

A. Carbon dioxide
B. ATP
C. Oxygen
D. Electron carriers

DOMAIN: **Applying – Relate**

Students relate knowledge of cellular respiration to circulatory and respiratory systems.

Common issue addressed:

Students do not relate the process of cellular respiration to the bigger physiological event that occurs in the body.

Validator's Comment:

___ 9. The table shows the relationship of glucose molecules used to CO_2 molecules released during cellular respiration.

Number of glucose molecules used during respiration	Number of CO_2 molecules released during respiration
1	6
2	12
3	18
4	24

Which cellular process would result in a cell releasing 120 gas molecules?

A. The mitochondria converting 20 glucose molecules into carbon dioxide.
B. The chloroplasts converting 30 glucose molecules into carbon dioxide.
C. The mitochondria converting 30 glucose molecules into oxygen.
D. The chloroplasts converting 20 glucose molecules into oxygen.

DOMAIN: **Applying – Find Solutions**

Students use a formula to find a quantitative solution involving the demonstration of the concept of cellular respiration.

Common issue addressed:

Students have problems extrapolating from the data given.

Validator's Comment:

___ 10. Yeast, a common fungus, is economically important to the beverage industry because when placed in grape juice, it

A. releases sugars that react with alcohol in the juice
B. acts as an enzyme to break down juice into alcohol
C. ferments carbohydrates in the juice and releases alcohol
D. produces starch that bonds with juice sugars to form alcohol

DOMAIN: **Applying – Explain**

Students provide an explanation for a natural phenomenon demonstrating understanding of the concept of fermentation.

Common misconception:

Fungi do not undergo fermentation.

Validator's Comment:

11.	When an animal has to survive without food for a long time, it will eventually break down proteins for energy. However, this process occurs only after exhausting the animal's reserves of A. carbohydrates only B. lipids only C. both carbohydrates and lipids D. carbon dioxide and water
DOMAIN:	**Applying – Explain** Students provide an explanation for a natural phenomenon demonstrating a general understanding of the concept of cellular respiration. *Common issue addressed:* Students usually think that it is only the oxidation of carbohydrate that can generate ATP.
Validator's Comment:	

12.	Humans engage in cellular respiration. Which other living things engage in cellular respiration? I. Snail II. Bacteria III. Rose plant IV. Cow V. Mushroom A. IV only B. I, II and III only C. I, II, IV and V only D. I, II, III, IV and V
DOMAIN:	**Reasoning - Analyze** Students analyze information to determine relevant relationship. *Common misconception:* Plants do not undergo cellular respiration.
Validator's Comment:	

13.	The following are involved in the process of cellular respiration: I. Energy II. Carbohydrates III. Carbon dioxide IV. Water V. Oxygen Which one of the following combinations correctly represents their involvement in the above process? A. II + III → I + IV + V B. II + IV → I + III + V C. I + II → III + IV + V D. II + V → I + III + IV
DOMAIN:	**Reasoning - Analyze** Students analyze information to determine relevant relationship. *Common issue addressed:* Students mix up the combinations.
Validator's Comment:	

14. During aerobic respiration, electrons travel from source to carrier to final acceptor in which sequence?

A. Food → NADH/FADH$_2$ → electron transport chain → oxygen
B. Glucose → pyruvate → ATP → oxygen
C. Glucose → ATP → electron transport chain → NADH/FADH$_2$
D. Food → glycolysis → Krebs cycle → NADH/FADH$_2$ → ATP

DOMAIN: **Reasoning - Analyze**
Students analyze information to determine relevant relationship.
Common issue addressed:
Students do not realize the role of electrons as energy carriers in cellular respiration.

Validator's Comment:

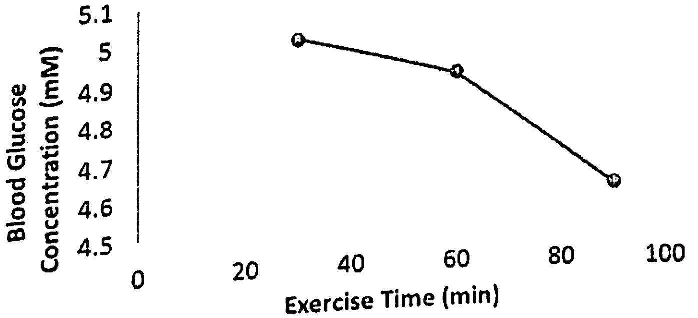
___15. In a swimming competition, Alden's muscle cells are not able to take in enough oxygen to make more ATP. His muscles begin to fatigue. Why?

A. As the cells run out of oxygen, they switch to anaerobic respiration which allows the cell to make small amounts of ATP in the absence of oxygen.
B. As the cells run out of oxygen, they die off gradually and his muscles have fewer contracting muscle cells.
C. The cells will never run out of oxygen if Alden is breathing.
D. As the cells run out of oxygen, they will continue to make the same amount of ATP, since oxygen is not required to make ATP.

DOMAIN: **Reasoning - Hypothesize**
Students formulate hypotheses as testable assumptions using analysis of scientific information.
Common misconception:
The cell will never run out of oxygen.

Validator's Comment:

___16. The graph below shows the change in blood glucose level during prolonged exercise.



Which of the following statements explains the change in blood glucose level shown in the graph?

A. Glucose was broken down to produce ATP for energy.
B. Glucose diffused from muscle cells into the bloodstream.
C. Glucose was used in burning fats.
D. Glucose was converted into muscle proteins.

DOMAIN: **Reasoning – Draw Conclusions**
Students make valid inferences on the basis of evidence and understanding of science concepts.
Common issue addressed:
Students cannot usually arrive at accurate interpretation of graphs and diagrams.

Validator's Comment:

FEEDBACK FORM

Aside from your comments above, what else are your suggestions to improve the instrument. Thank you.

Appendix G

Validated Learning Needs Analysis Protocol

LEARNING NEEDS ANALYSIS

Name: (required) ________________________

Course: ________________________

Sex: [ ] Male [ ] Female

Age (in years as of last birthday): ____________

Directions: The following questions will assess your needs about the topic bioenergetics. Bioenergetics is a branch of biology that deals with the study of how organisms utilize energy. Freely provide the information asked.

1. The following topics will be covered in the unit for bioenergetics:
    a. Metabolism
    b. Photosynthesis
    c. Cellular Respiration

Given those topics, which one interests you the most? ________________________

____

Why? ________________________

____

____

____

2. Goals, Expectations and Learning Needs

AFTER studying bioenergetics, this is what I am expecting myself to KNOW:

____

____

AFTER studying bioenergetics, this is what I am expecting myself to DO:

____

____

____

This is what I am expecting about my class in bioenergetics:

1. I am expecting the TOPIC to be : ________________________

____

2. I am expecting my TEACHER to be: ________________________

____

____

3. I am expecting my CLASSMATES to be: ____________________

4. I am expecting STUDENT-TO-STUDENT INTERACTIONS to be: ____________________

5. I am expecting the TEACHER-STUDENT INTERACTIONS to be: ____________________

6. However, I personally think that the following will LIMIT me from learning the topics very well: ____________________

7. If given the chance, I would want to add/change this topic in the discussion of bioenergetics: ____________________

3. Preferred Medium of Instruction

The LANGUAGE I prefer to be used in our class discussion is: ____________________ because____________________

4. Preferred Learning Environment

How would you want your classroom to be organized? (seat plan, seating arrangement, etc.) ____________________

5. Preferred Teaching Approach

1. I would appreciate if the teacher will include the following in his/her teaching strategies:____________________
2. I would want to suggest the following activities to be included in the teaching of bioenergetics: ____________________

Thank you.

Appendix H

Validated Questionnaire on the Importance of Democratic Practices in Classroom

DEMOCRATIC PRACTICES IN CLASSROOM

Name: (required) ______________________________
Course: ______________________________
Sex: [ ] Male [ ] Female
Age (in years as of last birthday): ____________________

Directions. Each of the statements below signifies some processes that are happening in the classroom. This is not a test. You will not be scored. Please rate each process on the extent of how important this is for you. For each, you may encircle the following number codes with their corresponding descriptors:

1 – Not important
2 – Slightly important
3 – Important
4 – Very important

1	The responsibility to learn is shared between the teacher and the students.	1	2	3	4
2	Students participate in making decisions that affect their learning (i.e. class rules and sanctions, formulation of instructional methods and materials, evaluation elements etc.)	1	2	3	4
3	Students' voices, views and ideas are freely expressed and heard.	1	2	3	4
4	Topics reflect students' interests and are connected to their daily lives.	1	2	3	4
5	Teacher considers students' learning styles.	1	2	3	4
6	Teacher considers students' learning needs and difficulties.	1	2	3	4
7	Teacher involves students in designing class lessons and activities.	1	2	3	4
8	Teacher and students discuss instructional issues together and arrive at a decision that is acceptable to everyone.	1	2	3	4
9	Teacher provides opportunities for students to negotiate instruction and take control of their learning.	1	2	3	4
10	The teacher and students observe democratic principles inside the classroom.	1	2	3	4

Note: This section was only included during the POSTTEST.

Give your comments or remarks about your bioenergetics class experience using CONSENSUS: ______________________________
____
____
____
____

Appendix I

Canfield Learning Style Inventory

CANFIELD LEARNING STYLE INVENTORY
(Canfield & Knight, 1983)

Course/Year/Blk: ________________

Name: (Required) ______________________________
Sex: [ ] Male [ ] Female

Directions. This inventory gives you an opportunity to describe how you learn best. There are no right or wrong answers. Read the questions and rank (1, 2, 3, or 4) the responses according to how well they describe your reactions or feelings. 1 is the most preferred rank, 4 is the least preferred rank.

1. Rank the following in terms of how well they describe the classes you've liked most.
___a. I enjoyed the other students and we shared our ideas and feelings with each other.
___b. The course was well organized and the topics followed one another in a meaningful sequence.
___c. I more or less set my own goals and studied the things of most interest to me.
___d. I knew how my work compared with others and the best work was fairly recognized.

2. Number the descriptions of teachers from 1 to 4 in the order in which you normally prefer them.
___a. Teachers who are pleasant, friendly, and who take a personal interest in me.
___b. Teachers who provide specific and clear information about assignments and requirements.
___c. Teachers who give me the opportunity to decide what I want to study and how I want to do things.
___d. Teachers who impose high standards and make me do the work necessary to accomplish them.

3. Rank the following courses in terms of their general appeal to you.
___a. Mathematics and physical science.
___b. Language and literature.
___c. Household and craft repair skills.
___d. Interviewing and counseling.

4. Rank the following in terms of their general value to you as ways to learn.
___a. Listening to others talk about a subject.
___b. Reading what others have written about it.
___c. Seeing pictures, graphs, movies, etc.
___d. Handling or working with something tangible.

5. Rank the following grades to indicate how likely you are to receive them on a paper or report.
___a. Excellent or outstanding.
___b. Good or above average.
___c. Satisfactory or about average.
___d. Unsatisfactory.

6. Rank the following in the order in which they would be most helpful for improving your school experience in general.
___a. More group activities and opportunities to get to know other students.
___b. More class outlines and clearer statements about what the classes were all about.
___c. More opportunities to think through my capabilities and set goals for my performance.
___d. More objective and frequent information on how my performance compares with others.

7. Rank the following in terms of how accurately they describe the worst teachers you've ever known.
___a. They were more interested in the subject matter than in the students.
___b. They were vague about assignments and I was never sure what was expected of me.
___c. They were too restrictive in letting me do things on my own, coming to my own conclusions, etc.
___d. They were too easy and the students lost respect for them.

8. Rank the following in the order in which you enjoy doing them.
___a. Figuring out how things differ in cost.
___b. Writing a report or a letter.
___c. Building or repairing something.
___d. Carrying on a conversation with a stranger.

9. Classes typically involve the following kinds of teaching activities. Rank them in the order in which you generally prefer them as ways to learn.
___a. Lectures, audio tapes, and question-answer sessions.
___b. Textbook assignments and other readings.
___c. Movies, slides, graphics, charts, etc.
___d. Experiments or projects in the laboratory.

10. Imagine that you have just received your grade on the final exam in a course that you felt was pretty easy and that you got the lowest grade in the class. Rank the following as to how you'd most likely feel.
___a. Somebody made a mistake in grading the papers.
___b. I'd be quite surprised, because that doesn't happen very often.
___c. It would surprise me a little, but that sometimes happens.
___d. It wouldn't surprise me very much at all.

11. In most courses, student performance is evaluated on some basis. Rank the following in terms of how you feel about such evaluations.
___a. They sometimes create jealousies and hard feelings among the students.
___b. Sometimes they are unrelated to the supposed content and purposes of the course.
___c. They sometimes aren't very helpful in evaluating my progress or in helping me focus my study activities.
___d. Sometimes they don't really distinguish between those who are doing well and those not doing so well.

12. Rank the following in terms of their value to you in learning.
___a. Having a chance to visit informally and develop an effective relationship with the teacher.
___b. Having specifics on what courses include and what they require.
___c. Having the chance to adopt my own approach and to make some contribution of my own.
___d. Having scholarly teachers explain the material and direct my study in the most meaningful and useful direction.

13. If you were in a course that required everyone to visit a home for the elderly and you could do any of the following, rank them in the order of their interest to you.
___a. Help them compute their income taxes or balance their checkbooks.
___b. Write a letter or read to them.
___c. Help repair or replace something for them.
___d. Sit and visit with them about their feelings.

14. How do the following appeal to you as ways to find out about new occupations or types of work?
___a. Have someone in the field tell me about it.
___b. Read a recent study explaining it.
___c. Watch a classroom demonstration of the work.
___d. Trying to do the work itself.

15. Imagine that you have just turned in a paper to an instructor. Rank how you think it would be evaluated.
___a. Excellent
___b. Above Average
___c. Average
___d. Below Average

16. As a student, I feel it is my responsibility to:
___a. Cooperate with the other students and help them when I can.
___b. Ask the teachers questions when the course is confusing.
___c. Make my own decisions as to what I can accomplish
___d. Assess the ability of the other students and work accordingly.

17. Consider the following topics for teacher training and rank them in the order in which you think they would generally be most helpful to teachers.
___a. How to get along with students and maintain good relationships with them.
___b. How to inform students of requirements, rules, the basis for grades, etc.
___c. How to utilize independent study techniques so students can work more or less on their own.
___d. How to maintain classroom discipline and get students to do the assigned work.

18. Rank the following classes in the order in which they appeal to you.
___a. Formal logic and mathematics.
___b. Developing the plot and writing short stories.
___c. Operating a machine to make something.
___d. Human behavior and the "helping" occupations.

19. Rank the following in the order in which you would typically like to learn about the properties of a new plastic.
___a. Hearing a lecture.
___b. Reading a book or text.
___c. Viewing a movie or slides.
___d. Experimenting with a small sample.

20. Assume you are going to be in school next year; rank the following evaluations in the order in which you think you'd receive them.
___a. In the top 10 percent or so.
___b. In the top 25 or 33 percent.
___c. In the middle 50 percent.
___d. In the bottom 25 or 33 percent.

21. Rank the following in terms of how accurately they described the classes you have DISLIKED.
___a. There was a lot of arguing, bickering, or fighting among the students.
___b. The class was disorganized and I couldn't tell what topic was coming next.
___c. There was no opportunity for me to pursue my own special interests or branch off on anything.
___d. No matter how well or how much anyone did, the teacher just accepted it.

22. Rank the following in the order in which you feel they describe your most effective teachers.
___a. They like students and have a sincere desire to understand and help them.
___b. They leave no confusion about what is to be done and how it is to be done.
___c. They consider each person as an individual and let each student work to their abilities and interests.
___d. They control their classrooms and require everyone to meet some minimum requirements.

23. Club members are generally required to help; rank the following in order of your preference for doing the club duties.
___a. Keeping the books on income, expenses, and finances.
___b. Keeping the minutes of the meetings and doing the correspondence.
___c. Setting up the room and keeping club equipment in order.
___d. Greeting newcomers and helping everyone feel welcome.

24. Imagine you're taking an Ecology course. Rank the way you'd like to study the topic.
___a. Hear speeches by qualified people.
___b. Read reports and studies.
___c. Watch movies, TV, films, etc.
___d. Take field trips.

25. Rank the following in terms of how well they describe your feelings about your school performance.
___a. I've been at or near the top of my class.
___b. I've been better than average.
___c. I've been near the middle.
___d. I've been in the lower half.

26. Rank the following in their importance to you in the way classes are handled.
___a. There is an opportunity to develop friends and the students support one another.
___b. Class sessions are logically related to each other; topics follow in an understandable and meaningful sequence.
___c. Based upon the topic and my abilities, I can determine what areas I'll pursue.
___d. Students' grades and the evaluation of their performance give fair recognition and credit to those doing best.

27. Rank the following in terms of how likely they would be as a reason for you to dislike a class.
___a. The teacher was hostile, easily angered, or inconsiderate.
___b. There were vague standards and vague or frequently changing requirements.
___c. There was too little opportunity to determine my own activities.
___d. The teacher lacked the ability to direct and control the class.

28. Rank the following in terms of their interest to you as a general field of work.
___a. Mathematics, engineering, accounting.
___b. Language, writing, speaking.
___c. Building, installing, operating equipment.
___d. Interviewing, selling, teaching.

29. Rank the following class activities in the order in which they normally appeal to you.
___a. The teacher lectures and answers questions.
___b. I can read about the topic in a text or some outside reading.
___c. Pictures, movies, graphs, displays, etc., are used.
___d. I can experiment with or actually use the material.

30. Imagine that you've just received the results of a final exam in a very difficult course and your grade was the highest in the class. Rank the following in terms of how you would most likely feel.
___a. I'd have expected to do well so it wouldn't surprise me.
___b. I'd be surprised, but it could happen.
___c. I'd feel like I had lucked out and guessed a lot of the correct answers.
___d. I'd probably think that someone had made a mistake in grading the test.

Summary of Scores

Directions: Be sure you enter a different number in each blank to indicate the order in which you ranked the responses to each item: 1, by the letter of the most descriptive response; 2, by the second most descriptive, etc. through 4. The item numbers go down the page as in the test. Add the figures across the page. Example: add the scores for 1a, 6a, 11a, 16a, 21a, and 26a. Place the total on the P line. Do the same for the remaining lines.

Name: (Required) ______________
Sex: [ ] Male [ ] Female
Course/Year/Blk: ______________

CONDITIONS

1.a ___	6.a ___	11.a ___	16.a ___	21.a ___	26.a ___	P ___
b ___	b ___	b ___	b ___	b ___	b ___	O ___
c ___	c ___	c ___	c ___	c ___	c ___	G ___
d ___	d ___	d ___	d ___	d ___	d ___	C ___

2.a ___	7.a ___	12.a ___	17.a ___	22.a ___	27.a ___	Is ___
b ___	b ___	b ___	b ___	b ___	b ___	D ___
c ___	c ___	c ___	c ___	c ___	c ___	Id ___
d ___	d ___	d ___	d ___	d ___	d ___	A ___

CONTENT

3.a ___	8.a ___	13.a ___	18.a ___	23.a ___	28.a ___	N ___
b ___	b ___	b ___	b ___	b ___	b ___	Q ___
c ___	c ___	c ___	c ___	c ___	c ___	In ___
d ___	d ___	d ___	d ___	d ___	d ___	P ___

MODE

4.a ___	9.a ___	14.a ___	19.a ___	24.a ___	29.a ___	L ___
b ___	b ___	b ___	b ___	b ___	b ___	R ___
c ___	c ___	c ___	c ___	c ___	c ___	I ___
d ___	d ___	d ___	d ___	d ___	d ___	D ___

EXPECTED PERFORMANCE

5.a ___	10.a ___	15.a ___	20.a ___	25.a ___	30.a ___	O/S ___
b ___	b ___	b ___	b ___	b ___	b ___	A/G ___
c ___	c ___	c ___	c ___	c ___	c ___	A/S ___
d ___	d ___	d ___	d ___	d ___	d ___	B/U ___

What Does It Mean?

Circle your score for each category from the previous page in the appropriate column in the matrix below. The categories read from left to right, i.e., P is Peer, O is Organization, G is Goal, C is Competition, etc. The higher your score in each category falls on the matrix, the more important that style is to your learning.

	Conditions								Content				Mode				Expectancy					
%	P	O	G	C	N	D	I	A	N	Q	I	P	L	R	I	D	A	B	C	D	%	%
99	6-7 8	6	6-7 8	6-11 12	6	6	6-8 9	6-8 9	6 7-8	6	6-7		6	6-8 9	6 7	6	6-7 8		6 7	6-15	6-9	99
95	9		9	13	7	7	10	10	9	7	8 9	6	7	10 11	8		9	6		16 17		95
90	10	7	10	14 15	8	8	11 12	11 12	10 11	8 9	10 11 12	7	8 9	12 13	9 10	7 8	10 11	7	8 9	18 19	10-13	90
80	12	8	11 12	16 17	9	10	13 14	13 14	12 13 14	10 11	13	8	10	14 15	11	9	12 13		10 11	20	14-7 18-21	80
70	14	9			10	11	15	15 16	15 16	12	14	9	11 12	16 17	12 13	10 11	14	8	12	21	22-5	70
60		10	13	18	11 12	12	16	17	17 18	13	15 16	10	13	18		12	15		13		26-9	60
50	15 16	11	14	19	13	13	17	18	19	14		11 12	14	19	14	13	16	9	14	22	30-3	50
40	17	12	15	20	14	14 15	18	19	20	15	17	13	15	20 21	15 16	14 15	17		15	23	34-7	40
30	18	13	16				19	20	21	16	18	14	16 17	22	17	16	18	10	16		38-41	30
20	19	14	17	21	15 16 17	16 17	20	2	22	17 18·19	19 20	15 16		23	18 19	17 18	10	11			42-5 46-9	20
10	20	15 16	18 19	22	18	18	21	22	23	20	21 22	17 18 19	18 19 20		20 21-2	19 20 21	20 21-2	12 13	17 18	24	50-3 54-7	10
5	21 22	17 18	20	23	19 20	19 29	22 23	23	24	21-2 23	23	20-1 22-	21 22-	24	23- 24	22 23-	23	14 15-	19 20		58-65 66-69	5
1	23/4.	19·24	21·24	24	21·24	21·24	24	24		24	24	24	24			24	24	24	24		70-84	1

To determine what type of learner you are, compute for the following dimensions and refer to the subsequent pages for further analysis.

X-dimension: Organization + Qualitative + Reading – Direct Experience – Inanimate – Iconic

Y-dimension: Peer + Instructor – Goal Setting – Independence

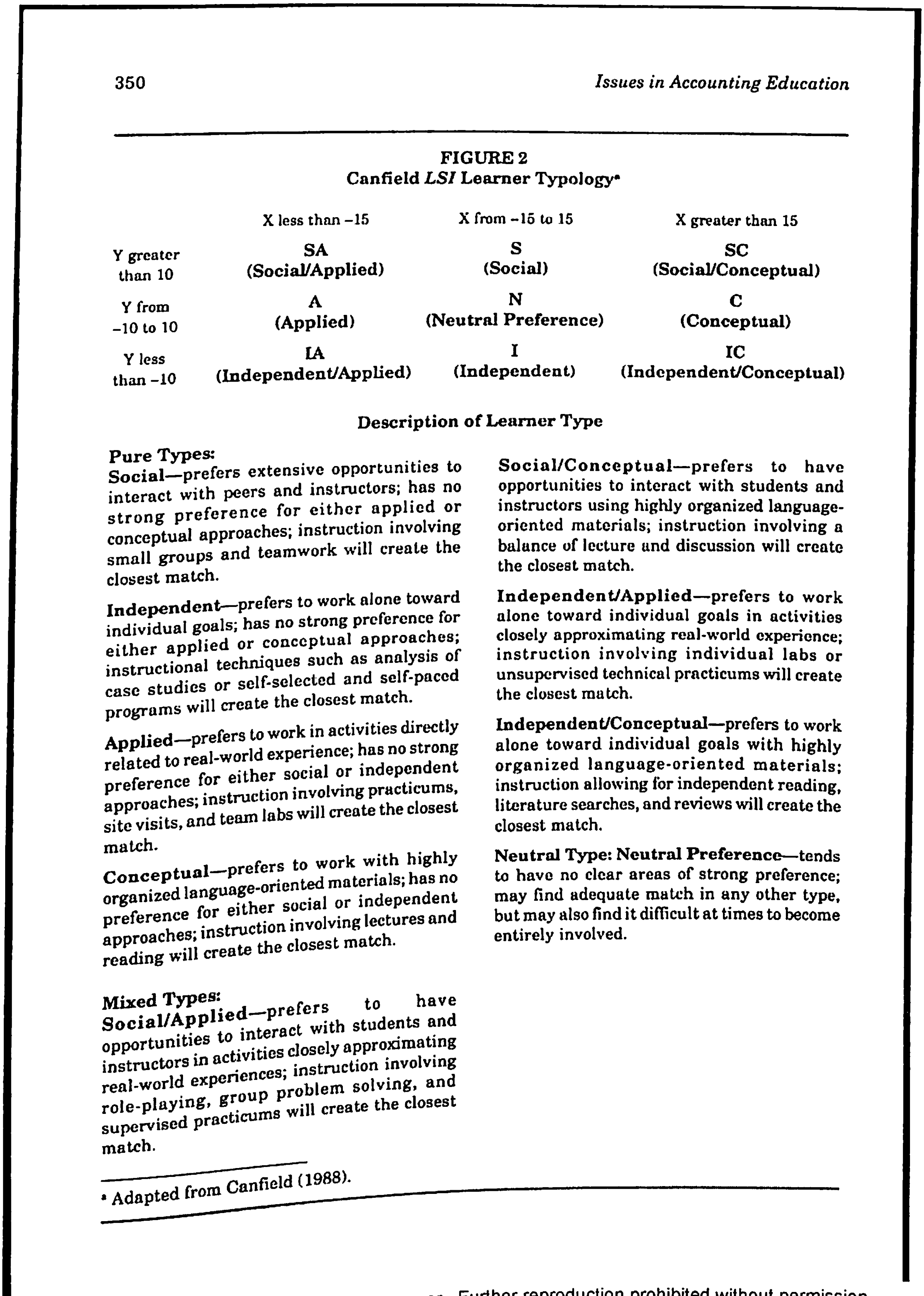


FIGURE 2
Canfield *LSI* Learner Typology*

	X less than −15	X from −15 to 15	X greater than 15
Y greater than 10	**SA** **(Social/Applied)**	**S** **(Social)**	**SC** **(Social/Conceptual)**
Y from −10 to 10	**A** **(Applied)**	**N** **(Neutral Preference)**	**C** **(Conceptual)**
Y less than −10	**IA** **(Independent/Applied)**	**I** **(Independent)**	**IC** **(Independent/Conceptual)**

Description of Learner Type

Pure Types:

Social—prefers extensive opportunities to interact with peers and instructors; has no strong preference for either applied or conceptual approaches; instruction involving small groups and teamwork will create the closest match.

Independent—prefers to work alone toward individual goals; has no strong preference for either applied or conceptual approaches; instructional techniques such as analysis of case studies or self-selected and self-paced programs will create the closest match.

Applied—prefers to work in activities directly related to real-world experience; has no strong preference for either social or independent approaches; instruction involving practicums, site visits, and team labs will create the closest match.

Conceptual—prefers to work with highly organized language-oriented materials; has no preference for either social or independent approaches; instruction involving lectures and reading will create the closest match.

Mixed Types:

Social/Applied—prefers to have opportunities to interact with students and instructors in activities closely approximating real-world experiences; instruction involving role-playing, group problem solving, and supervised practicums will create the closest match.

Social/Conceptual—prefers to have opportunities to interact with students and instructors using highly organized language-oriented materials; instruction involving a balance of lecture and discussion will create the closest match.

Independent/Applied—prefers to work alone toward individual goals in activities closely approximating real-world experience; instruction involving individual labs or unsupervised technical practicums will create the closest match.

Independent/Conceptual—prefers to work alone toward individual goals with highly organized language-oriented materials; instruction allowing for independent reading, literature searches, and reviews will create the closest match.

Neutral Type: Neutral Preference—tends to have no clear areas of strong preference; may find adequate match in any other type, but may also find it difficult at times to become entirely involved.

---

* Adapted from Canfield (1988).

Appendix J

Validated Attitude Towards Biology Scale

ATTITUDES TOWARDS BIOLOGY

Name: (optional) ________________________________

Course: ____

Sex: [ ] Male [ ] Female

Age (in years as of last birthday): _______________

Directions. Each of the statements below expresses a feeling toward biology. Please rate each statement on the extent to which you agree. For each, you may (1) strongly disagree, (2) disagree, (3) agree, or (4) strongly agree. This is not a test. There are no correct answers. You will not be scored. Just encircle the number code as best and as honest as you can.

1	Everybody needs knowledge of biology.	1	2	3	4
2	Biology helps in the development of my conceptual skills.	1	2	3	4
3	Biology is a very interesting subject.	1	2	3	4
4	Biology is an important part of our lives.	1	2	3	4
5	Biology is boring.	1	2	3	4
6	Biology is fascinating and fun.	1	2	3	4
7	Biology is our hope for solving many environmental problems.	1	2	3	4
8	Biology lessons become a source of boredom for me.	1	2	3	4
9	Biology makes me feel uncomfortable, restless, irritable and impatient.	1	2	3	4
10	During biology lectures, I can comprehend the important points.	1	2	3	4
11	For me, biology class seems scary.	1	2	3	4
12	I always try hard no matter how difficult the lesson in biology is.	1	2	3	4
13	I always try to do my best in biology.	1	2	3	4
14	I am always under a terrible strain in a biology class.	1	2	3	4
15	I am looking forward to attend our biology class.	1	2	3	4
16	I approach biology with a feeling of hesitation.	1	2	3	4
17	I can explain biology concepts in my own words.	1	2	3	4
18	I can focus in biology lessons.	1	2	3	4
19	I cannot understand the biology lessons after class.	1	2	3	4
20	I complete first my home work in biology before doing other things.	1	2	3	4
21	I consult my biology teacher in any topic/s that I cannot understand during science class.	1	2	3	4
22	I do not have the interest to complete my homework in biology.	1	2	3	4
23	I do not have the interest to discuss biology topics after the school time.	1	2	3	4
24	I enjoy learning biology.	1	2	3	4
25	I enjoy talking to my biology teacher after class.	1	2	3	4
26	I feel a definite positive reaction to biology because it is enjoyable.	1	2	3	4
27	I find biological processes very interesting.	1	2	3	4
28	I follow a regular schedule to study biology at home.	1	2	3	4
29	I fully concentrate on the topic discussed in my biology class.	1	2	3	4

30	I hate biology lessons.	1	2	3	4
31	I make many efforts to understand biology.	1	2	3	4
32	I really like biology.	1	2	3	4
33	I review lessons in biology daily at home.	1	2	3	4
34	I try hard to do well in biology.	1	2	3	4
35	I understand biology lessons taught in class by the teacher.	1	2	3	4
36	I usually relate the previously learned lessons in biology with the new one.	1	2	3	4
37	I would enjoy being a biologist.	1	2	3	4
38	I would not probably do well in courses related to biology.	1	2	3	4
39	Knowledge in biology is essential for understanding other courses and phenomena.	1	2	3	4
40	My biology teacher encourages me to learn more about biology.	1	2	3	4
41	My biology teacher makes good plans for us.	1	2	3	4
42	My mind goes blank when I am studying biology.	1	2	3	4
43	The important points emphasized by my teacher during class discussion helps me in learning biology.	1	2	3	4
44	The lessons taught in biology are not interesting.	1	2	3	4
45	The progress of biology improves the quality of our lives.	1	2	3	4
46	The work with living organisms in biology lessons is very interesting.	1	2	3	4
47	We do a lot of fun activities in biology class.	1	2	3	4
48	We learn important things in biology class.	1	2	3	4
49	When I fail in biology exam, I always try much harder.	1	2	3	4
50	When I hear the word 'biology,' I have a feeling of dislike.	1	2	3	4
51	Whenever I want to ask anything about biology, I consult my biology teacher.	1	2	3	4

Appendix K

Validated Bioenergetics Achievement Test

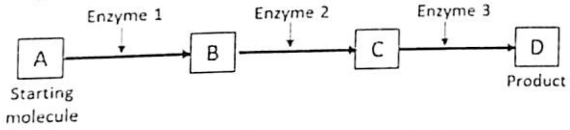
BIOENERGETICS TEST

Directions. Do NOT write anything on this test paper. Use your answer sheet in choosing the letter of the correct answer in the following items. Use CAPITAL letters.

1. Using a microscope, a student observes a small, green organelle inside a plant cell. Which of the energy transformation below likely occurs within the observed organelle?
   A. ATP to light B. Light to chemical C. Heat to electrical D. Chemical to chemical

2. Carbon dioxide and water are low energy molecules compared to the carbohydrate product formed when they are chemically combined under the aid of sunlight. What kind of reaction does this illustrate?
   A. Endergonic reaction C. Oxidation reaction
   B. Exergonic reaction D. Decomposition reaction

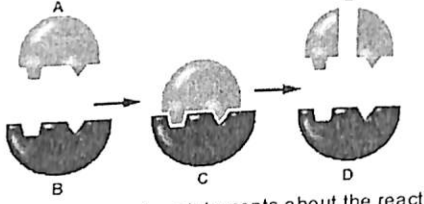
3. Study this metabolic pathway.



   Which of the following is NOT correct about the pathway?
   A. B is catalyzed by enzyme 2 to produce C. C. Enzyme 2 catalyzes B, C, and D.
   B. Enzyme 1 catalyzes A to produce B. D. C is catalyzed by enzyme 3 to produce D.

4. The energy that keeps the bird alive comes ultimately from
   A. the worm it just ate. B. the oxygen in the air. C. the seeds it just ate. D. the sun.

5. The figure below illustrates a chemical reaction catalyzed by an enzyme.



   All of the following statements about the reaction are true EXCEPT
   A. A is a substrate C. B catalyzes A to produce E
   B. B and D are enzymes D. D and E are products of the reaction

6. Which of the following materials needed for photosynthesis is converted to food and contributes most to plant's mass?
   A. Carbon dioxide B. Sunlight C. Water D. Minerals

7. The oxygen released during photosynthesis comes from
   A. Carbon dioxide B. Water C. NADPH D. Glucose

8. Which of the following does NOT occur during the Calvin cycle?
   A. Carbon fixation C. Release of oxygen
   B. Oxidation of NADPH D. Regeneration of the CO_2 acceptor

9. The following are needed during the light-dependent phase of photosynthesis EXCEPT
   A. light B. water C. chlorophyll D. carbon dioxide

10. Which of the following processes is carried out more efficiently by a C_4 plant than by a C_3 plant?
    A. Light absorption C. Fixation of carbon dioxide
    B. Photolysis D. Water absorption

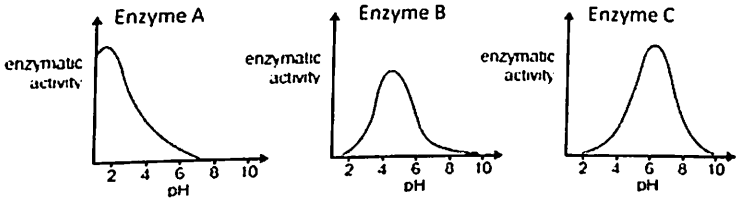
11. Which of the following pairs of location and process related to photosynthesis is not correctly matched?
    A. Thylakoid membrane: use of carbon dioxide C. Stroma: Calvin cycle
    B. Thylakoid membrane: production of oxygen D. Stroma: production of sugar

12. Cellular respiration releases energy by breaking down
    A. sugar from food B. ATP C. carbon dioxide D. oxygen

13. The products of aerobic respiration in a mammalian cell are
    A. water, ATP and oxygen C. lactic acid and ATP
    B. water, ATP and carbon dioxide D. ethanol and ATP

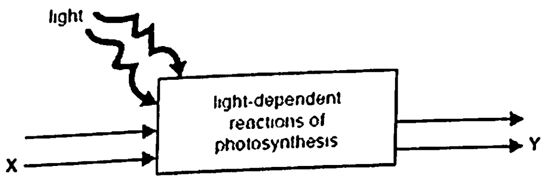
14. Which of the following molecules passes high-energy electrons into the electron transport chain?
A. NADH and $FADH_2$ B. ATP and ADP C. Citric acid D. Acetyl-CoA

15. The graphs below show the relationship between pH and enzymatic activity.



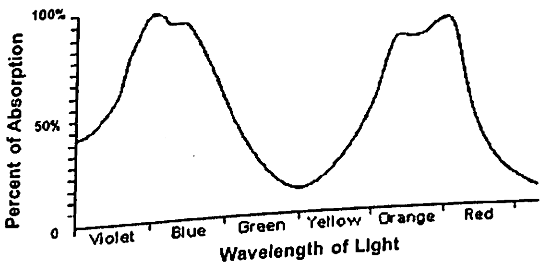
From these graphs, it is reasonable to infer that at a pH of 4
A. enzyme C would be inactive.
B. enzyme A activity is reduced.
C. all the three enzymes would be inactive.
D. enzyme B has the highest activity of the three enzymes.

16. The following diagram shows a simplified representation of the light-dependent reaction of photosynthesis.



What does the input item X represent?
A. glucose
B. water
C. carbon dioxide
D. Either carbon dioxide or water

17.



The graph represents the absorption spectrum of chlorophyll. The graph indicates that the energy used in photosynthesis is most likely obtained from which regions of the spectrum?
A. Yellow and orange red
B. Violet blue and green
C. Orange red and violet blue
D. Green and yellow

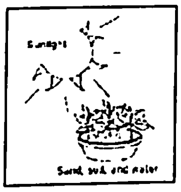
18. Which is the correct order by which light energy is absorbed by photosystems in the thylakoid membrane of the chloroplast?
1. Pigment molecules in the antenna complexes absorb energy from the incoming light.
2. One of the electrons in the pair of chlorophyll molecules becomes excited.
3. Electron is passed to an electron transport chain.
4. Energy is transferred to a reaction center consisting of a particular pair of chlorophyll molecules.

A. 1, 2, 3, 4
B. 1, 4, 2, 3
C. 1, 3, 4, 2
D. 1, 2, 4, 3

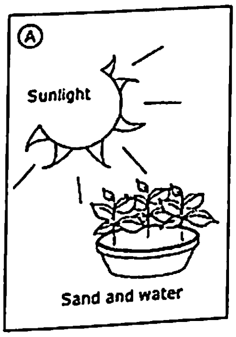
19. Glycolysis, a pathway that is common to both fermentation and aerobic respiration, begins with __________ and ends with __________.
A. glucose; pyruvate B. glucose; acetyl CoA C. glucose; CO_2 D. glucose; ATP

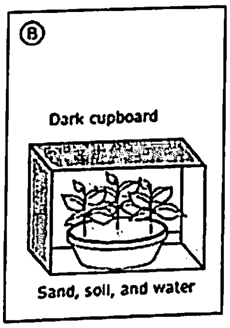
20. Which of the following processes in cellular respiration does NOT occur in the mitochondrion?
A. transition reaction
B. electron transport chain
C. Krebs cycle
D. Glycolysis

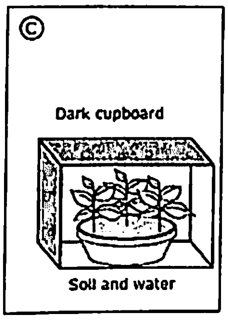
21. A girl has an idea that green plants need sunlight for healthy growth. In order to test her idea, she uses two pots of plants. She sets up one pot of plants as shown below.

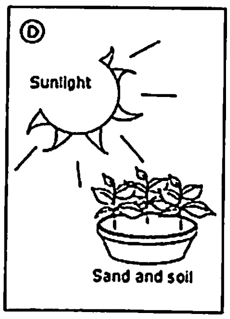


Which ONE of the following should she use for the second pot of plants?





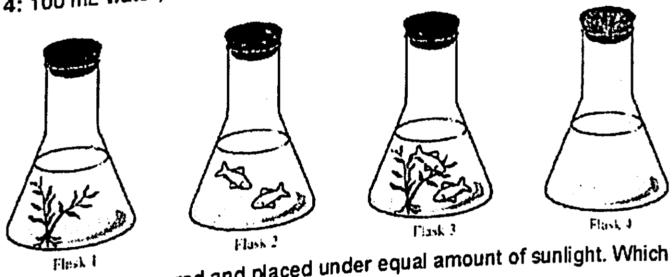




22. The box below shows a list of supplies that are available in the laboratory.

- Four flasks with stoppers
- Tap water
- Flasks
- Small aquarium plants
- Four small fish
- Bromothymol blue (a chemical indicator that changes color from blue to yellow as the level of carbon dioxide in a solution increases).

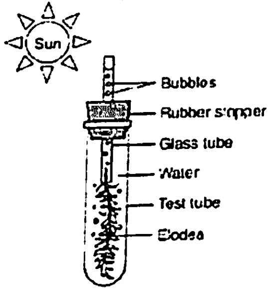
The class sets up an experiment with the four flasks as shown.
Flask 1: 100 mL water, 1 mL bromothymol blue, plant
Flask 2: 100 mL water, 1 mL bromothymol blue, 2 small fish
Flask 3: 100 mL water, 1 mL bromothymol blue, 2 small fish, plant
Flask 4: 100 mL water, 1 mL bromothymol blue



All four flasks are stoppered and placed under equal amount of sunlight. Which flasks will have yellow color after a few hours?
A. 1 only
B. 2 only
C. 1 and 3
D. 2 and 4

23. When an animal has to survive without food for a long time, it will eventually break down proteins for energy. However, this process occurs only after exhausting the animal's reserves of
A. carbohydrates only
B. lipids only
C. both carbohydrates and lipids
D. carbon dioxide and water

24 Pia placed a small water plant in bright sunlight for five hours as indicated by the set-up below. She observed bubbles being released from the plant.



If these bubbles were oxygen gas, it can be inferred that the plant is
A. Producing glucose
B. Transpiring
C. Releasing energy from water
D. Respiring

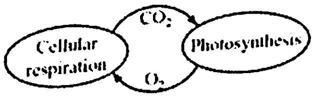
25. A student investigated the effect of temperature on the rate of photosynthesis in a water plant. The results are shown in the following table.

Temperature °C	Volume of oxygen released per cm³ per 5 minutes
5	2
15	4
25	7
35	10
45	12

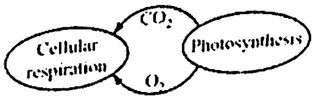
Which of the following statements accurately describes the relationship between temperature and rate of photosynthesis?
A. At 45°C, the water plant produced the most amount of oxygen.
B. As the temperature increases, the amount of carbon dioxide absorbed by the plant also increases.
C. As the temperature increases, the rate of photosynthetic activity becomes faster.
D. As the temperature increases, the amount of oxygen released by the water plant doubles.

26. Which of the following diagrams accurately represents the use of gases in both cellular respiration and photosynthesis?

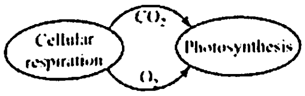
A.



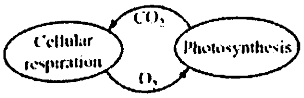
B.



C.



D.



27. Which of the following products of Krebs cycle will diffuse out of the cell, enter the bloodstream, and be released from the lungs during aerobic cellular respiration?
A. Carbon dioxide
B. ATP
C. Oxygen
D. Electron carriers

28. Yeast, a common fungus, is economically important to the beverage industry because when placed in grape juice, it
A. releases sugars that react with alcohol in the juice
B. acts as an enzyme to break down juice into alcohol
C. ferments carbohydrates in the juice and releases alcohol
D. produces starch that bonds with juice sugars to form alcohol

29. Which of the following statements is NOT correct about fermentation in animal cells?
A. It can provide a rapid burst of ATP when there is limited oxygen supply.
B. In our bodies, muscle cells more than other cells are likely to carry out fermentation.
C. Pyruvate can build up in muscles, changing the pH and causing muscle fatigue.
D. Only animal cells can carry out fermentation.

30. The table shows the relationship of glucose molecules used to gas molecules released during cellular respiration.

Number of glucose molecules used during respiration	Number of gas molecules released during respiration
1	6
2	12
3	18
4	24

Which cellular process would result in a cell releasing 120 gas molecules?

A. The mitochondria converting 20 glucose molecules into carbon dioxide.
B. The chloroplasts converting 30 glucose molecules into carbon dioxide.
C. The mitochondria converting 30 glucose molecules into oxygen.
D. The chloroplasts converting 20 glucose molecules into oxygen.

31. Humans undergo cellular respiration. Which other living things undergo cellular respiration?

I. Snail
II. Bacteria
III. Rose plant
IV. Cow
V. Mushroom

A. IV only
B. I, II and III only
C. I, II, IV and V only
D. I, II, III, IV and V

32. The following are involved during the process of cellular respiration:

I. Energy
II. Carbohydrates
III. Carbon dioxide
IV. Water
V. Oxygen

Which one of the following combinations correctly represents their involvement in the above process?

A. II + III → I + IV + V
B. II + IV → I + III + V
C. I + II → III + IV + V
D. II + V → I + III + IV

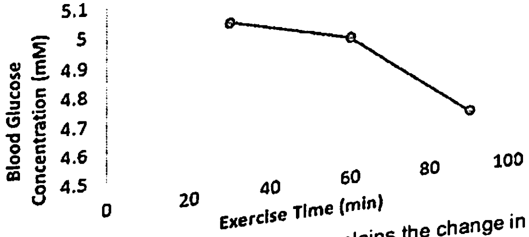
33. During aerobic respiration, electrons travel from source to carrier to final acceptor in which sequence?

A. Food → NADH/FADH$_2$ → electron transport chain → oxygen
B. Glucose → pyruvate → ATP → oxygen
C. Glucose → ATP → electron transport chain → NADH/FADH$_2$
D. Food →glycolysis →Krebs cycle →NADH/FADH$_2$ → ATP

34. In a swimming competition, Alden's muscle cells are not able to take in enough oxygen to make more ATP. His muscles begin weaken due to fatigue. Which explains why this happens?

A. As the cells run out of oxygen, they switch to anaerobic respiration which allows the cell to make small amounts of ATP in the absence of oxygen.
B. As the cells run out of oxygen, they die off gradually and his muscles have fewer contracting muscle cells.
C. The cells will never run out of oxygen if Alden is breathing.
D. As the cells run out of oxygen, they will continue to make the same amount of ATP, since oxygen is not required to make ATP.

35. The graph below shows the change in blood glucose level during prolonged exercise.



Which of the following statements explains the change in blood glucose level shown in the graph?

A. Glucose was broken down to produce ATP for energy.
B. Glucose diffused from muscle cells into the bloodstream.
C. Glucose was used in burning fats.
D. Glucose was converted into muscle proteins.

Appendix L

Course Syllabus in Biological Science

Romblon State University
COLLEGE OF BUSINESS AND ACCOUNTANCY
Odiongan, Romblon

UPDATED SYLLABUS (OBE)
NATSCI 102: BIOLOGICAL SCIENCE
First Semester 2015-2016

RSU Vision:

Romblon State University as a premier institution of higher education in the MIMAROPA Region for a globally competitive province of Romblon

RSU Mission:

Romblon State University is committed to provide advance education, technological, professional instruction and training in agriculture and fishery, forestry, science and technology, arts and other relevant fields of study. It shall undertake research and extension services, and provide progressive leadership in its areas of specialization.

Goals:

1. Quality education;
2. Globally competitive graduates;
3. Innovative and scientific approaches in teaching and learning;
4. Research competence and capability;
5. Community extension services; and
6. Values, attitudes, critical thinking and lifelong skills.

Objectives:

1. To develop relevant expertise and competence in the academe and deliver quality education for the total development of graduates skilled in their major field of specialization;
2. To develop creativity and scientific approaches, and encourage innovative ideas in the academe in order to provide efficient and effective services in the secondary level;
3. To develop research competence among BSED students in order to contribute to the general advancement of knowledge;
4. To facilitate the development of skills and attitudes necessary for success of the pre-service secondary teachers who shall be employable locally and abroad;
5. To extend educational and entrepreneurial expertise for community development; and
6. To develop students 'moral character and critical thinking.

I. **COURSE TITLE:** Biological Science

II. **COURSE NUMBER:** NatSci 102

III. **COURSE CREDIT:** 3 units

IV. **COURSE PRE-REQUISITES:** None

V. **COURSE DESCRIPTION**

This course is designed to provide a general background in understanding the basic principles and processes in the study of biology. It covers life processes and interactions at the cellular, organism, population and ecosystem levels.

VI. **COURSE REQUIREMENTS:**

The hybrid nature of the mode of delivery requires every student to have an e-mail address and connect to the internet at least once a week. In order to pass the course, students should be able to get 60% of the required points in the following requirements:

a. Midterm and Final Exams
b. Performance Tasks and Demonstration
c. Quizzes.
d. Recitation
e. Attendance

VII. **COURSE POLICIES:**

The following important course policies are to be observed and remembered from time to time:

a. This is an introductory course. You will be exposed to different levels of organization of life which requires you to understand how the life processes work and are sustained
b. You are expected to have a genuine desire to learn and to seek the truth through the skills you have developed.
c. You are expected to observe the University rules and policies.
d. Your greatest satisfaction is to have achieved your academic success through your own effort.
e. A graduate of Romblon State University is expected to have academic integrity. Refer to Student Manual for sanction for cheating and plagiarism.

VIII. **GRADING SYSTEM:**

2 Major Exams	200 points	484 – 500	1.0	369 - 391	2.25
5 Performance Tasks	100 points	461 - 483	1.25	346 - 367	2.5
Quizzes	60 points	438 – 460	1.5	323 - 345	2.75
Recitation Logs	10 points (max)	415 – 437	1.75	300 – 322	3.0
Attendance	30 points	392 – 414	2.0	Below 300	Failed
Demonstration	100 points				

IX. COURSE LEARNING OUTCOMES:

After finishing this course, students should be able to:

a. Explain how life is understood and investigated by scientists;
b. Describe how energy is used at the cellular level;
c. Explain the mechanism of the continuity of life;
d. Describe how plants and animals are able to carry on with life processes;
e. Explain how life forms change through time;
f. Explain the interaction of living organisms with their environment as well as their interdependence with other life forms; and
g. Demonstrate short and simple activity/experiment that demonstrates important biological concepts.

X. COURSE CONTENT:

Topic and Time Allotment	Student Learning Outcomes	Teaching-Learning Strategy	Assessment Strategy	Evidence of Outcomes	Inputs/Remarks
I. INTRODUCTION TO LIFE SCIENCE a. Historical development of the concept of life b. The origin of the first life forms c. Unifying themes in the study of life	Students can: a. Explain the evolving concept of life based on emerging pieces of evidence. b. Describe classic experiments that model conditions which may have enabled the first forms to evolve. c. Describe how unifying themes (e.g structure and function, evolution and ecosystems) in the study of life show the connections among living things and how they interact with each other and with their environment. d. Value life by taking good care of all beings, humans, plants and animals.	Computer-Aided Lecture Inquiry Reading Assignment	Paper and Pencil Test	Score in a paper and pencil test	
II. BIOENERGETICS a. The Cell as the basic unit of life b. How photosynthetic organisms capture light	Students can: a. Explain how cells carry out functions required for life. b. Explain how photosynthetic organisms use light energy to	Computer-Aided Lecture Inquiry Demonstration Worksheet-Based Activities	Paper and Pencil Test	Score in a paper and pencil test	

Topic and Time Allotment	Student Learning Outcomes	Teaching-Learning Strategy	Assessment Strategy	Evidence of Outcomes	Inputs/Remarks
energy to form sugar molecules c. How organism obtain and utilize energy	combine carbon dioxide and water to form energy-rich compounds. c. Trace the energy flow from the environment to the cells. d. Describe how organisms obtain and utilize energy. e. Recognize that organisms require energy to carry out functions required for life. f. Make a poster that shows the complementary relationship of photosynthesis and cellular respiration.				
III. PERPETUATION OF LIFE a. Plant and animal reproduction b. How genes work c. How genetic engineering is used to produce novel products	Students can: a. Describe the different ways of how plants reproduce. b. Illustrate the relationships among structures of flowers, fruits, and seeds. c. Describe the different ways of how representative animals reproduce. d. Explain how the information in the DNA allows the transfer of genetic information and synthesis of proteins. e. Describe the process of genetic engineering. f. Conduct a survey of the current uses of genetically modified organisms. g. Evaluate the benefits and risks of using GMOs. h. Conduct a survey of products containing substances that can trigger genetic disorders such as	Computer-Aided Lecture Inquiry	Paper and Pencil Test	Score in a paper and pencil test	

Topic and Time Allotment	Student Learning Outcomes	Teaching-Learning Strategy	Assessment Strategy	Evidence of Outcomes	Inputs/Remarks
	phenylketonuria.				
IV. HOW ANIMALS SURVIVE a. Nutrition: Getting food to cells b. Gas exchange with the environment c. Circulation: the internal transport system d. The need for homeostasis e. Salt and water balance and waste removal f. The immune system: defense from disease g. How hormones govern body activities h. The nervous system i. The body in motion	Students can: a. Explain the different metabolic processes involved in the various organ systems. b. Describe the general and unique characteristics of the different organ systems in representative animals. c. Make a presentation of some diseases that are associated with the various organ systems.	Computer-Aided Lecture Inquiry	Paper and Pencil Test Performance Assessment	Score in a paper and pencil test Score in a performance-assessment test	
V. HOW PLANTS SURVIVE a. Plant form and function b. Plant growth and development	Students can: a. Describe the structure and function of the different plant organs. b. Explain the different metabolic processes involved in the plant organ systems. c. Design a setup on propagating plants using other methods as hydroponics and aeroponics.	Computer-Aided Lecture Inquiry	Paper and Pencil Test Performance Assessment	Score in a paper and pencil test Score in a performance-assessment test	
VI. THE PROCESS OF EVOLUTION a. The evidence for evolution b. The origin and extinction of	Students can: a. Describe evidence of evolution such as homology, DNA/protein	Computer-Aided Lecture Inquiry	Paper and Pencil Test Performance	Score in a paper and pencil test	

Topic and Time Allotment	**Student Learning Outcomes**	**Teaching-Learning Strategy**	**Assessment Strategy**	**Evidence of Outcomes**	**Inputs/Remarks**
species	sequences, plate tectonics, fossil record, embryology, and artificial selection/ agriculture. b. Explain how populations of organisms have changed and continue to change over time showing patterns of descent with modification from common ancestors to produce the organismal diversity observed today. c. Describe how the present system of classification of organisms is based on evolutionary relationships. d. Design a poster tracing the evolutionary changes in a crop plant (i.e. rice or corn) that occurred through domestication.		Assessment	Score in a performance-assessment test	
VII. INTERACTION AND INTERDEPENDENCE a. The principles of the ecosystem b. Biotic potential and environmental resistance c. Terrestrial and aquatic ecosystems d. How human activities affect the natural ecosystem	Students can: a Describe the principles of ecosystem. b Categorize the different biotic potential and environmental resistance (e.g. diseases, availability of food, and predators) that affect population explosion. c. Describe how the different terrestrial and aquatic ecosystems are interlinked with one another. d. Prepare an action plan containing mitigation measures to address current environmental concerns and challenges in the community.	Computer-Aided Lecture Inquiry	Paper and Pencil Test Performance Assessment	Score in a paper and pencil test Score in a performance-assessment test	

XI. REFERENCES:

- Rabago, L. M., Joaquin, C. C., Lagunzad, C. G. B., & Carvajal, J. C. (2006). *Functional biology: Modular approach.* Quezon City: Vibal Publishing House
- Mader, S. S. (1998). *Biology 6th Edition.* USA: MgGraw-Hill Companies, Inc. 679 pp
- Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., & Jackson, R. B. (2011). *Campbell Biology (9th ed.).* San Francisco, CA: Pearson Benjamin Cummings.

Prepared by:

EDDIE G. FETALVERO
Course Instructor

Appendix M

Learning Plan in Bioenergetics

LEARNING PLAN

TOPIC: BIOENERGETICS

LEARNING OUTCOME:
Make a poster that shows the complementary relationship of photosynthesis and cellular respiration. (50 points)

TOPIC 1: REVIEW OF CELL STRUCTURES	**1 hr**
Objectives	Students can • Identify cell parts and their functions. • Determine the parts that are related with how the cell uses energy.
Teaching-Learning Strategy	Lecture with powerpoint presentation
Assessment Strategy	• Paper and Pencil Quiz (5 pts.) • Asgn. (10)
Evidence of Outcomes	Score in a paper and pencil quiz
Inputs/Remarks	Hand-outs

PRETEST*	**1 hr**

TOPIC 2: METABOLISM	**3 hrs**
Objectives	Students can • Identify the forms of energy. • Differentiate between anabolism and catabolism; potential and kinetic energy; chemical and mechanical energy. • Trace the energy flow from the environment to the cells • Explain the two laws of thermodynamics and how they work in natire. • Differentiate between exergonic and endergonic reactions. • Explain how reduction-oxidation reaction works. • Describe the role of enzymes in chemical reaction. • Describe a metabolic pathway and explain how it is controlled.
Teaching-Learning Strategy	Lecture with powerpoint presentation
Assessment Strategy	• Paper and Pencil Quiz (15 pts.) • Asgn. (10)
Evidence of Outcomes	Score in a paper and pencil quiz
Inputs/Remarks	Hand-outs

TOPIC 3: PHOTOSYNTHESIS	**3 hrs**
Objectives	Students can • Describe how plants obtain and utilize energy. • Describe why light is a source of energy. • Describe the absorption spectra of common plant pigments and how they are affected by weather and amount of daylight. • Describe a photosystem, its composition and how it works. • Identify the structures of chloroplasts that are responsible for photosynthesis. • Explain how photosynthetic organisms use light energy to combine carbon dioxide and water to form energy-rich compounds. • Differentiate between light dependent and independent reactions by focusing on the inputs and outputs and tracing the flow of electrons. • Explain why photorespiration occurs. • Differentiate among C3, C4 and CAM photosynthesis. • Explain how plant cells carry out functions required for life. • Recognize that plants require energy to carry out functions required for life.
Teaching-Learning Strategy	Lecture with powerpoint presentation
Assessment Strategy	• Paper and Pencil Quiz (15 pts.) • Asgn. (15)
Evidence of Outcomes	Score in a paper and pencil quiz
Inputs/Remarks	Hand-outs

TOPIC 3: CELLULAR RESPIRATION	3 hrs
Objectives	Students can • Describe how animals obtain and utilize energy. • Describe the processes involved in cellular respiration by focusing on the inputs and outputs in each stage and tracing the flow of electrons. • Differentiate between aerobic respiration and fermentation. • Explain how plant cells carry out functions required for life. • Recognize that animals require energy to carry out functions required for life.
Teaching-Learning Strategy	Lecture with powerpoint presentation
Assessment Strategy	• Paper and Pencil Quiz (15 pts.) • Asgn (10)
Evidence of Outcomes	Score in a paper and pencil quiz
Inputs/Remarks	Hand-outs

POSTTEST*	1 hr

REQUIREMENTS

Attendance	10 pts.	1 point deduction for every absence
Recitation	10 pts.	Use of recitation cards
Assignment	10 pts.	(45/4.5 = 10)
Short quizzes	50 pts.	
Project	50 pts.	
Long Test	35 pts.	
TOTAL	165 pts.	Conversion: (Score x 50)/ 165) + 50

POLICIES ON CLASSROOM MANAGEMENT:

1. Must come to school in complete uniform except during wash-day. The teacher reserves the right to refuse a student not in proper uniform from entering the class, depending on the gravity of reason/s.
2. No earrings and unbuttoned shirt for men.
3. Before the class begins:
   a. Arrange the chairs properly.
   b. Pick up the litters.
   c. Keep the classroom in order.
   d. Cellphones must be switched to silent mode.
4. Upon teacher's arrival
   a. Stand up.
   b. Must start the class with a prayer. This will be done alphabetically starting with the males.
   c. Stay standing until the exchange of greetings is over (i.e. "Good morning/afternoon class" "Good afternoon sir!"
5. Checking of Attendance
   a. A class monitor will be assigned to check the attendance. For the purpose of the study, please wear your name tag for the entire period.
   b. Follow the seat plan. There shall be no switching of places. Seat plan only expires upon the instruction of the teacher. (Need to submit picture.)
6. During Discussion/Lesson Proper
   a. Wait to be recognized before speaking.
   b. Stand up when reciting.
   c. Strictly speak in English during class discussions etc.
   d. Strictly no eating of whatsoever.
   e. No sleeping.
   f. No making noise/causing disorder, disrespecting teacher and classmates.
7. On Examination
   a. Arrange chairs in a bumper to bumper orientation (6x10).
   b. Some examinations are in the form of test papers. Students must pay the corresponding photocopying fees.
   c. No cheating.
8. On Requirements and Assignments
   a. Requirements not passed on the due date will not be accepted and will be graded zero.
9. On Dismissal
   a. Stand up when teacher says "Goodbye class."
   b. Respond by saying, "Goodbye and thank you sir!"
10. Each violation committed will be deducted one point per case.
11. Others:
    a. Fighting, cheating, smoking in class and coming to school under the influence of liquor are grave offenses. Once caught and found guilty, the student will be dropped from the subject.
12. Disciplinary measures consistent with the Student manual await erring students.

Appendix N

Results of Learning Needs Analysis

SUMMARY OF LEARNING NEEDS
(Results of Within Group Consensus)

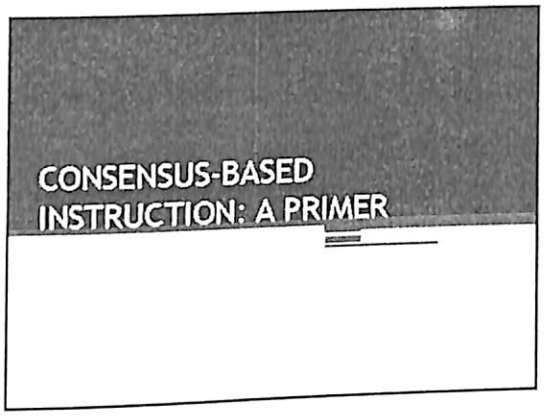
AREAS OF CONCERN	GROUP 1	GROUP 2	GROUP 3	GROUP 4
1. TOPIC OF MOST INTEREST	Photosynthesis. More easy to understand than other topics. Want to gain more knowledge about it.	Cellular Respiration: Because it occurs in living organisms; want to know about the breaking of the chemical bonds in food, and the use of the released energy	Photosynthesis. Because aside from the knowledge that we've learned from high school days; we know that we can learn more from this topic.	Metabolism. Because of its peculiarity, the topics under it, and it would be best to go on the lessons according to what should be tackled first. Some of us found this topic exciting because here, it will enable us to know how plants, and animals use food, water etc. to grow, and heal and to make energy.
2. EXPECTATIONS ON				
GOAL: To Know	The forms of energy. How plants obtain and utilize energy. How animals obtain and utilize energy.	How metabolism, photosynthesis, and cellular respiration differ from each other in terms of utilization of energy.	About the environment and how this topic will work or can help in our daily lives.	How energy is transformed between living things and their environment; how the energy is exchanged; sought answers to questions regarding this topic; Achieve (meet) the objectives of this topic.
GOAL: To do	Understand more about bioenergetics. Apply those knowledge about bioenergetics that was taught by our teacher.	More research related to bioenergetics for information support.	Make a poster about what we have learned; share our knowledge.	Some practical application from what we have learned and to finally give our part to our environment after knowing things like this.
Topic	Interesting and exciting.	Challenging since it is already familiar.	More exciting and clear.	Interesting, more challenging, and exciting; will surely give us or provide new ideas; could broaden our critical thinking; will amaze us.
Teacher	Sometimes to be funny and nice.	Responsible enough to satisfy our expectations/learning needs.	Patient in explaining the lessons and artistic in using visual aids, powerpoint and etc.	Understanding, open-minded, smart, slightly strict, provides specific and clear information, give us the opportunity to speak and to share; friendly; will encourage us every time.; give everyone importance; and for a

AREAS OF CONCERN	GROUP 1	GROUP 2	GROUP 3	GROUP 4
				better communication, having a nice humor is best.
Classmates/Student-to-Student Interactions	Active in participating in every topic and activity that we will be doing.	More cooperative, participative, active and friendly.	Confident in participating and cooperate in class discussion.	Always there everytime we need them (depends on the situation); fill our emptiness, honest, friendly, open-minded, have a nice humor, selfless, know their limits, understanding, know how to cooperate; a good listener and a follower; and helpful.
Teacher-Student Interactions	Nice.	Smooth and mutual.	More confident in cooperating in the class discussion.	Give and take.
Limitation			Assignments and quizzes.	
Add/Change topic		Trivias related to this topic/discussion. Trivia may help to catch up student's interest.		
3. PREFERRED MEDIUM OF INSTRUCTION	TAGLISH because it is where we understand and learn more.	TAGLISH for better understanding	TAGLISH because in this way, we can express our feelings or what we are thinking clearly and so that everybody can understand.	More on ENGLISH, because we are looking forward towards our future, it would help us to be prepared when we graduate; new opportunities will come, example, presenting some proposal, we will be pushed to present it using English language whether we like it or not, you will like it, so it would be best for us to adopt this kind of language. And for a better communication outside the country. Speaking in English will give us high respect specially if you are fluent and good enough.
4. PREFERRED LEARNING ENVIRONMENT	Seats in random arrangement.	Seating arrangement in alphabetical order	Proper seating arrangement in alphabetical order.	We prefer to have a seat plan, so that the teacher would easily identify us and to give justice to those whose surnames start with A. That we believe will limit

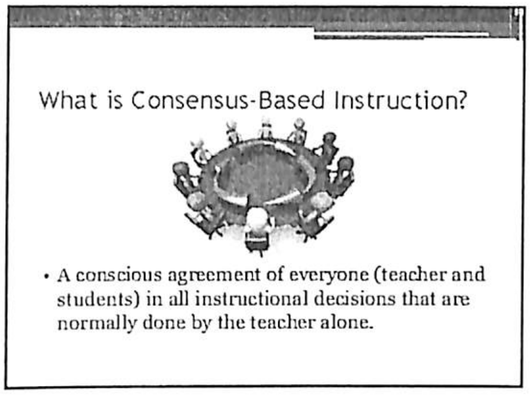
AREAS OF CONCERN	GROUP 1	GROUP 2	GROUP 3	GROUP 4
				them from talking, cheating and etc. (Joke)
5. TEACHING APPROACH				
Suggested Teaching Strategy	Teacher will let us participate and share our own ideas about the topics he is going to present.	Any way the teacher wants as long as we are learning.	Powerpoint presentation and video clips.	Entertainment Games Practical application of what we have learned Laboratory experiments Outdoor activities
Suggested Activities	Laboratory activity.	Pre-test and games	Actual activities or experiment time.	Quizzes will be accompanied by tangible materials (i.e. putting a stone on top of the table, was there a kinetic energy?) Activities like observing with matching questionnaires. Recitation. Graded with cards. Example: stootsies (a piece of paper, numbers 1-5, write on it.)

Appendix O

CBI Orientation Material

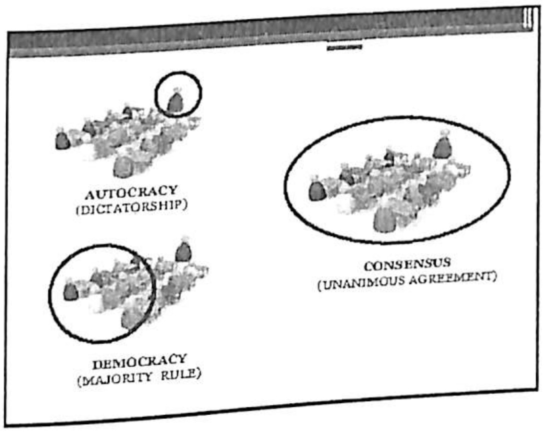


CONSENSUS-BASED INSTRUCTION: A PRIMER



What is Consensus-Based Instruction?

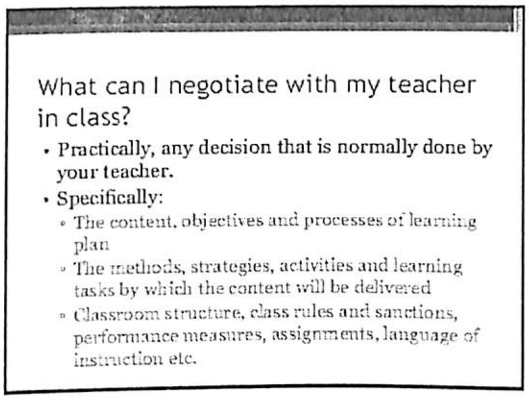
- A conscious agreement of everyone (teacher and students) in all instructional decisions that are normally done by the teacher alone.



AUTOCRACY
(DICTATORSHIP)

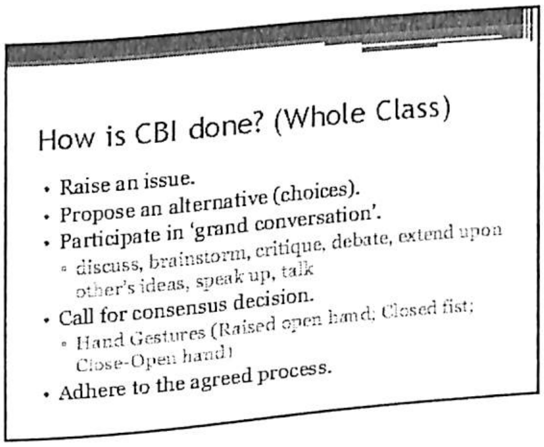
CONSENSUS
(UNANIMOUS AGREEMENT)

DEMOCRACY
(MAJORITY RULE)



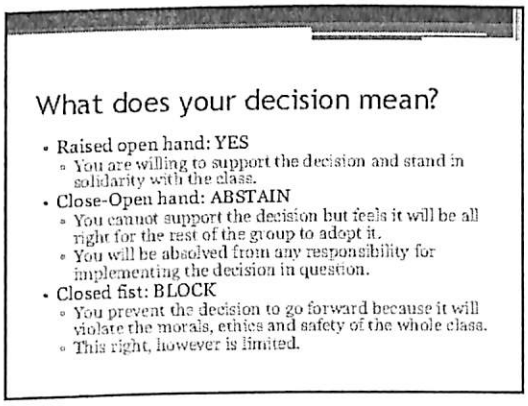
What can I negotiate with my teacher in class?

- Practically, any decision that is normally done by your teacher.
- Specifically:
  - The content, objectives and processes of learning plan
  - The methods, strategies, activities and learning tasks by which the content will be delivered
  - Classroom structure, class rules and sanctions, performance measures, assignments, language of instruction etc.



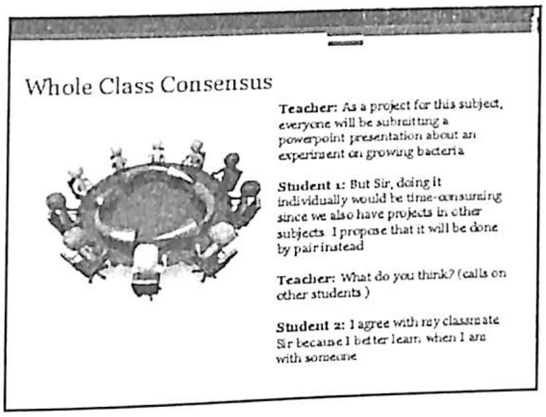
How is CBI done? (Whole Class)

- Raise an issue.
- Propose an alternative (choices).
- Participate in ‘grand conversation’.
  - discuss, brainstorm, critique, debate, extend upon other's ideas, speak up, talk
- Call for consensus decision.
  - Hand Gestures (Raised open hand; Closed fist; Close-Open hand)
- Adhere to the agreed process.



What does your decision mean?

- Raised open hand: YES
  - You are willing to support the decision and stand in solidarity with the class.
- Close-Open hand: ABSTAIN
  - You cannot support the decision but feels it will be all right for the rest of the group to adopt it.
  - You will be absolved from any responsibility for implementing the decision in question.
- Closed fist: BLOCK
  - You prevent the decision to go forward because it will violate the morals, ethics and safety of the whole class.
  - This right, however is limited.



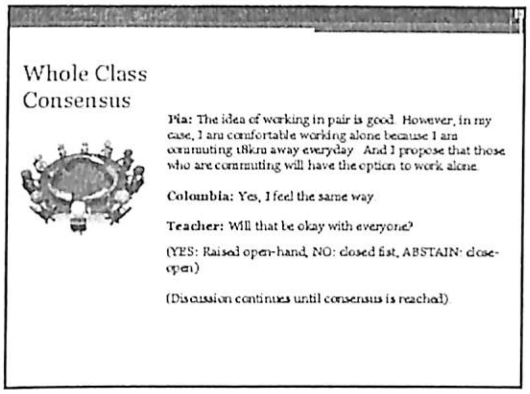
Whole Class Consensus

Teacher: As a project for this subject, everyone will be submitting a powerpoint presentation about an experiment on growing bacteria

Student 1: But Sir, doing it individually would be time-consuming since we also have projects in other subjects. I propose that it will be done by pair instead

Teacher: What do you think? (calls on other students.)

Student 2: I agree with my classmate Sir because I better learn when I am with someone



Whole Class Consensus

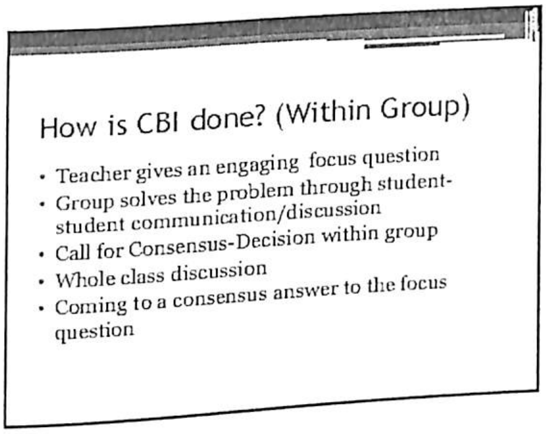
Pia: The idea of working in pair is good. However, in my case, I am comfortable working alone because I am commuting 18km away everyday. And I propose that those who are commuting will have the option to work alone

Colombia: Yes, I feel the same way

Teacher: Will that be okay with everyone?

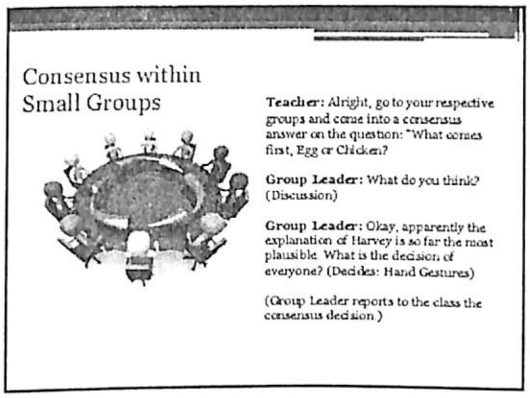
(YES: Raised open-hand, NO: closed fist, ABSTAIN: close-open)

(Discussion continues until consensus is reached)



How is CBI done? (Within Group)

- Teacher gives an engaging focus question
- Group solves the problem through student-student communication/discussion
- Call for Consensus-Decision within group
- Whole class discussion
- Coming to a consensus answer to the focus question



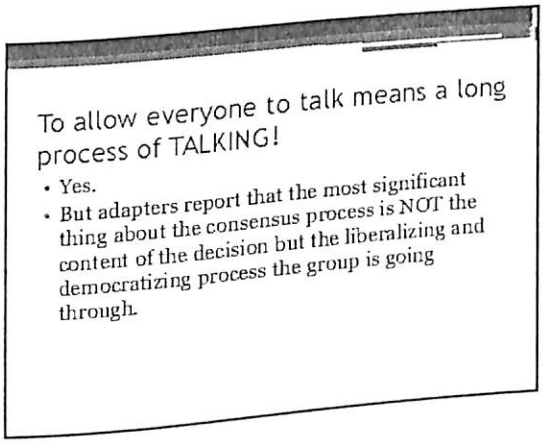
Consensus within Small Groups

Teacher: Alright, go to your respective groups and come into a consensus answer on the question: "What comes first, Egg or Chicken?

Group Leader: What do you think? (Discussion)

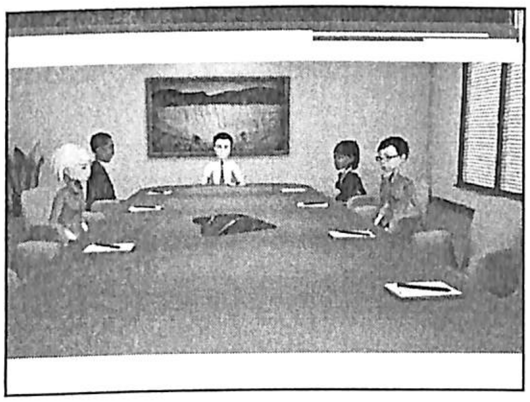
Group Leader: Okay, apparently the explanation of Harvey is so far the most plausible. What is the decision of everyone? (Decides: Hand Gestures)

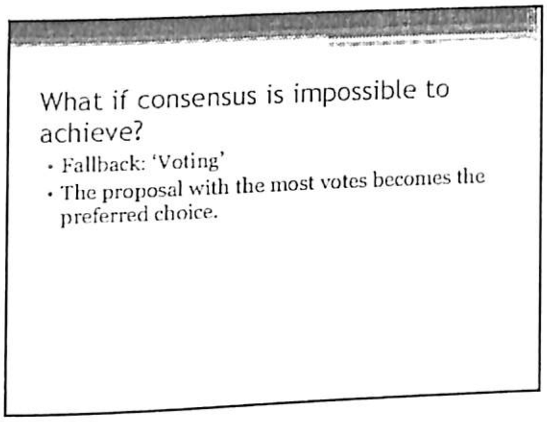
(Group Leader reports to the class the consensus decision.)



To allow everyone to talk means a long process of TALKING!

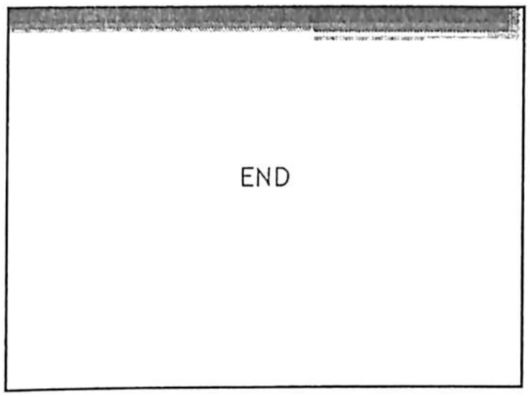
- Yes.
- But adapters report that the most significant thing about the consensus process is NOT the content of the decision but the liberalizing and democratizing process the group is going through.





What if consensus is impossible to achieve?

- Fallback: 'Voting'
- The proposal with the most votes becomes the preferred choice.



END

Appendix P

Students' Reflections about their Experience with CBI

STUDENT	COMMENTS
A	Maganda ang pagtuturo n gaming guro sa aming lesson sa bioenergetics. Binibigya nya ng panahon o oras na magsalita ang bawat mag-aaral. Dahil sa kanya marami kaming natutunan.
B	In my bioenergetics class I experience a lot of activities. It is not a boring topic because our teacher make some activities that make us happy example of this is the experiment time, trivia, games and participation/ recitation with a corresponding points, in that way I consider that bioenergetics is a very interesting lesson and I want to say Thank you to our teacher, because he did a lot efforts for us to understand the lesson clearly.
C	Ang comment ko dito ay pag mayroong consensus napapadali ito at nagkakaintindihan ng maayos ang estudyante. At ang aming guro pag may pinapagawa na activity ito ang gingamit kung gusto mo ba ito o hindi at gumagawa ng paraan para maging parehas ang iyong sagot kung hindi ito pareho.
D	Nakakaenjoy ang lahat ng mga ginagawa naming. Everytime na may consensus minsan nachachallenge din kami. Di nawawalan ng tawanan sa klase at lalo pa talagang nakaka interesado ang bioenergetics.
E	When we're having our consensus group during bioenergetics class, I'd realize that it is really important that in every activity, the participation and the majority of your group be prioritized. I'd enjoyed lot of things in this subject! I Gonna miss this..
F	My class experience in biology using our consensus is enjoy because we do a lot of activities and we already have games, experiments, and our teacher also funny and because of that I will miss him so much. I miss you sir Ed.
G	For me using consensus in our class is nice. It is way of "Pagkakaisa" Teamwork. If meron man kaming hindi napapagkasunduan ay naaayos agad dahil dito. And before the consensus you think seriously what will be happen after the consensus at kung ano ang maibubunga nito sa amin.
H	Para sa akin masaya dahil sa paggamit ng Consensus ay nagkakasundo ang bawat isa. At tsaka enjoy dahil magaling at masaya ang aming guro. Hindi sya boring magturo.
I	Ang lahat ay nagkakasundo sa anumang napapagkasunduan. Using consensus is very important because it make us more cooperative in our group and nakakatulong din para hindi magkagulo ang isang group in studying bioenergetics.
J	Sa bawat discussion sa bioenergetics, sa magandang process sa pag derive na gagawin para sa lessons mas magiging masaya ang klase at maraming knowledge pa ang natutunan namin.
K	About our bioenergetics class experience using CONSENSUS we also understand the fact that some students or my classmates can agree or disagree so that nagkakasundo kami at napag-uusapan kung sino man ang hindi sang ayon dito. Dahil sa Consensus doon namin malalaman ang isang grupo namin kung ito ay may sasabihin pa o wala.
L	Dahil sa pagkakaroon ng consensus ang klase, madali ng magkaisa ang mga estudyante, na ang bibigyan lang ng pagkakataong magsalita ay ang salungat ng karamihang bumoto at nalalaman din dito kung sino ang ayaw sa pinagbobotohan.

STUDENT	COMMENTS
M	It was a helpful each and every one to decide if what is the best thing to do in class. Every one cooperates and if someone disagree our teacher will asked if "What is the reason why?" And we will have a consensus again until everyone will agree to the decisions.
N	Bioenergetics lesson is very enjoyable, fun, challenging, and interesting not only of its different topics but also the way our teacher teach us.
O	Hindi ko favorite subject ang biology, but it is slightly interesting for me. I enjoy learning about biology. During my secondary level wala akong masyadong natutunan about biology at ngayon ko lang nalaman yung iba't ibang terms about biology and it is because of our teacher he has a good strategy in teaching.
P	Lahat kami ay nagkaka-isa para sa isang desisyon. Masaya kami dahil naipapahayag namin ang aming nais sabihin sa ibang desisyon.
Q	About bioenergetics class I experience using consensus I was understand of what my classmate opinion and about consensus this is a good idea for us. At para mas lalong mapalawak ang bawat idea ng bawat isa. Natatawa ako sa ibang topic sa biology.
R	I really appreciate the experience about bioenergetics in class because more knowledge and nadagdagan pa yung mga dating mga kaalaman ko. And I really enjoy the topics na tinuro sa amin marami pa kaming natutunan about biology yung feeling na gusto mo lagging mag experiment ng mga iba't –ibang bagay. I hope other students enjoying the subject about biology.
S	About our experience in our bioenergetics class using consensus help us to communicate to our teacher of what learning style that we need, we are able to connect or concile with our teacher and it really help to provide opportunities to every student.
T	Kapag ginagamit namin ang consensus sa aming bioenergetics class ay nalalaman kung ano ang mga sariling opinyon ng aking mga kaklase at dahil sa mga opinyong ito kami ay nagkakasundo sa isang desisyon.
U	Using consensus, our teacher gives us a chance to express the ideas we want to share with others and he encourage us to speak and show our talent in facing to many people ng walang pag aalinlangan.
V	It's so enjoying and I really learn a lot at new things and information that I read only in our bioenergetics class. I don't feel bored every time I enter the class because I know that there's new information that would be discuss I really amaze the way our teacher teach and how he make our bioenergetics class so much enjoying.
W	Masaya dahil lahat ng mga student's ay nagkakaisa sa mga aktibidad.
X	My bioenergetics class experiences. Honestly I cannot understand some other lessons, during the discussion of our teacher. But that is not the fault of my teacher; it's my fault because sometimes my mind is flying away haha... But of course I learn a lot in our bioenergetics class. I'll try my best to help myself, to be interested in biology.
Y	Laging nagkakaisa at walang nangyayaring anomang gulo dahil lahat ay nagkakaunawaan. Wala ring nagiging sisihan sa anumang resulta ng mga

STUDENT	COMMENTS
	aktibidad na ginagawa. Nagiging maayos ang samahan ng bawat isa at nagtutulungan.
Z	Attending biology class is fun and interesting. I have learned a lot from it, even though it's hard for me to understand it at first. I have tried my best to answer all questions that was given in exams. I'm looking forward for my next topic and hoping to learn more and more.
AA	In my bioenergetics class experienced. Our teacher encourages me to learn more about biology for more understanding and it was amazing and interesting. I learn important things in biology on how photosynthesis, cellular respiration take place, and what metabolism is. And using consensus our teacher give us chances to express our ideas, thought and feelings.
BB	It is fun and interesting I learned many things about bioenergetics maraming natutunan tungkol sa photosynthesis, metabolism, structure of cells, at cellular respiration na malaking tulong sa araw- araw nating pamumuhay,
CC	Using consensus in class is good because everyone understand each other and we're free to decide about anything. It's fun and great because everyone can show their feeling about the decisions and it's my prefer than the others. Like making decision with everyone and also with our teacher we're comfortable in making decision. I also learned everything using consensus.
DD	It's more interesting to study a bioenergetics because you will know about the things in the environment and the different function on how they support their self and how they survive.
EE	My comments or remarks about our bioenergetics class experience are it was an interesting topic because we learn more about it. It was an acting topic because we do a lot of activities related to it. Our teacher is very active in teaching us and he is also energetic.
FF	It is effective to everyone because it gives to the learners for them to share their ideas and express their feelings during the class consensus/ group activity.
GG	It's so fun and I enjoy experiencing the bioenergetics lessons. Knowing the important of group consensus. I learned more in biology lessons and I learn important things in each lesson in biology.
HH	If we have a consensus everybody agree of what we're talking so there's a decision that is acceptable to everyone.
II	For me bioenergetics class experience using consensus is a good way to share the opinion of other student to do good for them to work or activities that they encountered in their class lesson.
JJ	My experience about bioenergetics class consensus is a very happy because by using consensus in making a decision is a good idea. Yun bang nagkakasundo lahat at nagcocooperate. I'm so happy for that.
KK	Consensus is a good way to how teacher and students interact and it helps student to share what they want to say about the topic in the class.
LL	During our consensus experience, I experienced the equality treatment I all students. No one feel regretted in our consensus time. They can express their reasons why they didn't want that or why they like that. But as an introvert student, I just follow the majority and let them decide.

STUDENT	COMMENTS
MM	Do consensus activity was very good, because nagkakaisa tayo and para malaman natin kung sino ang mga hindi payag at sa mga gusto. Gamit ang consensus ay madali nating naresulba ang mga bagay bagay at malaki ang naging tulong nito sa aming mga student sa paggawa ng mga group decision.
NN	Nakaka enjoy po talaga at marami kaming natutunan. Para kasing mas madali kapag ganun yung set up ng isang klase. Hindi boring at the same time natutu pa. Sana maulit ito. Ang galling ni Sir Ed! See you again Sir!
OO	Maganda po ang na experience ko sa bioenergetics. Dito po madami akong natutunan, kahit na minsan mahirap intindihin.
PP	Enjoy when we have our group activity kasi ditto kami nagkakasundo at nagshashare ng thoughts. Masaya ako kasi madami akong natutunan sa bioenergetics.
QQ	Yung remarks or comment ko about bioenergetics class is napakadami kong natutunan. Yung prof. naming is hindi gumagawa ng desisyon kapag hindi kami nag coconsensus kasi gusto nya negotiate ang bawat isa so that he can know who is agree or disagree in every activities or lesson that we will do. So sir thanks you for being part of our lives and I'm very proud to you because you're a good teacher to everyone. You make our day completely with your jokes and trivia. So Sir don't forget us and thank you for choosing us to be your student. And that's all thank you again and god bless always.
RR	We are freely to share our ideas during the bioenergetics class, we shared different ideas that is being faired to make a decision that acceptable for everyone. It is nice to have consensus because no one feel disappointed if what they wants did not follow because it is being explain to us why that kind of decision is needed and what is the importance of it.
SS	In every meeting they have a consensus lahat kami na nandito ay nagkakaintindihan, sometimes hindi kasi yung iba disagree at yung iba agree pero sa huli nagkakaayusan naman. I'm happy when they have an activity and experiment I enjoy.
TT	Mybioenergetics class experience was so great by using consensus mas lalo pa akong nagging open sa mga classmates ko at yung mga gusto kong sabihin ay pinapakinggan nila at kung an0 naman ang mali sa pagkakaintindi ko ay kino-correct nila ako.
UU	Biology/ bioenergetics is a very interesting subject fascinating and fun. Biogenetics makes me happy and interested when I had comprehended some important points and information. I enjoy learning bioenergetics together with our teacher and classmates especially it involves activities like games and trivia. My teacher discussed the lesson very well. AMAZING!
VV	It is a very good idea because we can share our ideas to our group even we are not sharing it 100% to the class. We enjoy it during the ideas were out to our lips that means we learned more in biology class and make us interesting to the subject.
WW	Interesting ! We have the rights to express our opinions by sharing to others.
XX	For me maganda ang mga plano/ tinuturo sa amin ng aming teacher marami akong natutunan at mas lalo ko pang naintindihan kung ano iyong mga under ng

STUDENT	COMMENTS
	bioenergetics. Magaling magturo an gaming teacher talagang malinaw para maunawaan.
YY	It's more effective dahil nagkakaintindihan ang bawat isa.
ZZ	Epektibo ang consensus kapag may activity na pinapagawa ang guro.
AAA	My Experience in bioenergetics class unforgettable dahil marami akong natutunan at nalaman about biology. My experience in consensus is happy and fun dahil binibigyan ng pagkakataon ang bawat isa kung ano kanilang desisyon. Ang masasabi k okay Sir kahit maikling panahon na nagging teacher ka naming marami po kaming natutunan.
BBB	Based on what we experienced about our bioenergetics class using consensus.I can easily say that this kind of class is very effective and it tight our relationship as a classmate and it strengthen our unity. So using consensus in a class can improve and help everyone express their thoughts and ideas freely and develop how to negotiate and interact with others.

Appendix Q

Transcript of Students' Informal Video-Recorded Interview about CBI

Q: Nagustuhan nyo ba yug consensus?

A: Yes sir.

Q: Bakit sa anong paraan?

A: Di ba kunyari yung bawat isa may mga gustong sabihin or ipatupad na kailangan dapat gawin natin. Kapag ginamitan ng consensus, nagkakasundo tayo. Nagkakaayos tayo kung ano man yung dapat nating gawin sa ating grupo.

Q: Gusto nyo ba yung idea na bago magsimula ang klase ay magkasundo or mag-usap muna kung ano lang yung kayang ibigay ng teacher yung magmemeey ba yung teacher at estudyante na walang napipressure, walang pamimilit.

B: Yes sir. Di ba sir yung estudyante minsan, natatakot ya dun sa teacher, hindi nya ano yung ugali ng teacher. Dapat parang magkakasundo yung estudyante at teacher, para matuto yung estudyante kasi sir pag hindi sya close doon sa teacher, parang hindi nya alam kung saan sya kukuha ng source ng tamang sagot kasi yung iba kasing estudyante hindi rin naman alam sir.

Q: Nagustuhan mo ba yung teacher mo sa consensus?

B: Kasi ay andami ko talagang natutunan. Nung una talaga sir hate ko yung biology kasi sabi ko ano ang makukuha ko rito, parang nakakatamad, nakakaboring, nakakaantook, pero yung nagconsensus sir na ganun nga sabi ko'y parang enjoy sya sir na ang dami mong matututunan, na ganug bagay. Madami pa palang mga bagay na matututunan about biology, para lang dun sa mga bagay na hindi mo pa alam sir.

Q: Doon sa mga napagusapan natin na ito ang gagawin, lahat bay un ay naipatupad doon sa consensus class?

B: Yes sir.

Q: Ano ang nagustuhan mo doon lahat?

B: Yung naggogroup sir, tapos yung parang sabi mo na, ganito yung gusto ko, ganito yung gusto nya, hanggang mabuo yung mga sagot sir na dapat talaga yung a point na tinatanong nung teacher. Yun talaga yung tamang sagot at yun ang napagkasunduan nila sir.

Q: Yung mga video clips, yung mga trivia, yung mga observation activities, yung mga experiments, isa yun sa mga naagusapan ninyo di ba? Saan talaga yung sat tingin ninyo ay , akma talaga sa akin ito ah, gusto koi to ah?

C: Yung ano sir…yung mga powerpoint na may kasamang visual aids, mga tangible na bagay para example saka yung mga trivia. Para imbes na yun lang malalaman naming ay may malalaman pang iba.

Q: Ano ang mahalagang naidulot sa iyo ng consensus?

D: Malaki po sir kasi yung pagkakaisa ng bawat estudyante, you interact between the teacher kunyari may tinatanong yung teacher sa yo, kung ano yung gusto mo, kung okay bay un. Kung hindi mag-aagree yung isa hindi magagawa or mabubuo yung sinasabing consensus.

Q: Nagiba ba yung paningin mo sa biology? Mas natuwa k aba sa iyong biology class?

D: Yes sir. Kasi po talaga yung biology, yung science ang pinakweakness ko na subject, yung pinakamahirap para sa akin. Kaya po talagang yung sa biology, talagang mas maraming natutunan, mas lalong lumawak yung kaalaman ko,

Q: Sa pakiramdam nyo ba natakot kayo or nagging free kayo sa pagexpress ng idea sa consensus class?

C: Noong una sir ay natakot kami, pero yung nagcoconsensus na sir ay, dun lang naming na nalaman na malupit pala, masaya.

Q: Gusto nyong gawin din ito sa iba ninyong subjects?

Group: Yes. Depende. Kung pwede. Kasi sir mas enjoy.

Appendix R

Factor Analysis of Attitude Towards Biology Scale

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.896
Bartlett's Test of Sphericity	Approx. Chi-Square	1.020E4
	df	2211
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	14.366	21.441	21.441	4.526	6.755	6.755
2	4.257	6.353	27.795	4.491	6.703	13.458
3	3.167	4.726	32.521	4.375	6.530	19.988
4	2.443	3.647	36.168	3.838	5.728	25.717
5	2.095	3.127	39.295	3.602	5.376	31.093
6	1.904	2.841	42.136	2.953	4.408	35.500
7	1.593	2.377	44.513	2.874	4.289	39.790
8	1.587	2.369	46.882	2.167	3.234	43.024
9	1.480	2.209	49.091	1.910	2.850	45.874
10	1.362	2.032	51.123	1.656	2.472	48.346
11	1.240	1.851	52.974	1.629	2.431	50.777
12	1.205	1.799	54.773	1.570	2.343	53.120
13	1.128	1.683	56.456	1.528	2.280	55.400
14	1.095	1.635	58.091	1.438	2.146	57.546
15	1.054	1.573	59.664	1.293	1.930	59.476
16	1.034	1.544	61.208	1.160	1.732	61.208
17	.983	1.467	62.675			
18	.964	1.438	64.113			
19	.922	1.376	65.490			
20	.912	1.361	66.850			
21	.850	1.269	68.119			
22	.842	1.257	69.376			
23	.834	1.244	70.620			
24	.801	1.196	71.816			
25	.766	1.143	72.960			
26	.735	1.098	74.057			
27	.730	1.090	75.148			
28	.718	1.069	76.216			
29	.700	1.045	77.261			
30	.687	.996	78.257			
31	.646	.965	79.222			
32	.632	.944	80.166			
33	.615	.918	81.083			
34	.608	.907	81.991			
35	.586	.874	82.865			
36	.555	.828	83.694			
37	.545	.813	84.507			
38	.535	.799	85.306			
39	.525	.783	86.089			
40	.510	.761	86.849			
41	.496	.741	87.590			
42	.481	.688	88.278			
43	.450	.672	88.951			
44	.436	.650	89.601			
45	.431	.644	90.245			
46	.413	.616	90.881			
47	.405	.604	91.466			
48	.392	.584	92.050			
49	.378	.564	92.615			
50	.365	.546	93.160			
51	.355	.529	93.690			
52	.344	.513	94.203			
53	.329	.491	94.694			
54	.324	.483	95.177			
55	.318	.475	95.652			
56	.311	.464	96.115			
57	.300	.448	96.563			
58	.289	.431	96.994			
59	.263	.392	97.386			
60	.253	.377	97.763			
61	.248	.370	98.133			
62	.239	.357	98.490			
63	.230	.343	98.834			
64	.214	.320	99.154			
65	.199	.297	99.451			
66	.191	.285	99.736			
67	.177	.264	100.000			

Extraction Method: Principal Component Analysis.

Rotated Component Matrix

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
ITEM54	**0.7428**	0.0871	0.1286	-0.0510	0.0361	0.0558	0.2318	0.0155	0.1027	-0.0002	-0.0147	0.0014	-0.0503	0.0485	0.0958	-0.0177
ITEM55	**0.6880**	-0.0024	0.1578	0.1659	0.0853	0.1388	0.1364	0.0598	0.1258	0.0430	-0.0866	-0.1044	-0.0386	-0.0244	0.0324	-0.0854
ITEM51	**0.6814**	0.1088	0.0343	0.2087	0.0733	0.0325	0.0548	-0.0662	-0.0624	-0.0299	0.0261	0.1787	0.2256	0.0258	0.0251	0.1047
ITEM53	**0.6713**	0.1789	0.0009	-0.0058	0.0865	0.0408	0.1060	-0.0246	-0.0802	-0.0798	0.2404	-0.0828	0.1580	-0.1211	0.1094	0.0137
ITEM50	**0.5645**	0.1078	0.0473	0.1072	0.0157	0.2130	0.1716	0.0523	-0.1093	0.0682	-0.0418	0.1275	0.4065	0.1367	0.0649	-0.0428
ITEM58	**0.5437**	0.0970	0.2065	0.2287	0.1868	0.0499	0.1564	0.1929	-0.0533	0.1516	0.1534	0.0831	-0.0282	0.0137	-0.0539	0.1003
ITEM56	**0.4613**	0.0830	0.0598	0.1109	0.0455	0.0280	0.3487	0.0275	0.1252	0.1076	-0.0829	-0.0422	-0.1796	0.3029	-0.0348	0.0982
ITEM57	**0.4605**	0.1752	0.2495	0.3772	0.2554	-0.0500	0.1556	0.2407	0.0783	0.0390	0.0447	-0.0280	-0.1751	0.0772	-0.0066	0.0694
ITEM46	**0.4429**	0.1752	0.4197	-0.0298	0.1293	0.1834	0.1277	0.0889	-0.0330	0.0549	-0.2111	0.2082	0.0255	0.1012	-0.0107	0.1350
ITEM49	**0.4429**	0.1432	0.0513	0.1215	0.1862	0.0357	0.1164	0.2769	-0.0649	0.2746	-0.0700	0.2156	0.2549	0.0222	-0.1548	-0.2539
ITEM25	0.0965	**0.6907**	0.0609	0.0747	0.0780	0.1510	0.2319	-0.0658	-0.1372	0.0202	-0.0247	0.0379	-0.0449	0.0353	0.0846	0.0109
ITEM26	0.1103	**0.6735**	0.0860	0.1049	0.1345	0.1681	0.0711	-0.0318	-0.0663	0.0626	-0.0872	0.0014	0.1323	0.0406	-0.0672	0.0479
ITEM27	0.2035	**0.6591**	0.1817	0.1603	0.1121	0.1297	-0.0050	-0.0202	0.1439	0.0979	-0.0106	0.0571	-0.0932	-0.0667	0.0084	0.0649
ITEM28	-0.0089	**0.6180**	0.0723	0.0658	0.0755	0.0844	0.1336	0.0521	0.2904	-0.0645	-0.0819	0.0166	0.0909	-0.1136	0.0551	-0.1250
ITEM30	0.1239	**0.5742**	0.1249	0.0570	0.0890	0.0503	0.0928	0.1288	0.3347	0.0248	0.1481	0.0928	-0.0109	-0.0108	-0.1784	-0.0971
ITEM22	0.1603	**0.5605**	0.0235	-0.0374	0.1470	0.1408	-0.0170	0.1768	0.1507	0.1259	-0.0001	0.1008	-0.0833	0.2298	0.1195	0.0433
ITEM32	0.0449	**0.5382**	0.0232	0.0370	0.0967	0.0163	0.0213	0.2013	0.1925	-0.0053	0.1565	-0.0268	0.1511	-0.0658	0.1747	0.1436
ITEM24	0.0344	**0.5292**	-0.0380	0.1270	0.1955	0.1247	0.1553	-0.0465	0.0238	-0.0582	0.2918	0.2816	-0.0342	0.1213	0.0313	-0.0135
ITEM42	0.0307	-0.0335	**0.7216**	0.1347	-0.0119	-0.0509	0.0976	0.0449	-0.0052	0.0869	0.1474	-0.1181	0.0597	0.0100	0.2186	-0.2678
ITEM43	0.0972	-0.0266	**0.7198**	0.2753	0.0070	0.0723	-0.0133	0.0277	0.0891	0.1116	-0.0098	-0.0305	0.1375	-0.0075	0.0672	-0.1899
ITEM39	0.1116	0.1211	**0.6860**	0.1053	0.1233	0.1370	0.1145	0.0745	-0.1263	0.0027	-0.0659	0.1597	-0.0608	0.0202	0.0903	0.1780
ITEM37	0.1824	0.1580	**0.6446**	0.1154	0.1599	0.0917	0.1498	-0.0595	-0.1105	-0.0646	-0.0611	0.0544	0.1185	0.1744	0.0851	0.1549
ITEM38	-0.0548	0.1017	**0.6341**	0.2277	0.2262	-0.1084	0.0596	0.0013	0.1403	0.0414	0.0643	-0.0294	-0.0317	0.0912	-0.1725	0.2411
ITEM45	0.1508	0.0539	**0.5828**	0.1494	0.2105	0.0698	-0.0342	0.1713	-0.0310	-0.0353	-0.1831	0.2975	-0.0302	-0.2047	-0.1202	0.1603
ITEM44	0.3006	0.2030	**0.4933**	0.1533	0.0726	0.0524	0.1266	0.0668	0.0240	0.1257	-0.0610	0.2755	0.0865	0.1910	0.1023	-0.2075
ITEM60	0.2485	0.1354	**0.4217**	0.2115	0.1062	0.0990	0.0737	-0.0053	-0.0347	0.3747	0.0983	-0.0883	-0.1359	0.0786	-0.1346	-0.1140
ITEM63	0.0465	0.0958	0.1981	**0.7814**	0.0814	-0.0094	0.0452	0.0418	0.0203	-0.0481	-0.0873	0.0139	0.0523	0.0107	0.0462	0.0464
ITEM62	0.1121	0.0729	0.1580	**0.7489**	0.2020	-0.0408	-0.0720	0.0271	-0.0255	-0.0404	-0.0018	0.0169	0.0819	0.0692	-0.0817	-0.1346
ITEM59	0.0756	0.1586	0.2704	**0.5657**	-0.0438	0.0602	0.1068	0.1092	-0.0382	0.0016	-0.0704	-0.0828	0.0893	-0.0360	-0.2941	-0.0926
ITEM61	0.1673	0.1142	0.2327	**0.5339**	0.1068	0.1696	-0.0322	0.1031	0.1456	0.3103	0.0696	-0.0474	0.0780	-0.0531	0.1341	0.0107
ITEM65	0.2212	0.1498	0.2567	**0.5205**	0.2024	0.0448	0.0995	0.0267	0.0367	0.2631	-0.0408	0.0835	-0.0027	0.0818	0.0453	0.2490
ITEM66	0.0487	-0.1514	-0.0351	**0.4671**	0.0918	-0.0251	0.1156	0.1730	0.2097	0.2134	0.1007	0.3222	0.1122	0.1001	0.2147	0.2040
ITEM67	0.1622	-0.0166	0.0836	**0.4667**	0.0332	-0.0328	0.0889	0.1142	0.1429	0.1957	0.1415	0.3091	-0.0866	0.2581	0.1972	-0.0201
ITEM64	0.0797	0.1383	0.0901	**0.4209**	-0.0683	0.0878	0.1902	0.0553	-0.1048	0.4077	0.0328	0.0415	-0.0673	-0.0053	0.0891	0.3969
ITEM4	0.0676	0.1560	0.1564	0.0320	**0.7106**	0.1123	0.1320	-0.1169	0.0978	0.0844	-0.0368	0.0025	0.2060	0.0507	-0.0482	-0.0428
ITEM3	0.0958	0.1066	0.1173	0.1343	**0.6786**	0.1227	0.1380	0.1238	0.0328	0.1170	0.0566	0.0891	-0.0416	0.0314	-0.0548	-0.0344
ITEM6	0.0834	0.0862	0.1061	0.2517	**0.6677**	-0.1082	0.0838	0.2618	0.2170	0.0838	-0.0521	0.0519	0.0531	-0.0276	0.1007	0.0605
ITEM1	0.1003	0.2597	0.1684	-0.0008	**0.5530**	0.1958	0.0550	0.1007	-0.0026	0.0275	0.0525	0.0137	0.1836	0.0787	0.1008	0.1234
ITEM5	0.1738	0.1431	-0.0357	0.2247	**0.5216**	0.1177	0.2614	0.0663	-0.0896	0.0388	-0.2644	-0.0422	-0.0978	0.0379	0.2144	-0.1071
ITEM17	0.2337	0.1433	0.1470	0.1473	**0.4235**	0.2915	0.0050	0.2513	-0.0400	0.2958	-0.0060	0.1121	-0.0977	0.1950	0.0181	-0.1120
ITEM2	0.2134	0.3335	0.0821	-0.0038	**0.4165**	0.2593	-0.0553	0.1147	-0.0821	-0.0257	0.1410	0.0958	-0.0889	0.0005	-0.0577	0.2144
ITEM7	0.1652	0.1356	0.1091	0.0505	**0.3517**	0.2674	0.1681	0.3245	-0.0502	0.1444	-0.0237	-0.0910	0.2932	0.1269	-0.0599	0.3386
ITEM9	0.0766	0.1136	0.0562	0.0316	0.0467	**0.7170**	0.0979	0.1064	0.0614	0.0044	0.1541	0.1132	0.1612	-0.1078	-0.0364	0.0338
ITEM8	0.1313	0.1707	0.0283	0.0175	0.0802	**0.6648**	0.1111	-0.0295	0.1182	0.0374	-0.0085	0.0479	0.0663	-0.1642	0.0249	0.1512
ITEM14	0.0629	0.1158	0.0637	-0.0287	0.0561	**0.6571**	0.0112	0.1283	0.1181	0.0383	-0.0609	-0.0275	-0.2095	0.1280	-0.0439	-0.0906
ITEM12	-0.0100	0.2980	-0.0044	0.0555	0.3285	**0.5749**	0.0311	-0.0926	-0.0247	-0.0499	0.2263	0.1758	0.0147	-0.0166	0.0443	-0.1059
ITEM13	0.1684	0.3747	0.1047	0.0173	0.2408	**0.4955**	-0.0245	-0.0224	0.1335	0.0697	0.1292	-0.0411	0.0385	0.2032	0.1073	0.0098
ITEM35	0.2009	0.0940	0.1411	0.0457	0.1221	0.0216	**0.7978**	-0.0442	0.0666	0.0561	-0.0175	-0.1159	0.0674	0.0656	-0.0098	-0.0156
ITEM36	0.2380	0.0857	0.2122	0.0820	0.1471	0.0245	**0.7314**	-0.0231	0.0930	0.0211	-0.0586	0.0330	-0.0430	0.0758	-0.0521	-0.0265
ITEM34	0.2263	0.1622	0.0177	0.0053	0.0317	0.0935	**0.6970**	0.1022	-0.0415	0.0671	0.0576	0.0534	0.1976	-0.0442	0.0428	-0.0184
ITEM33	0.1158	0.0982	0.0039	0.0208	0.1195	0.0844	**0.6150**	0.0494	-0.1798	-0.1180	0.0600	0.2012	-0.0070	-0.0794	0.1821	0.1216
ITEM21	0.1106	0.1036	0.0516	0.0450	0.0233	0.1098	0.0120	**0.7176**	-0.1194	0.0813	-0.1470	-0.1005	0.1478	0.1348	0.1053	0.1550
ITEM23	-0.0476	-0.0801	-0.0270	0.1721	0.1671	0.0449	0.0944	**0.6012**	0.1147	-0.0567	0.3015	0.0458	-0.1307	0.0939	-0.0230	-0.2651
ITEM19	0.0290	0.0995	0.1902	0.2114	0.3670	-0.0097	-0.1043	**0.4933**	0.2703	0.0421	0.0337	0.0424	0.1571	0.0222	0.0046	-0.0063
ITEM48	0.2759	0.1480	0.2125	0.3768	0.2633	0.0430	0.0489	**0.4281**	0.0749	0.0612	0.0965	0.0283	0.0243	-0.0738	-0.1576	0.0546
ITEM31	-0.0545	0.2979	-0.0994	0.0293	0.0387	0.0909	0.0026	0.0951	**0.6515**	0.0643	0.1339	0.0353	-0.0236	-0.0480	0.0051	-0.0556
ITEM29	0.0600	0.3262	0.0055	0.1723	0.0895	0.2330	-0.0024	-0.0582	**0.6077**	-0.1040	-0.1267	-0.0087	0.1445	-0.0902	0.0465	0.0163
ITEM15	0.0932	-0.0285	-0.0048	-0.0745	0.0732	0.3089	-0.0911	-0.0646	**0.5033**	-0.0070	0.4139	0.1443	-0.0385	0.1651	-0.1018	0.0796
ITEM16	0.0039	0.0207	0.0662	0.0951	0.2308	0.0046	-0.0113	0.0429	0.0176	**0.7209**	0.0108	0.0550	0.1134	-0.0714	-0.0098	0.0381
ITEM20	0.0708	0.1688	-0.0282	0.0069	-0.0132	0.2038	0.0301	0.0736	0.0742	0.0894	**0.7088**	0.0113	0.0193	0.0136	0.0636	-0.0141
ITEM18	0.0556	0.1553	0.1155	0.1405	0.2840	0.1857	0.0846	0.0823	-0.0371	0.2003	**-0.3486**	0.1363	0.1685	0.1829	0.0727	-0.0579
ITEM40	-0.0184	0.2545	0.1301	0.0229	0.0550	0.2562	0.0238	-0.1615	0.1350	0.0343	0.0624	**0.6342**	-0.0254	-0.1790	0.0345	-0.0169
ITEM47	0.3231	0.2051	0.3853	0.0681	0.1676	0.0440	0.1049	0.1311	-0.0731	0.0604	-0.1285	**0.4950**	-0.1384	0.1597	-0.1113	0.0126
ITEM10	0.1393	0.0256	0.0873	0.1124	0.1664	-0.0126	0.0976	0.0996	0.0930	0.0622	-0.0131	-0.0749	**0.7028**	0.0727	-0.0308	-0.0014
ITEM11	0.0555	0.0196	0.1415	0.0746	0.1130	-0.0608	0.0223	0.1333	-0.0660	-0.0713	0.0234	-0.0493	0.1068	**0.7374**	-0.0093	0.0023
ITEM41	0.1351	0.0961	0.3163	0.1711	0.1165	-0.0235	0.1400	0.0831	-0.0043	-0.1943	-0.0715	0.0686	0.0186	0.1669	0.5721	0.0477
ITEM52	0.1416	0.2896	0.0627	-0.1827	-0.0113	0.0309	0.0609	-0.0181	-0.0216	0.2510	0.1398	-0.0481	-0.0579	-0.2490	0.5122	-0.0594

Extraction Method Principal Component Analysis Rotation Method. Varimax with Kaiser Normalization.

a Rotation converged in 60 iterations.

Summary of Analyzed Factors and their Labels

FACTOR	FACTOR LOADING	FACTOR LABEL
FACTOR 1:		**IMPORTANCE OF BIOLOGY**
ITEM54	0.7428	Everybody needs knowledge of biology.
ITEM55	0.6880	Biology helps in the development of my conceptual skills.
ITEM51	0.6814	Biology is our hope for solving many environmental problems.
ITEM53	0.6713	Biology is an important part of our lives.
ITEM50	0.5645	The progress of biology improves the quality of our lives.
ITEM58	0.5437	The work with living organisms in biology lessons is very interesting.
ITEM56	0.4613	I make many efforts to understand biology.
ITEM57	0.4605	I find biological processes very interesting.
ITEM46	0.4429	We learn important things in biology class.
ITEM49	0.4429	Knowledge in biology is essential for understanding other courses and phenomena.
FACTOR 2		**INTEREST IN BIOLOGY LESSONS**
ITEM25	0.6907	The lessons taught in biology are not interesting.
ITEM26	0.6735	I cannot understand the biology lessons after class.
ITEM27	0.6591	I do not have the interest to discuss biology topics after the school time.
ITEM28	0.6180	I do not have the interest to complete my homework in biology.
ITEM30	0.5742	My mind goes blank when I am studying biology.
ITEM22	0.5605	I hate biology lessons.
ITEM32	0.5382	I would not probably do well in courses related to biology.
ITEM24	0.5292	Biology lessons become a source of boredom for me.
FACTOR 3		**PERCEPTION OF THE BIOLOGY TEACHER**
ITEM42	0.7216	Whenever I want to ask anything about biology, I consult my biology teacher.
ITEM43	0.7198	I consult my biology teacher in any topic/s that I cannot understand during science class.
ITEM39	0.6860	My biology teacher makes good plans for us.
ITEM37	0.6446	My biology teacher encourages me to learn more about biology.
ITEM38	0.6341	I enjoy talking to my biology teacher after class.
ITEM45	0.5828	We do a lot of fun activities in biology class.
ITEM44	0.4933	The important points emphasized by my teacher during class discussion helps me in learnir
ITEM60	0.4217	I understand biology lessons taught in class by the teacher.
FACTOR 4		**KEENNESS TO LEARN BIOLOGY**
ITEM63	0.7814	I complete first my home work in biology before doing other things.
ITEM62	0.7489	I review lessons in biology daily at home.
ITEM59	0.5657	I follow a regular schedule to study biology at home.
ITEM61	0.5339	I can focus in biology lessons.
ITEM65	0.5205	I fully concentrate on the topic discussed in my biology class.
ITEM66	0.4671	I can explain biology concepts in my own words.
ITEM67	0.4667	I usually relate the previously learned lessons in biology with the new one.
ITEM64	0.4209	During biology lectures, I can comprehend the important points.
FACTOR 5		**ENJOYMENT OF BIOLOGY**
ITEM4	0.7106	Biology is fascinating and fun.
ITEM3	0.6786	I really like biology.
ITEM6	0.5677	I would enjoy being a biologist.
ITEM1	0.5530	I enjoy learning biology.
ITEM5	0.5216	I am looking forward to attend our biology class.
ITEM17	0.4235	I feel a definite positive reaction to biology because it is enjoyable.
ITEM2	0.4165	Biology is boring.
ITEM7	0.3517	Biology is a very interesting subject.
FACTOR 6		**ANXIETY TOWARDS BIOLOGY**
ITEM9	0.7170	I am always under a terrible strain in a biology class.
ITEM8	0.6648	For me, biology class seems scary.
ITEM14	0.6571	I approach biology with a feeling of hesitation.
ITEM12	0.5749	Biology makes me feel uncomfortable, restless, irritable and impatient.
ITEM13	0.4955	When I hear the word 'biology,' I have a feeling of dislike.
FACTOR 7		**EFFORT IN LEARNING BIOLOGY**
ITEM35	0.7978	I always try to do my best in biology.
ITEM36	0.7314	I try hard to do well in biology.
ITEM34	0.6970	When I fail in biology exam, I always try much harder.
ITEM33	0.6150	I always try hard no matter how difficult the lesson in biology is.

Appendix S

Reliability Analysis of the Factor Analyzed Attitude Towards Biology Scale
(n = 365)

1. Overall Reliability of the Scale

Case Processing Summary

		N	%
Cases	Valid	365	100.0
	Excluded[a]	0	.0
	Total	365	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.922	51

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM1	143.2027	232.992	.540	.920
ITEM2	143.1808	232.956	.490	.920
ITEM4	143.2740	233.595	.486	.920
ITEM8	143.4192	234.552	.390	.921
ITEM30	143.3068	232.785	.494	.920
ITEM36	143.0082	234.211	.445	.921
ITEM46	143.1233	231.685	.576	.920
ITEM52	143.3096	238.390	.200	.923
ITEM53	142.9041	235.543	.392	.921
ITEM55	143.0932	234.859	.461	.921
ITEM9	143.4466	235.028	.389	.921
ITEM22	143.1644	233.094	.500	.920
ITEM25	143.0959	233.906	.487	.921
ITEM26	143.2767	233.261	.502	.920
ITEM33	143.1616	237.422	.297	.922
ITEM44	143.2822	231.978	.564	.920
ITEM49	143.1479	234.225	.489	.921
ITEM51	143.0822	234.762	.443	.921
ITEM24	143.2575	233.857	.459	.921
ITEM28	143.1671	235.057	.412	.921
ITEM40	143.4986	235.509	.310	.922
ITEM47	143.1507	232.431	.543	.920
ITEM48	143.4932	231.624	.543	.920
ITEM50	143.0986	233.842	.478	.921
ITEM54	142.8493	234.496	.468	.921
ITEM58	143.1589	232.244	.565	.920
ITEM13	143.2356	231.895	.541	.920
ITEM20	143.6685	238.316	.228	.923
ITEM21	143.6000	237.252	.290	.922
ITEM23	144.0575	239.104	.198	.923
ITEM31	143.7205	237.993	.232	.923
ITEM32	143.4767	235.096	.402	.921
ITEM38	143.7507	235.012	.364	.922
ITEM41	143.3342	236.086	.355	.922
ITEM3	143.4247	232.448	.524	.920
ITEM5	143.2603	234.825	.440	.921
ITEM6	143.5562	233.363	.449	.921
ITEM18	143.4795	235.552	.396	.921
ITEM27	143.2630	231.337	.577	.920
ITEM29	143.4822	235.882	.353	.922
ITEM37	143.2027	231.860	.500	.920
ITEM42	143.5205	236.976	.270	.922
ITEM11	143.5534	239.764	.188	.923
ITEM14	143.4411	237.297	.322	.922
ITEM17	143.3123	231.787	.583	.920
ITEM19	143.8575	233.892	.424	.921
ITEM57	143.2767	231.948	.598	.920
ITEM15	143.5863	239.034	.199	.923
ITEM16	143.7425	238.675	.237	.923
ITEM39	143.3014	232.035	.473	.921
ITEM56	143.1534	236.015	.401	.921

2. Reliability Analysis of Factor 1 (Importance of Biology)

Reliability Statistics

Cronbach's Alpha	N of Items
.862	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM54	27.8356	14.308	.646	.842
ITEM55	28.0795	14.507	.619	.845
ITEM51	28.0685	14.399	.608	.845
ITEM53	27.8904	14.664	.531	.852
ITEM50	28.0849	14.375	.594	.847
ITEM58	28.1452	14.295	.618	.844
ITEM56	28.1397	15.148	.475	.856
ITEM57	28.2630	14.612	.567	.849
ITEM46	28.1096	14.532	.544	.851
ITEM49	28.1342	14.924	.512	.853

3. Reliability Analysis of Factor 2 (Interest in Biology Lessons)

Reliability Statistics

Cronbach's Alpha	N of Items
.830	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM25	20.5452	10.249	.577	.807
ITEM26	20.7260	10.150	.576	.807
ITEM27	20.7123	9.793	.642	.798
ITEM28	20.6164	10.259	.549	.811
ITEM30	20.7562	10.037	.561	.809
ITEM22	20.6137	10.243	.537	.812
ITEM32	20.9260	10.519	.470	.821
ITEM24	20.7068	10.279	.524	.814

4. Reliability Analysis of Factor 3 (Perceptions of the Biology Teacher)

Reliability Statistics

Cronbach's Alpha	N of Items
.846	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM42	19.3973	12.652	.562	.830
ITEM43	19.4575	12.326	.642	.820
ITEM39	19.1781	12.042	.667	.816
ITEM37	19.0795	12.365	.628	.822
ITEM38	19.6274	12.773	.551	.831
ITEM45	19.4027	12.543	.554	.831
ITEM44	19.1589	13.052	.570	.829
ITEM60	19.2932	13.719	.472	.840

5. Reliability Analysis of Factor 4 (Keenness to Learn Biology)

Reliability Statistics

Cronbach's Alpha	N of Items
.817	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM63	18.8027	9.098	.645	.779
ITEM62	18.8932	9.332	.589	.788
ITEM59	18.6685	9.887	.451	.808
ITEM61	18.6438	9.494	.585	.789
ITEM65	18.6384	9.275	.613	.784
ITEM66	18.8164	9.793	.462	.806
ITEM67	18.4932	9.861	.483	.803
ITEM64	18.5562	10.099	.447	.807

6. Reliability Analysis for Factor 5 (Enjoyment of Biology)

Reliability Statistics

Cronbach's Alpha	N of Items
.820	8

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM4	20.3726	9.778	.603	.790
ITEM3	20.5233	9.657	.607	.789
ITEM6	20.6548	9.886	.502	.805
ITEM1	20.3014	9.980	.580	.794
ITEM5	20.3589	10.286	.491	.805
ITEM17	20.4110	10.001	.548	.798
ITEM2	20.2795	10.185	.458	.810
ITEM7	20.2466	9.895	.529	.800

7. Reliability Analysis for Factor 6 (Anxiety Towards Biology)

Reliability Statistics

Cronbach's Alpha	N of Items
.764	5

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM9	11.4712	4.173	.579	.705
ITEM8	11.4438	4.176	.532	.722
ITEM14	11.4658	4.689	.460	.745
ITEM12	11.2904	3.965	.574	.707
ITEM13	11.2603	4.308	.524	.725

8. Reliability Analysis for Factor 7 (Effort in Learning Biology)

Reliability Statistics

Cronbach's Alpha	N of Items
.790	4

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ITEM35	9.4411	2.170	.696	.688
ITEM36	9.4932	2.152	.645	.714
ITEM34	9.4986	2.503	.593	.744
ITEM33	9.6466	2.471	.478	.799

Appendix T

Reliability Analysis of Questionnaire on Importance of Democratic Practices in Classroom

(n = 50)

Reliability Statistics

Cronbach's Alpha	N of Items
.701	10

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
item1	29.72	12.124	.211	.700
item2	30.36	10.194	.489	.657
item3	29.74	11.625	.429	.684
item4	30.40	8.857	.627	.620
item5	30.50	10.255	.367	.678
item6	29.90	10.908	.453	.670
item7	31.12	8.965	.478	.655
item8	30.26	9.584	.526	.646
item9	30.30	11.561	.218	.699
item10	30.46	11.396	.058	.749

Appendix U

Reliability Analysis of Bioenergetics Achievement Test
(n = 80)

Reliability Statistics

Cronbach's Alpha	N of Items
.719	35

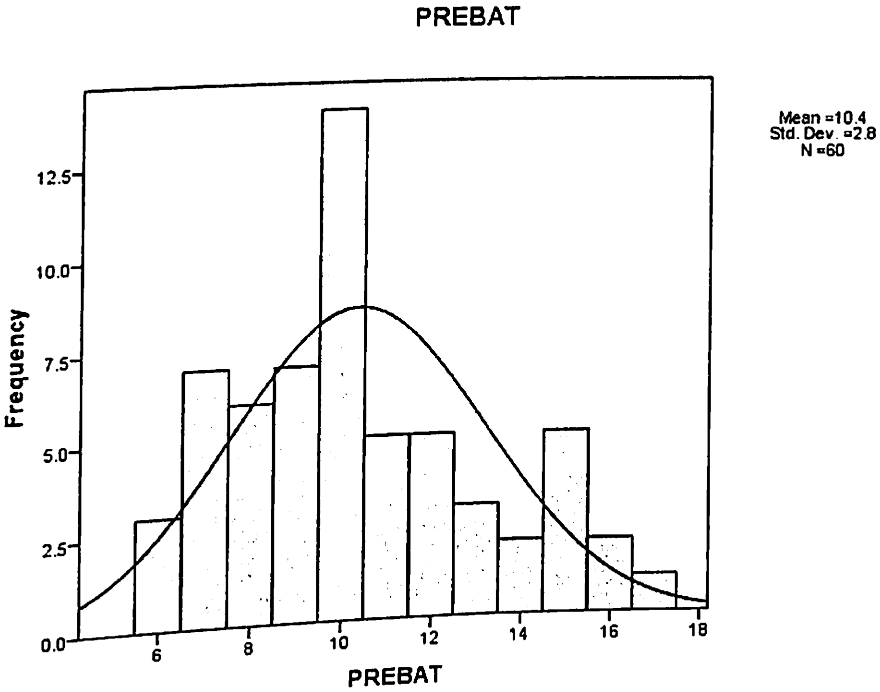
Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
item1	15.5949	24.270	.196	.714
item2	15.7975	24.010	.246	.711
item3	15.2785	24.896	.203	.715
item4	15.4810	24.125	.259	.711
item5	15.9114	24.005	.272	.710
item6	15.7975	23.728	.306	.707
item7	15.6203	23.469	.363	.704
item8	15.8608	23.916	.277	.709
item9	15.8987	24.579	.141	.717
item10	15.8734	23.932	.277	.709
item11	15.9241	23.892	.303	.708
item12	15.7595	24.236	.196	.714
item13	15.7975	23.984	.251	.711
item14	15.5443	24.585	.138	.718
item15	15.7468	24.781	.084	.721
item16	15.7975	24.189	.208	.713
item17	15.8101	25.105	.021	.725
item18	15.8228	23.994	.253	.711
item19	15.6076	24.575	.131	.718
item20	15.8354	24.703	.105	.720
item21	15.4557	24.174	.259	.711
item22	16.0000	24.462	.201	.714
item23	15.6962	23.778	.290	.708
item24	16.0253	24.922	.095	.719
item25	15.9873	23.884	.337	.706
item26	15.4810	24.073	.271	.710
item27	15.8861	22.871	.521	.694
item28	15.8734	23.574	.356	.704
item29	15.5570	25.917	-.142	.734
item30	15.9241	24.020	.273	.710
item31	15.7468	23.499	.350	.704
item32	15.9873	24.705	.136	.717
item33	15.7848	23.633	.325	.706
item34	15.5063	24.535	.157	.716
item35	15.6456	24.616	.119	.719

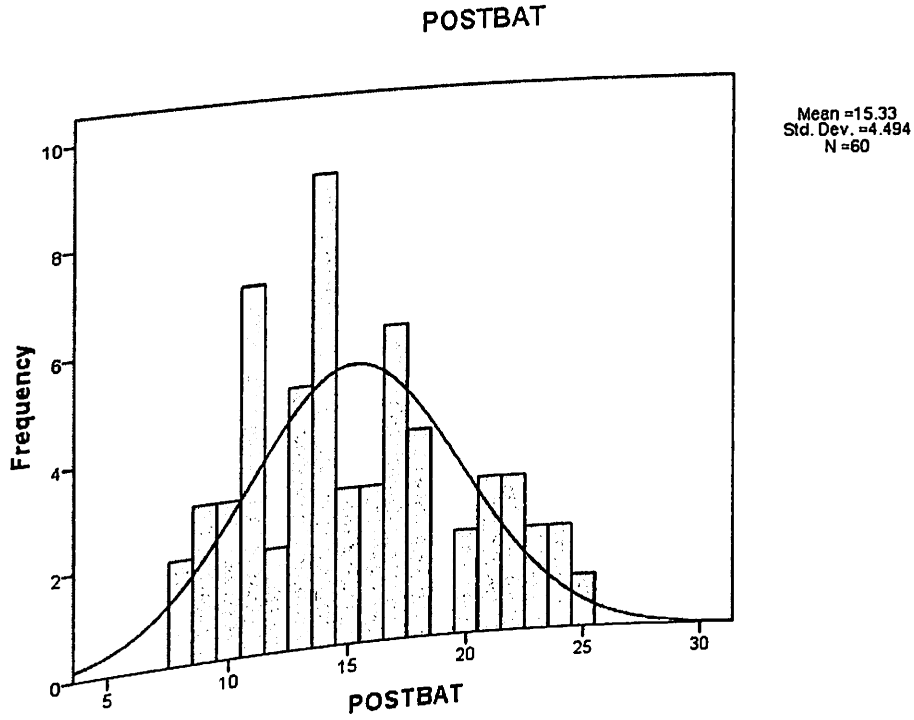
Appendix V

Tests for Normality of Distributions

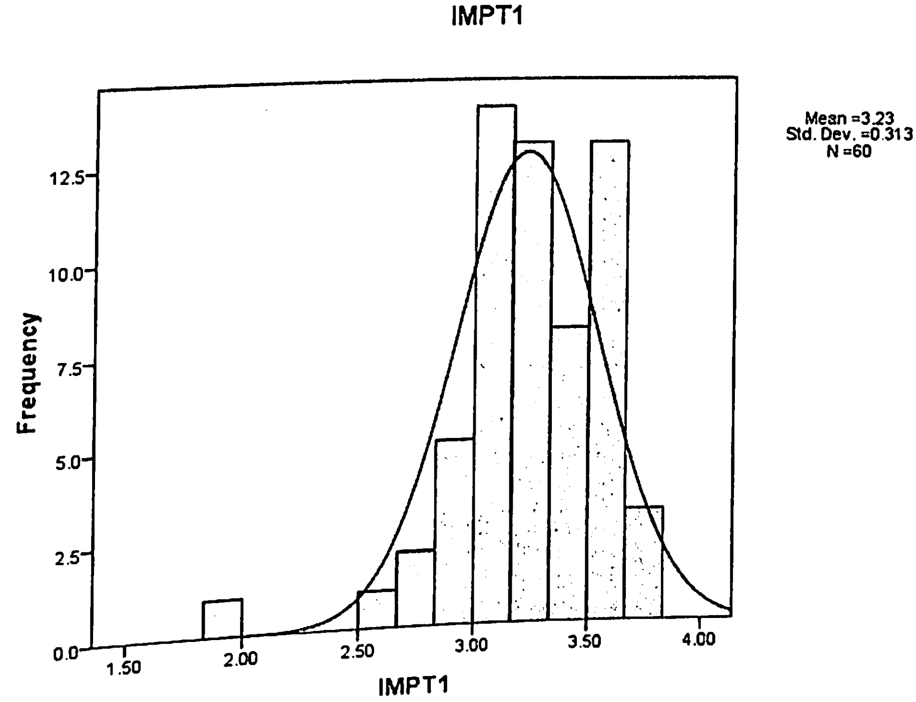
1. Pretest Score in Bioenergetics Achievement Test



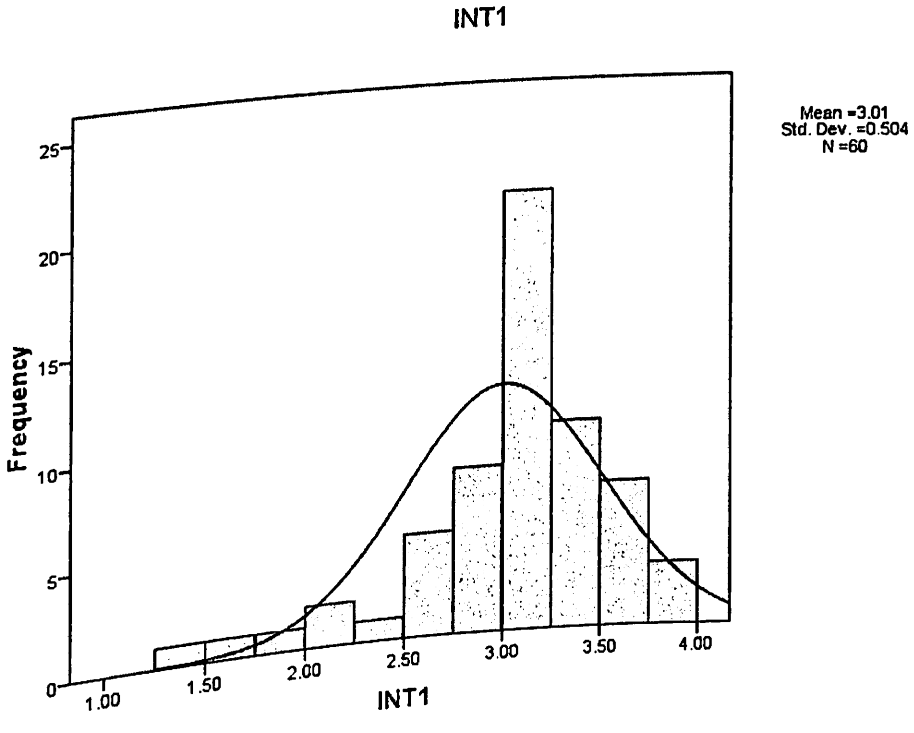
2. Posttest Score in Bioenergetics Achievement Test



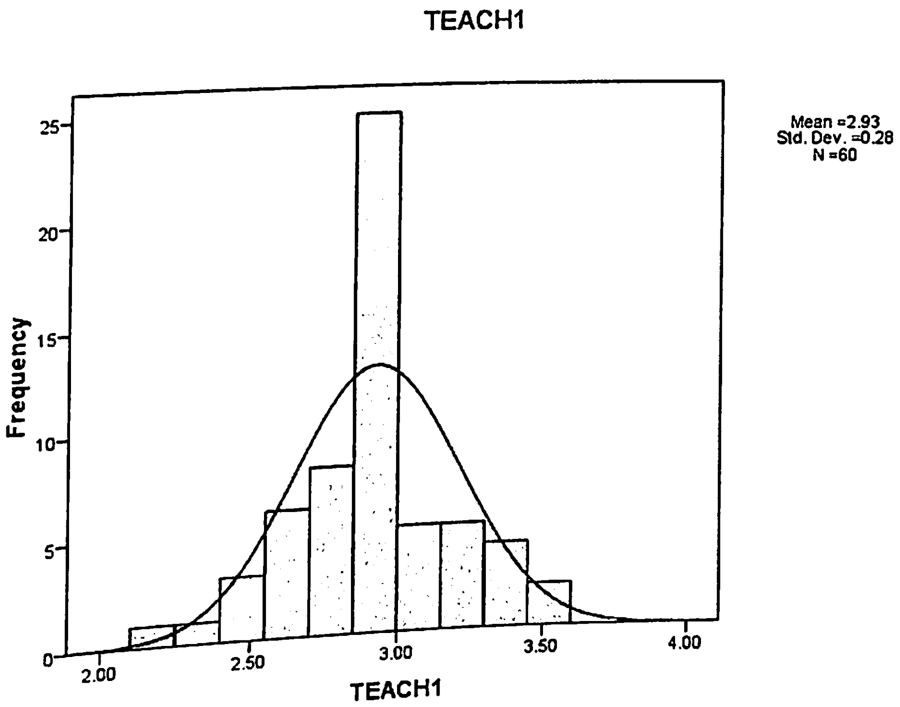
3. Pretest Score in Students' Attitude on the Importance of Biology



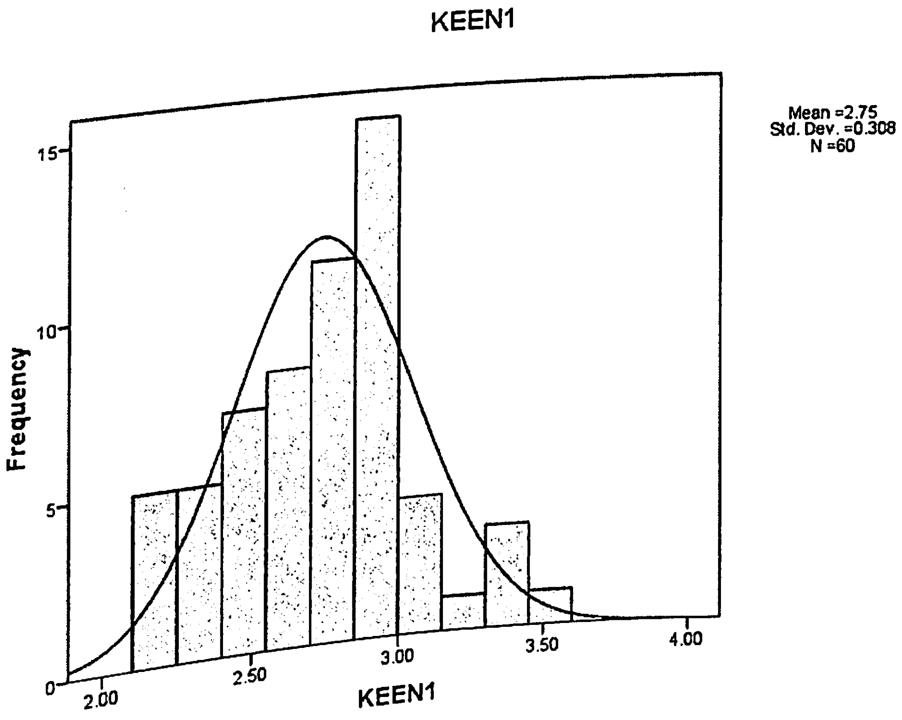
4. Pretest Score in Students' Interest in Biology Lessons



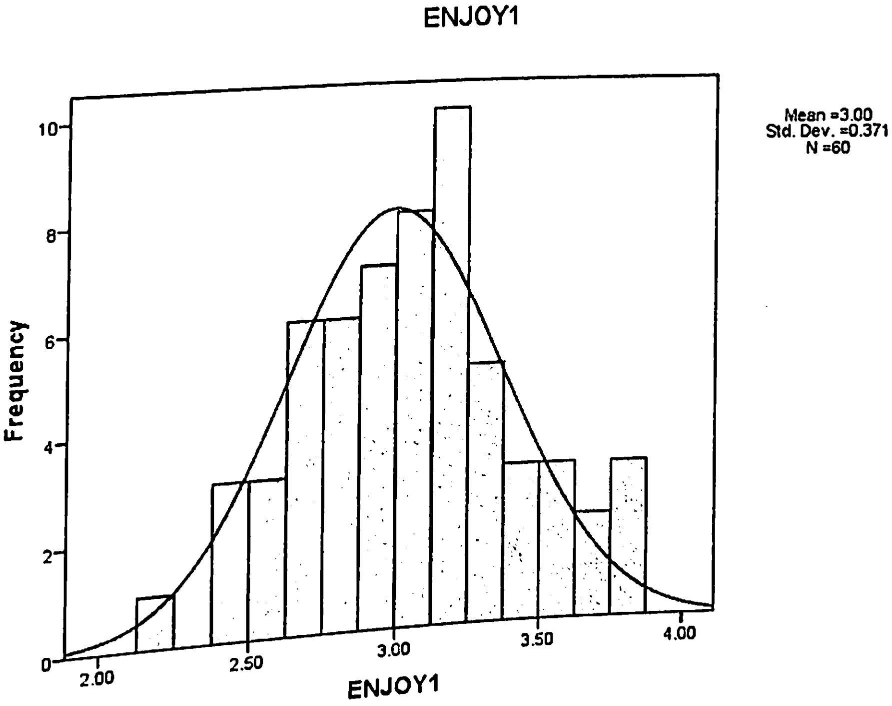
5. Pretest Score in Students' Perceptions of their Biology Teacher



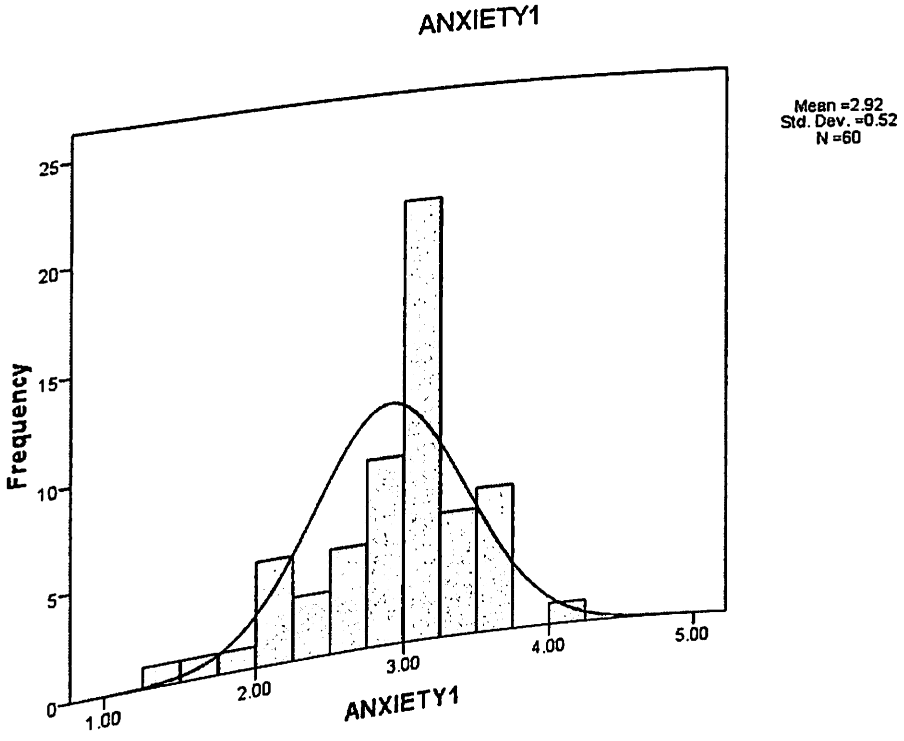
6. Pretest Score in Students' Keenness to Learn Biology



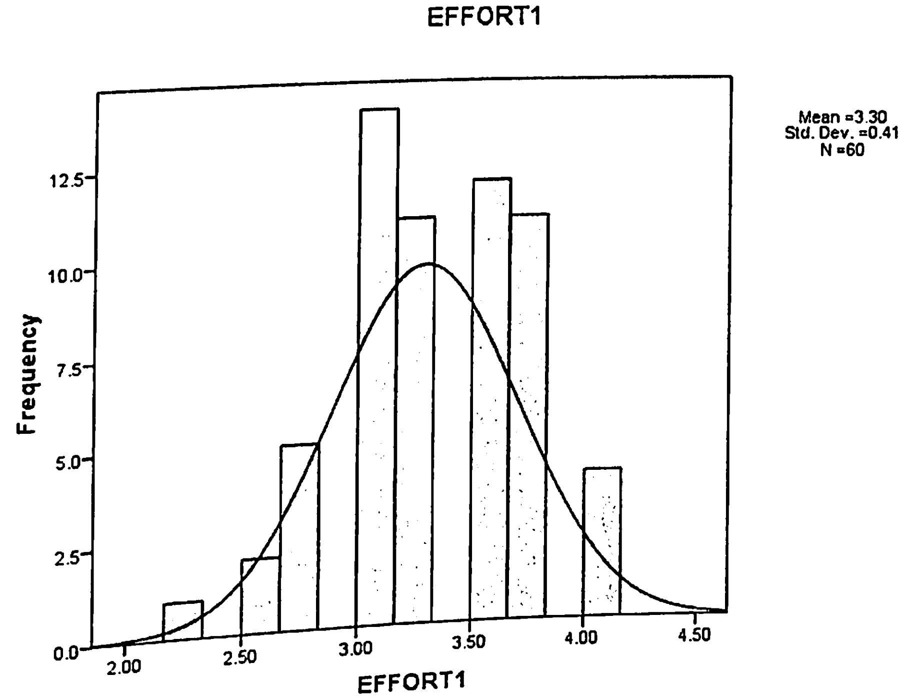
7. Pretest Score in Students' Enjoyment of Biology



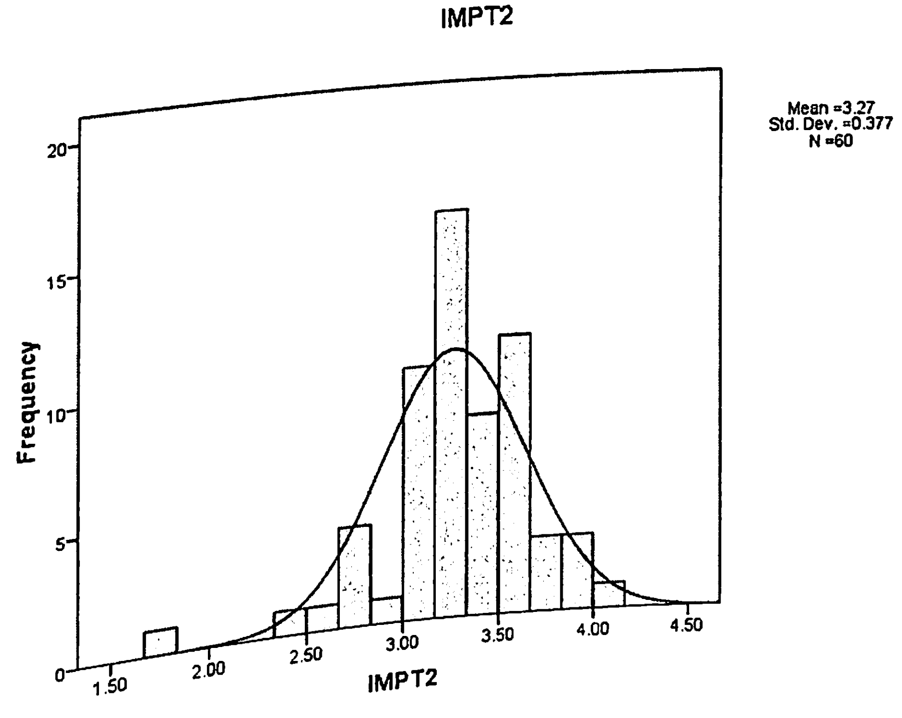
8. Pretest Score in Students' Anxiety Towards Biology



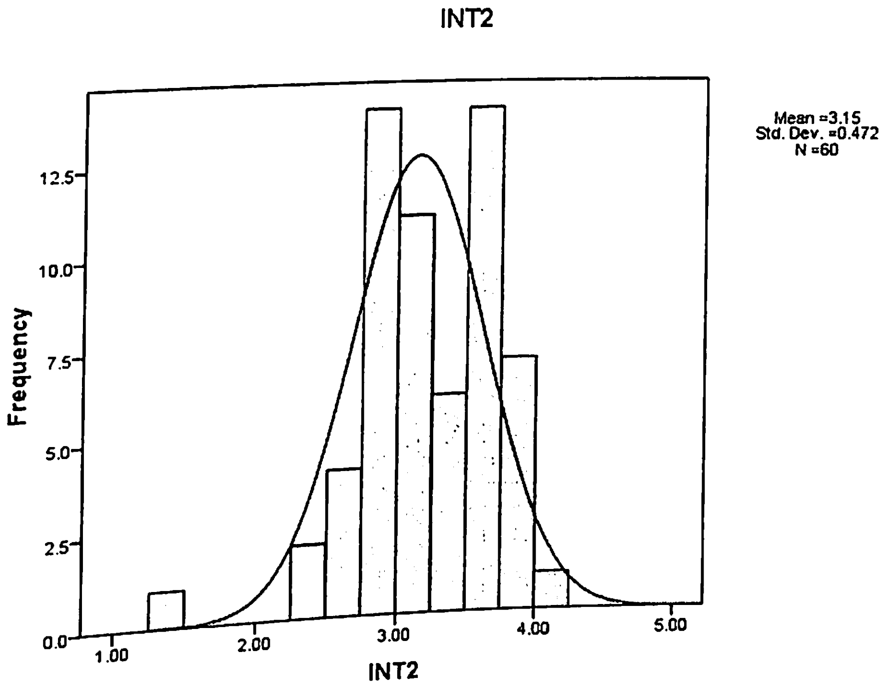
9. Pretest Score in Students' Effort in Learning Biology



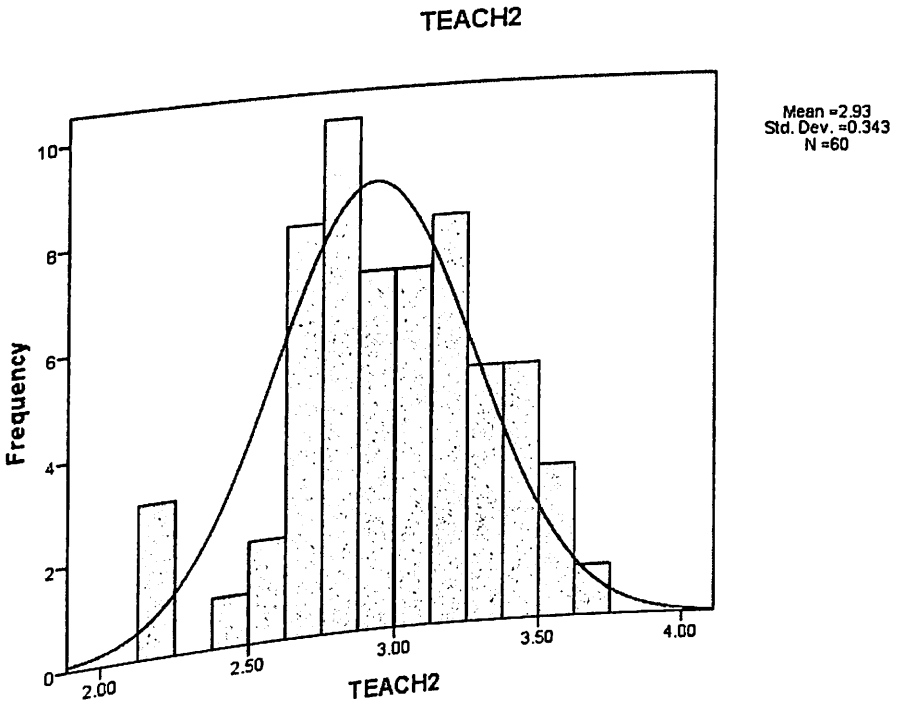
10. Posttest Score in Students' Attitude on the Importance of Biology



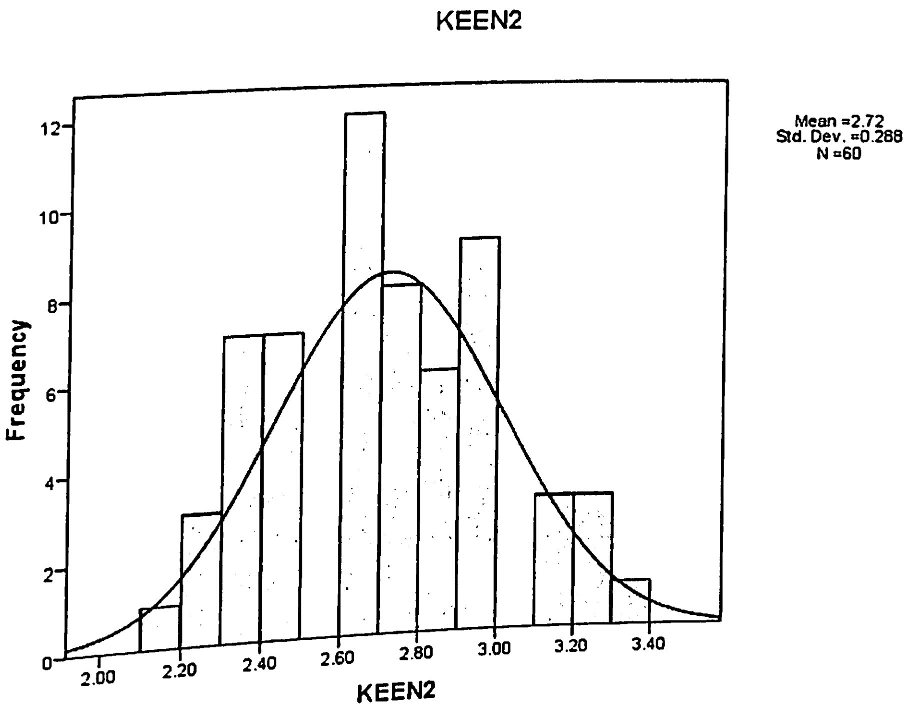
11. Posttest Score in Students' Interest in Biology Lessons



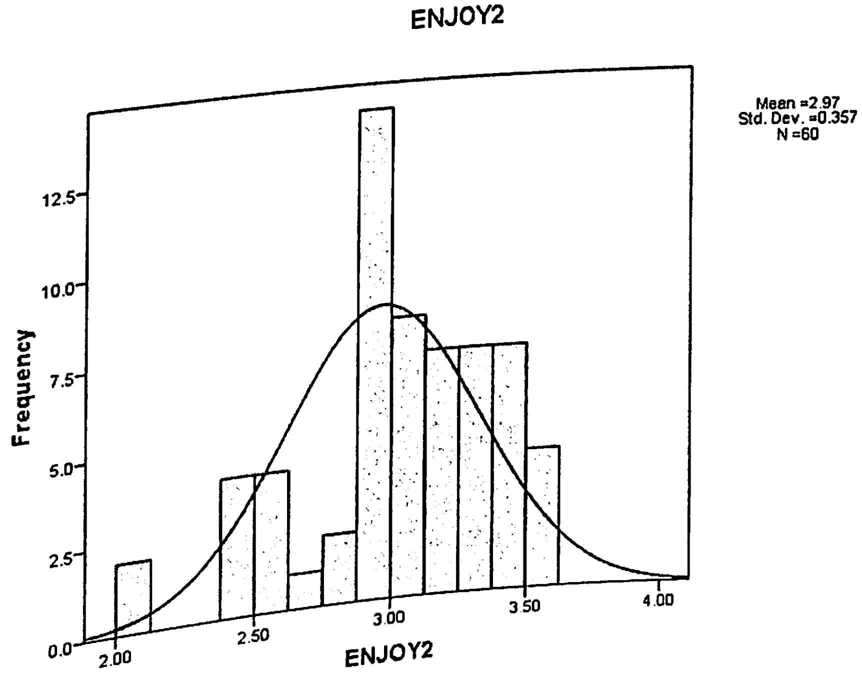
12. Posttest Score in Students' Perceptions of their Biology Teacher



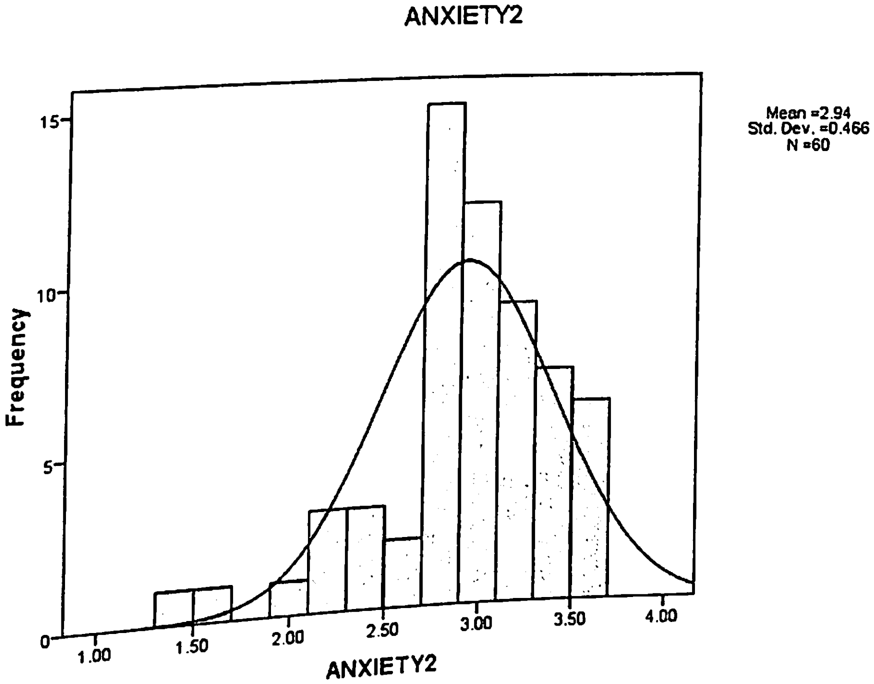
13. Posttest Score in Students' Keenness to Learn Biology



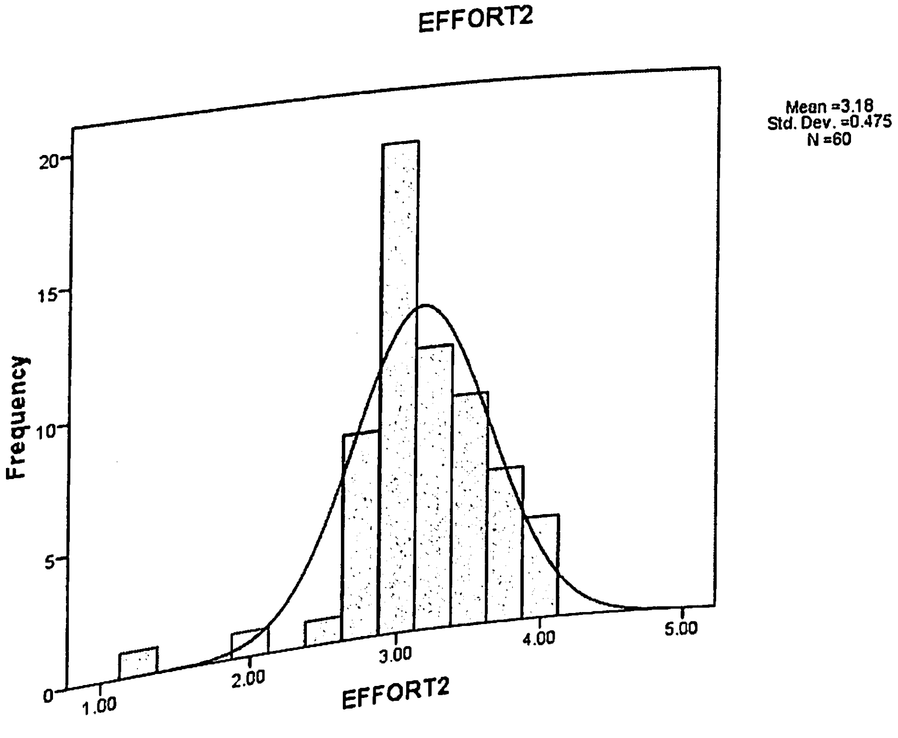
14. Posttest Score in Students' Enjoyment of Biology



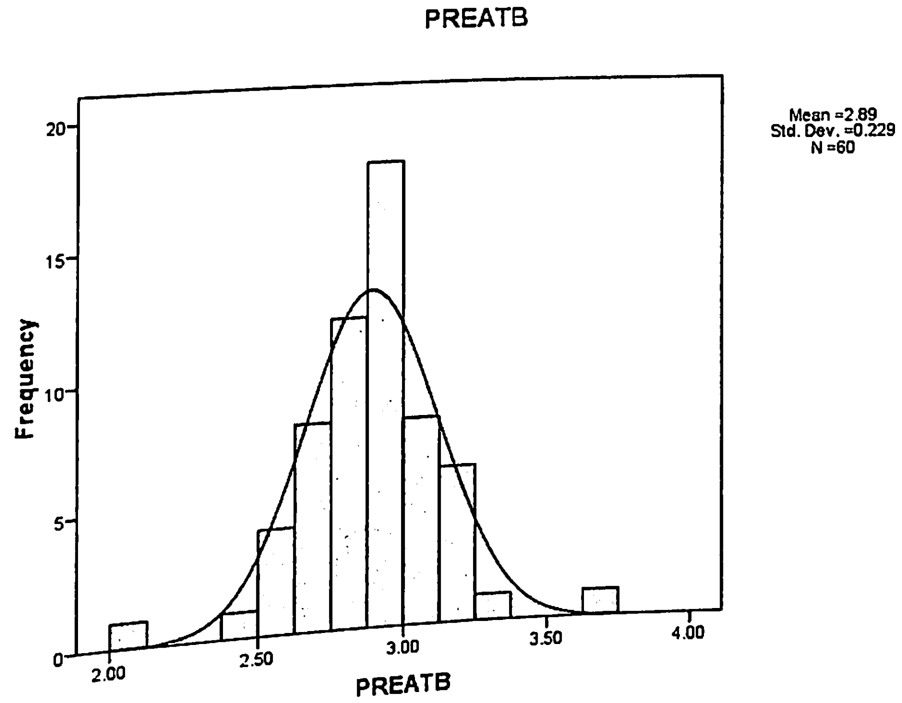
15. Posttest Score in Students' Anxiety Towards Biology



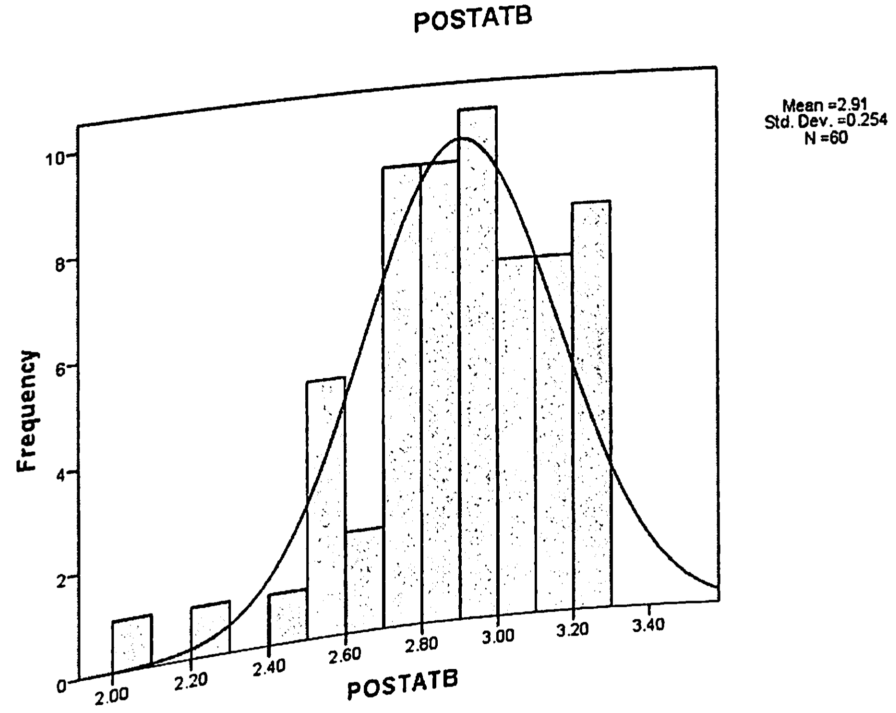
16. Posttest Score in Students' Effort in Learning Biology



17. Pretest Score in Students' Overall Attitude Towards Biology



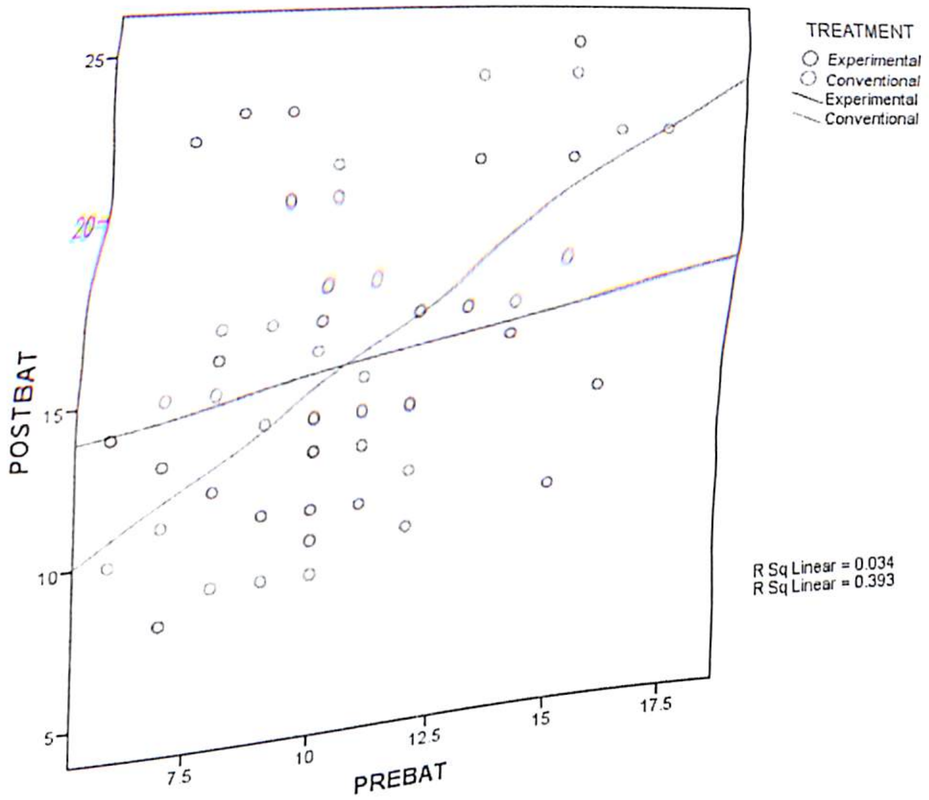
18. Posttest Score in Students' Overall Attitude Towards Biology



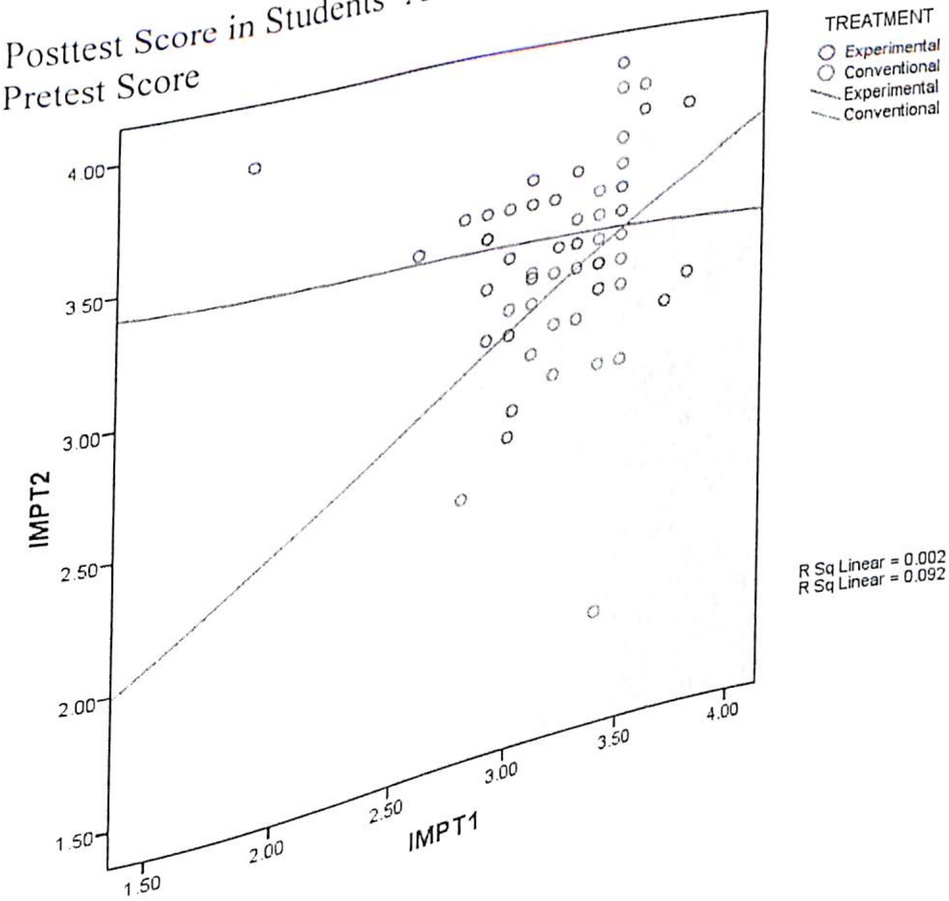
Appendix W

Tests for Linear Relationship between the Dependent Variables and the Covariates for Each Group

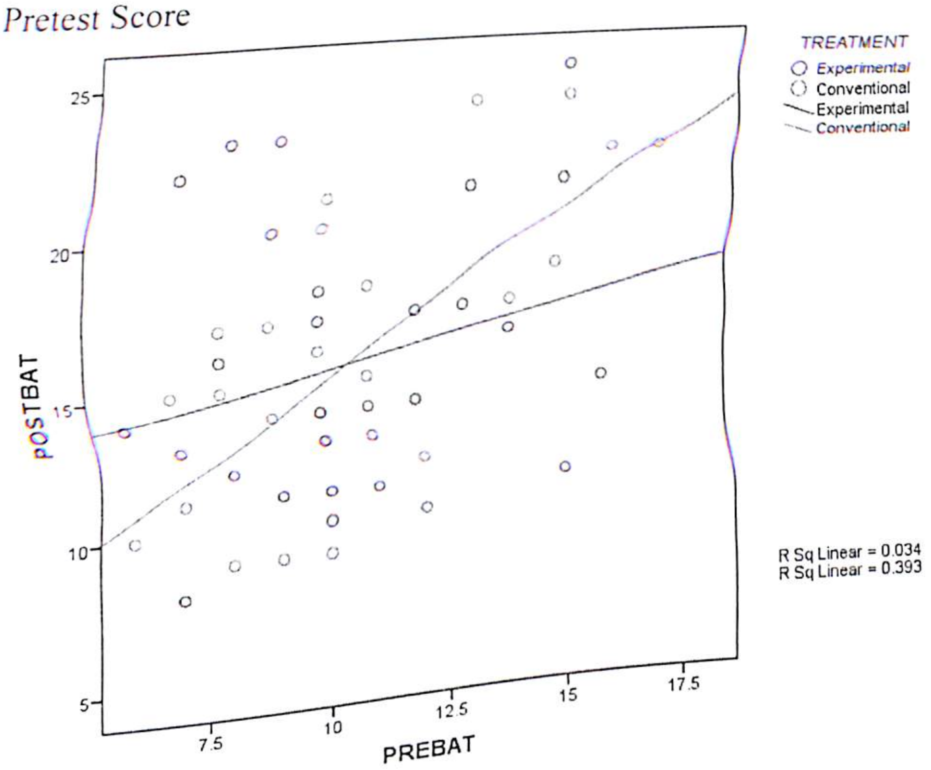
1. DV: Posttest Score in Bioenergetics Achievement Test
   CV: Pretest Score



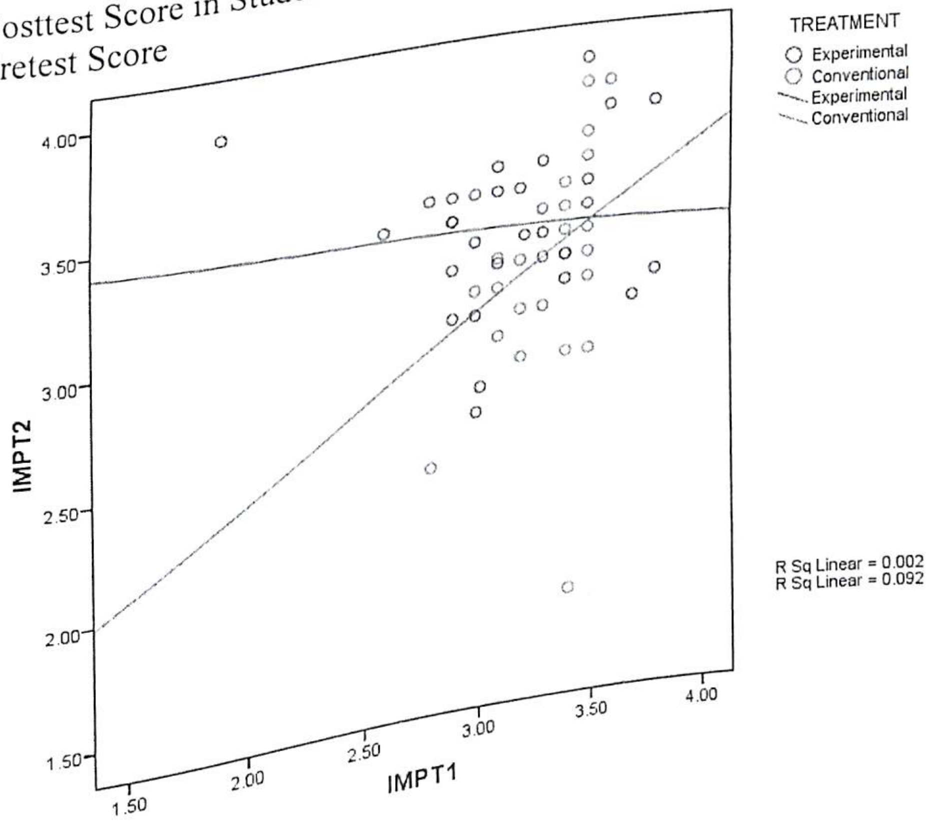
2. DV: Posttest Score in Students' Attitude on Importance of Biology
   CV: Pretest Score



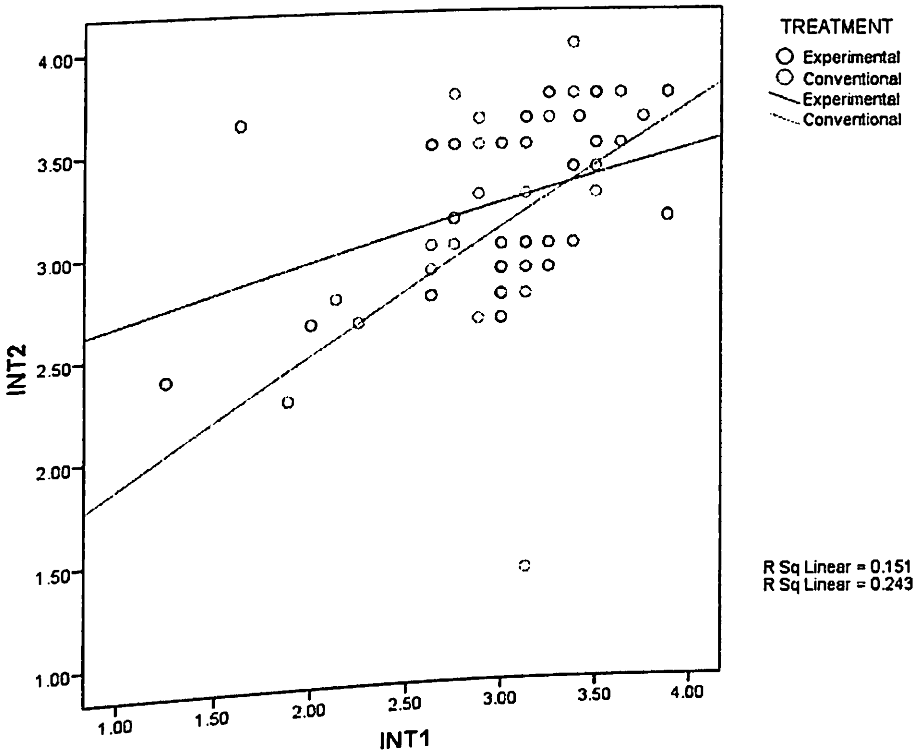
1. DV: Posttest Score in Bioenergetics Achievement Test
   CV: Pretest Score



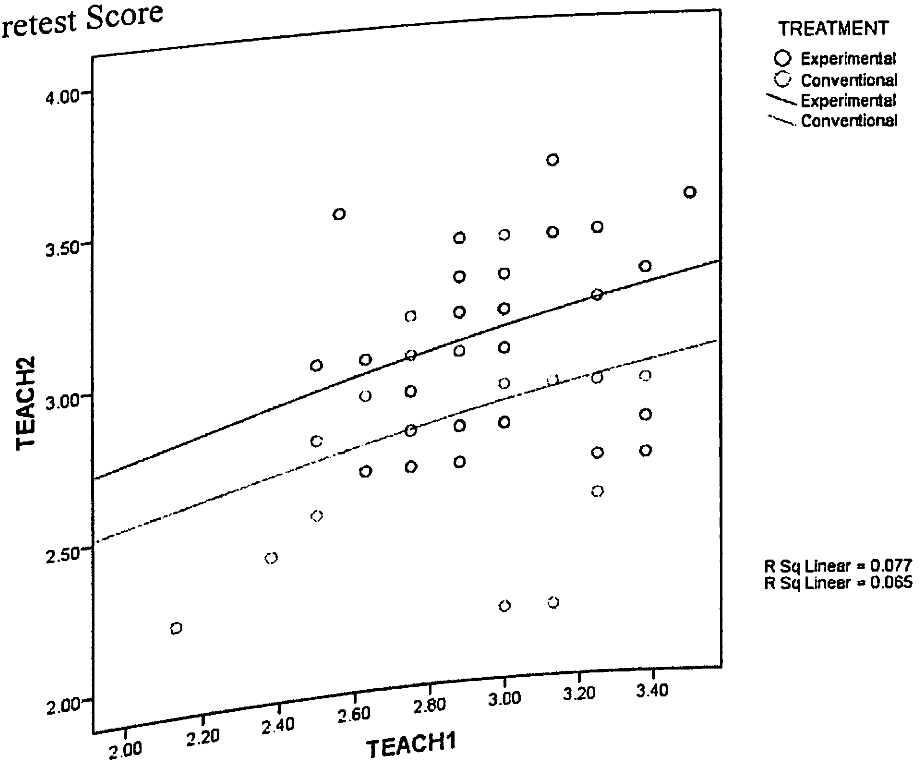
2. DV: Posttest Score in Students' Attitude on Importance of Biology
   CV: Pretest Score



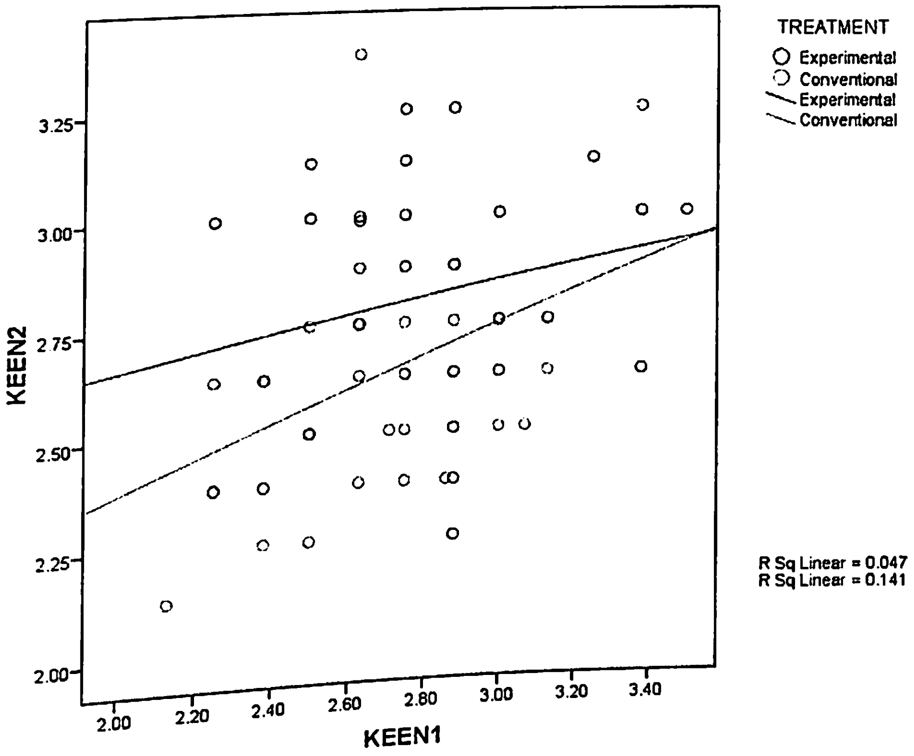
3. DV: Posttest Score in Students' Interest in Biology Lessons
   CV: Pretest Score



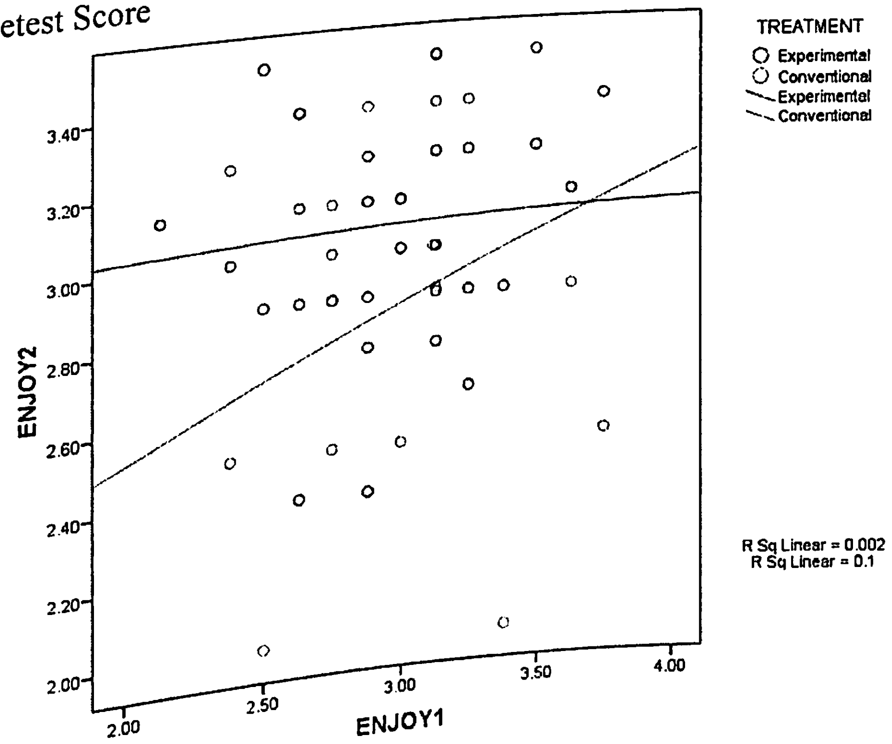
4. DV: Posttest Score in Students' Perceptions of their Biology Teacher
   CV: Pretest Score



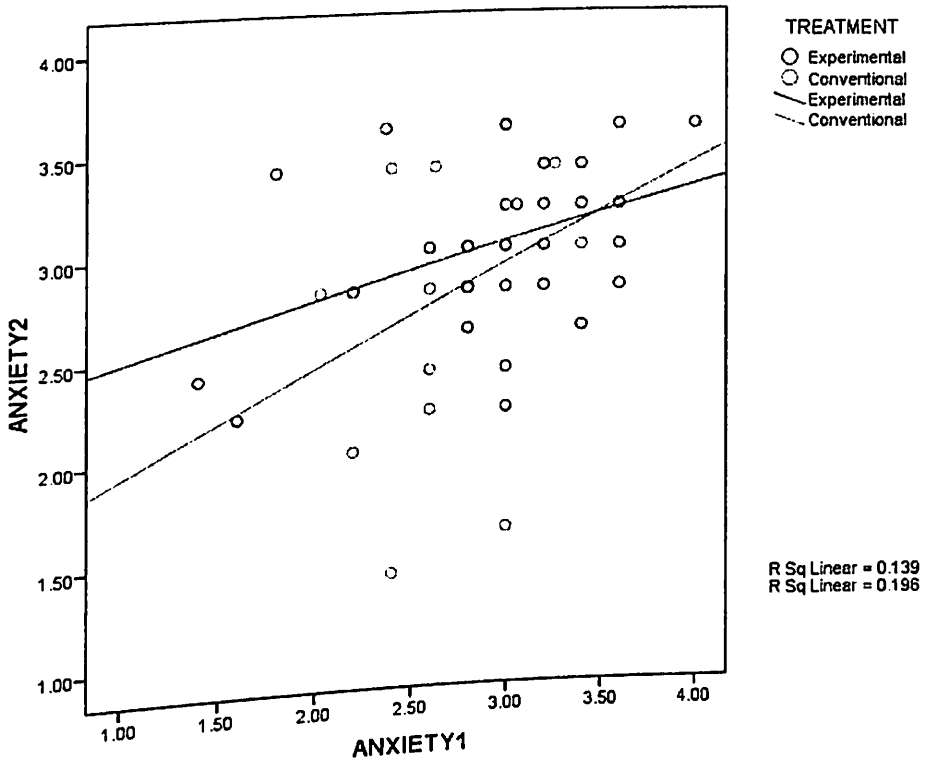
5. DV: Posttest Score in Students' Keenness to Learn Biology
CV: Pretest Score



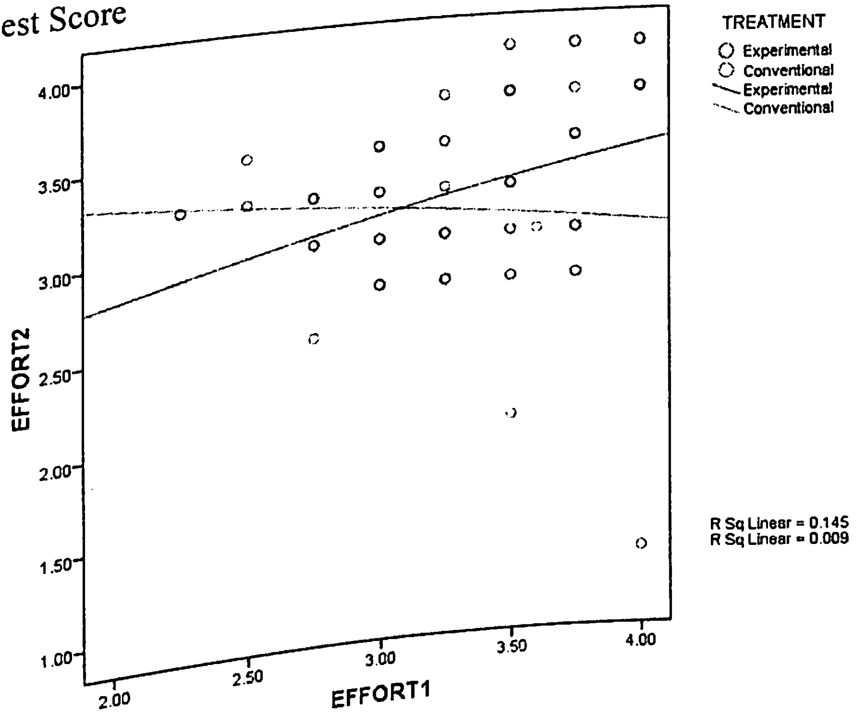
6. DV: Posttest Score in Students' Enjoyment of Biology
CV: Pretest Score



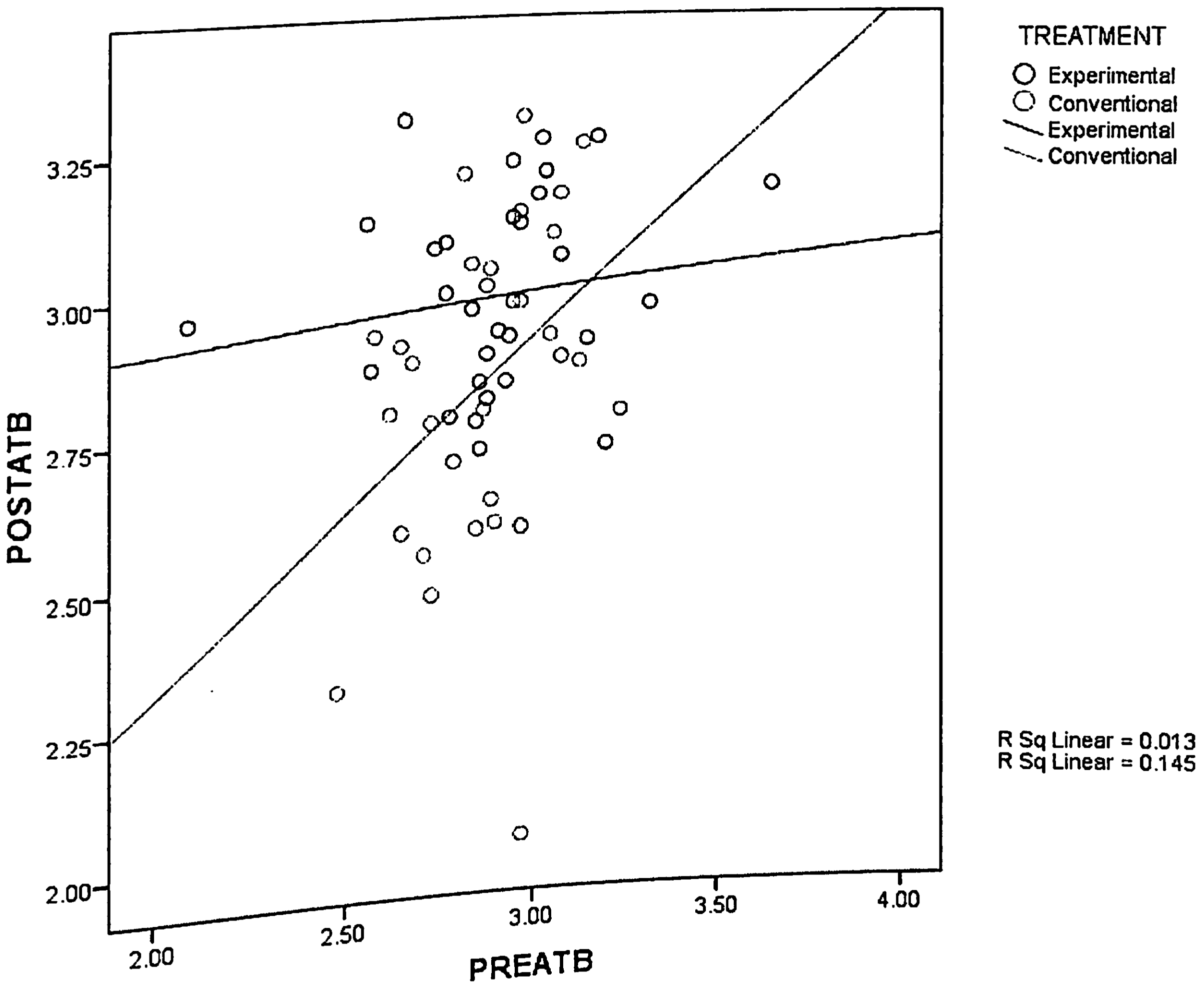
7. DV: Posttest Score in Students' Anxiety Towards Biology
CV: Pretest Score



8. DV: Posttest Score in Students' Effort in Learning Biology
CV: Pretest Score



9. DV: Posttest Score in Students' Overall Attitude Towards Biology
   CV: Pretest Score



Appendix X

Tests for Homogeneity of Variances (Main Effects of Instructional Approach on Students' Attitude Towards Biology and their Achievement in Bioenergetics Test)

1. DV: IMPT2; CV: IMPT1; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:IMPT2

F	df1	df2	Sig.
.290	1	58	.592

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + IMPT1 + TREATMENT

2. DV: INT2; CV: INT1; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:INT2

F	df1	df2	Sig.
.005	1	58	.942

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + INT1 + TREATMENT

3. DV: TEACH2; CV: TEACH1; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:TEACH2

F	df1	df2	Sig.
.232	1	58	.632

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + TEACH1 + TREATMENT

4. DV: KEEN2; CV: KEEN1; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:KEEN2

F	df1	df2	Sig.
.610	1	58	.438

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + KEEN1 + TREATMENT

5. DV: ENJOY2; CV: ENJOY1; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:ENJOY2

F	df1	df2	Sig.
2.903	1	58	.094

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ENJOY1 + TREATMENT

6. DV: ANXIETY2; CV: ANXIETY1; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:ANXIETY2

F	df1	df2	Sig.
.142	1	58	.708

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ANXIETY1 + TREATMENT

7. DV: EFFORT2; CV: EFFORT1; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:EFFORT2

F	df1	df2	Sig.
2.956	1	58	.091

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + EFFORT1 + TREATMENT

8. DV: POSTATB; CV: PREATB; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:POSTATB

F	df1	df2	Sig.
2.087	1	58	.154

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PREATB + TREATMENT

9. DV: POSTBAT; CV: PREBAT; IV: TREATMENT

Levene's Test of Equality of Error Variances[a]

Dependent Variable:POSTBAT

F	df1	df2	Sig.
.322	1	58	.573

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PREBAT + TREATMENT

Appendix Y

Tests for Homogeneity of Variances
(Interaction Effects of Instructional Approach and Sex on Students' Attitude Towards Biology and their Achievement in Bioenergetics Test)

1. DV: IMPT2; CV: IMPT1; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:IMPT2

F	df1	df2	Sig.
.109	3	56	.954

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + IMPT1 + TREATMENT + GENDER + TREATMENT * GENDER

2. DV: INT2; CV: INT1; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:INT2

F	df1	df2	Sig.
.554	3	56	.648

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + INT1 + TREATMENT + GENDER + TREATMENT * GENDER

3. DV: TEACH2; CV: TEACH1; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:TEACH2

F	df1	df2	Sig.
.924	3	56	.435

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + TEACH1 + TREATMENT + GENDER + TREATMENT * GENDER

4. DV: KEEN2; CV: KEEN1; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:KEEN2

F	df1	df2	Sig.
1.018	3	56	.392

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + KEEN1 + TREATMENT + GENDER + TREATMENT * GENDER

5. DV: ENJOY2; CV: ENJOY1; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:ENJOY2

F	df1	df2	Sig.
.992	3	56	.403

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ENJOY1 + TREATMENT + GENDER + TREATMENT * GENDER

6. DV: ANXIETY2; CV: ANXIETY1; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:ANXIETY2

F	df1	df2	Sig.
.233	3	56	.873

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ANXIETY1 + TREATMENT + GENDER + TREATMENT * GENDER

7. DV: EFFORT2; CV: EFFORT1; IV: TREATMENT; MV: SEX (Tolerable)

Levene's Test of Equality of Error Variances[a]

Dependent Variable:EFFORT2

F	df1	df2	Sig.
2.794	3	56	.049

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + EFFORT1 + TREATMENT + GENDER + TREATMENT * GENDER

8. DV: POSTATB; CV: PREATB; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:POSTATB

F	df1	df2	Sig.
1.229	3	56	.308

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PREATB + TREATMENT + GENDER + TREATMENT * GENDER

9. DV: POSTBAT; CV: PREBAT; IV: TREATMENT; MV: SEX

Levene's Test of Equality of Error Variances[a]

Dependent Variable:POSTBAT

F	df1	df2	Sig.
.189	3	56	.903

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PREBAT + TREATMENT + GENDER + TREATMENT * GENDER

Appendix Z

Tests for Homogeneity of Variances

(Interaction Effects of Instructional Approach and Learning Style on Students' Attitude Towards Biology and their Achievement in Bioenergetics Test)

1. DV: IMPT2; CV: IMPT1; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:IMPT2

F	df1	df2	Sig.
1.236	5	54	.305

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + IMPT1 + TREATMENT + LS + TREATMENT * LS

2. DV: INT2; CV: INT1; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:INT2

F	df1	df2	Sig.
.127	5	54	.986

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + INT1 + TREATMENT + LS + TREATMENT * LS

3. DV: TEACH2; CV: TEACH1; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:TEACH2

F	df1	df2	Sig.
.685	5	54	.637

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + TEACH1 + TREATMENT + LS + TREATMENT * LS

4. DV: KEEN2; CV: KEEN1; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:KEEN2

F	df1	df2	Sig.
1.231	5	54	.307

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + KEEN1 + TREATMENT + LS + TREATMENT * LS

5. DV: ENJOY2; CV: ENJOY1; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:ENJOY2

F	df1	df2	Sig.
2.893	5	54	.022

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ENJOY1 + TREATMENT + LS + TREATMENT * LS

6. DV: ANXIETY2; CV: ANXIETY1; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:ANXIETY2

F	df1	df2	Sig.
1.018	5	54	.417

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + ANXIETY1 + TREATMENT + LS + TREATMENT * LS

7. DV: EFFORT2; CV: EFFORT1; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:EFFORT2

F	df1	df2	Sig.
.907	5	54	.483

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + EFFORT1 + TREATMENT + LS + TREATMENT * LS

8. DV: POSTATB; CV: PREATB; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:POSTATB

F	df1	df2	Sig.
1.219	5	54	.313

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PREATB + TREATMENT + LS + TREATMENT * LS

9. DV: POSTATB; CV: PREATB; IV: TREATMENT; MV: LEARNING STYLE

Levene's Test of Equality of Error Variances[a]

Dependent Variable:POSTBAT

F	df1	df2	Sig.
1.534	5	54	.195

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + PREBAT + TREATMENT + LS + TREATMENT * LS

Appendix AA

Tests for Homogeneity of Regression Slopes

1. Interaction Between Instructional Approach and the covariate IMPT1

Tests of Between-Subjects Effects

Dependent Variable:IMPT2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.826[a]	3	.275	2.034	.119
Intercept	1.859	1	1.859	13.738	.000
TREATMENT	.473	1	.473	3.492	.067
IMPT1	.331	1	.331	2.445	.124
TREATMENT * IMPT1	.410	1	.410	3.030	.087
Error	7.578	56	.135		
Total	650.108	60			
Corrected Total	8.404	59			

a. R Squared = .098 (Adjusted R Squared = .050)

2. Interaction Between Instructional Approach and the covariate INT1

Tests of Between-Subjects Effects

Dependent Variable:INT2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.917[a]	3	.972	5.317	.003
Intercept	4.961	1	4.961	27.133	.000
TREATMENT	.485	1	.485	2.650	.109
INT1	2.689	1	2.689	14.708	.000
TREATMENT * INT1	.400	1	.400	2.188	.145
Error	10.240	56	.183		
Total	610.082	60			
Corrected Total	13.156	59			

a. R Squared = .222 (Adjusted R Squared = .180)

3. Interaction Between Instructional Approach and the covariate TEACH1

Tests of Between-Subjects Effects

Dependent Variable:TEACH2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.639[a]	3	.546	5.784	.002
Intercept	2.070	1	2.070	21.915	.000
TREATMENT	.002	1	.002	.025	.874
TEACH1	.403	1	.403	4.263	.044
TREATMENT * TEACH1	.001	1	.001	.015	.902
Error	5.288	56	.094		
Total	522.548	60			
Corrected Total	6.927	59			

a. R Squared = .237 (Adjusted R Squared = .196)

4. Interaction Between Instructional Approach and the covariate KEEN1

Tests of Between-Subjects Effects

Dependent Variable:KEEN2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.827^a	3	.276	3.794	.015
Intercept	2.750	1	2.750	37.818	.000
TREATMENT	.075	1	.075	1.028	.315
KEEN1	.404	1	.404	5.553	.022
TREATMENT * KEEN1	.045	1	.045	.622	.434
Error	4.071	56	.073		
Total	449.837	60			
Corrected Total	4.899	59			

a. R Squared = .169 (Adjusted R Squared = .124)

5. Interaction Between Instructional Approach and the covariate ENJOY1

Tests of Between-Subjects Effects

Dependent Variable:ENJOY2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.009^a	3	.336	2.895	.043
Intercept	5.023	1	5.023	43.221	.000
TREATMENT	.267	1	.267	2.300	.135
ENJOY1	.259	1	.259	2.231	.141
TREATMENT * ENJOY1	.178	1	.178	1.535	.221
Error	6.508	56	.116		
Total	537.365	60			
Corrected Total	7.517	59			

a. R Squared = .134 (Adjusted R Squared = .088)

6. Interaction Between Instructional Approach and the covariate ANXIETY1

Tests of Between-Subjects Effects

Dependent Variable:ANXIETY2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.572^a	3	.857	4.675	.006
Intercept	5.820	1	5.820	31.742	.000
TREATMENT	.271	1	.271	1.477	.229
ANXIETY1	2.144	1	2.144	11.693	.001
TREATMENT * ANXIETY1	.195	1	.195	1.063	.307
Error	10.268	56	.183		
Total	530.280	60			
Corrected Total	12.839	59			

a. R Squared = .200 (Adjusted R Squared = .157)

7. Interaction Between Instructional Approach and the covariate EFFORT1

Tests of Between-Subjects Effects

Dependent Variable:EFFORT2

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.782[a]	3	.261	1.167	.331
Intercept	7.321	1	7.321	32.783	.000
TREATMENT	.433	1	.433	1.940	.169
EFFORT1	.080	1	.080	.357	.553
TREATMENT * EFFORT1	.504	1	.504	2.256	.139
Error	12.506	56	.223		
Total	618.125	60			
Corrected Total	13.288	59			

a. R Squared = .059 (Adjusted R Squared = .008)

8. Interaction Between Instructional Approach and the covariate PREATB

Tests of Between-Subjects Effects

Dependent Variable:POSTATB

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.707[a]	3	.236	4.271	.009
Intercept	1.203	1	1.203	21.806	.000
TREATMENT	.212	1	.212	3.849	.055
PREATB	.305	1	.305	5.534	.022
TREATMENT * PREATB	.178	1	.178	3.226	.078
Error	3.089	56	.055		
Total	510.370	60			
Corrected Total	3.796	59			

a. R Squared = .186 (Adjusted R Squared = .143)

9. Interaction Between Instructional Approach and the covariate PREATB

Tests of Between-Subjects Effects

Dependent Variable:POSTBAT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	269.727[a]	3	89.909	5.463	.002
Intercept	287.012	1	287.012	17.440	.000
TREATMENT	60.844	1	60.844	3.697	.060
PREBAT	200.477	1	200.477	12.182	.001
TREATMENT * PREBAT	62.970	1	62.970	3.826	.055
Error	921.606	56	16.457		
Total	15298.000	60			
Corrected Total	1191.333	59			

a. R Squared = .226 (Adjusted R Squared = .185)

Appendix BB

Differences in Gained Scores per Item of BAT Between CBI and CIA

ITEM	CBI			CIA			DIFF. IN GAIN (CBI – CIA)
	PRE	POST	GAIN	PRE	POST	GAIN	
1	13	20	7	13	13	0	7
2	4	8	4	5	10	5	-1
3	17	25	8	22	30	8	0
4	9	21	12	11	25	14	-2
5	8	6	-2	6	9	3	-5
6	6	10	4	3	7	4	0
7	7	20	13	2	14	12	1
8	9	11	2	4	9	5	-3
9	7	11	4	7	5	-2	6
10	8	10	2	8	11	3	-1
11	2	9	7	5	7	2	5
12	3	12	9	6	21	15	-6
13	6	11	5	9	8	-1	6
14	7	20	13	9	16	7	6
15	9	15	6	10	12	2	4
16	8	14	6	4	9	5	1
17	17	12	-5	16	15	-1	-4
18	11	9	-2	13	15	2	-4
19	3	17	14	3	23	20	-6
20	8	12	4	5	11	6	-2
21	22	22	0	18	20	2	-2
22	5	5	0	7	6	-1	1
23	14	15	1	15	13	-2	3
24	2	4	2	4	3	-1	3
25	5	5	0	4	8	4	-4
26	20	24	4	16	23	7	-3
27	12	7	-5	2	13	11	-16
28	3	9	6	4	9	5	1
29	13	21	8	18	19	1	7
30	7	7	0	10	9	-1	1
31	8	11	3	8	10	2	1
32	3	12	9	6	12	6	3
33	11	10	-1	8	10	2	-3
34	21	21	0	23	21	-2	2
35	8	16	8	8	15	7	1

Appendix CC

Multiple Regression Analyses

1. Model: DV: POSTBAT; IV: Overall and Component Posttest Scores in ATB (All Groups)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	INT2	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: POSTBAT

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.337[a]	.114	.099	4.266

a. Predictors: (Constant), INT2

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	135.658	1	135.658	7.453	.008[a]
	Residual	1055.675	58	18.201		
	Total	1191.333	59			

a. Predictors: (Constant), INT2

b. Dependent Variable: POSTBAT

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.205	3.751		1.388	.171
	INT2	3.211	1.176	.337	2.730	.008

a. Dependent Variable: POSTBAT

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	IMPT2	.065[a]	.455	.651	.060	.769
	TEACH2	.018[a]	.128	.898	.017	.832
	KEEN2	.100[a]	.808	.422	.106	.994
	ENJOY2	.025[a]	.161	.873	.021	.660
	ANXIETY2	-.293[a]	-1.503	.138	-.195	.393
	EFFORT2	-.030[a]	-.207	.836	-.027	.765
	POSTATB	-.065[a]	-.342	.734	-.045	.429

a. Predictors in the Model: (Constant), INT2

b. Dependent Variable: POSTBAT

2. Model: DV: GAINMET; IV: Overall and Component Gained Scores in ATB (CBI Group)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GAINTEACH	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: GAINMET

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.398[a]	.158	.128	1.664

a. Predictors: (Constant), GAINTEACH

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	14.603	1	14.603	5.272	.029[a]
	Residual	77.564	28	2.770		
	Total	92.167	29			

a. Predictors: (Constant), GAINTEACH

b. Dependent Variable: GAINMET

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.560	.349		4.472	.000
	GAINTEACH	-2.573	1.121	-.398	-2.296	.029

a. Dependent Variable: GAINMET

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	GAINIMPT	.261[a]	1.396	.174	.259	.831
	GAININT	.201[a]	1.158	.257	.218	.986
	GAINKEEN	.086[a]	.444	.660	.085	.816
	GAINENJOY	.162[a]	.913	.370	.173	.961
	GAINANXIETY	.015[a]	.087	.931	.017	.996
	GAINEFFORT	.309[a]	1.835	.078	.333	.979
	GAINATB	-.323[a]	-1.954	.061	-.352	.999

a. Predictors in the Model: (Constant), GAINTEACH

b. Dependent Variable: GAINMET

3. Model: DV: GAINTEST; IV: Overall and Component Gained Scores in ATB (Males)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GAINATT	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: GAINTEST

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.541[a]	.293	.234	3.73254

a. Predictors: (Constant), GAINATT

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	69.175	1	69.175	4.965	.046[a]
	Residual	167.182	12	13.932		
	Total	236.357	13			

a. Predictors: (Constant), GAINATT

b. Dependent Variable: GAINTEST

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.006	1.135		3.528	.004
	GAINATT	14.219	6.381	.541	2.228	.046

a. Dependent Variable: GAINTEST

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	GAINIMPT	-.023[a]	-.083	.935	-.025	.817
	GAININT	-.162[a]	-.648	.530	-.192	.987
	GAINTEACH	-.370[a]	-1.609	.136	-.437	.982
	GAINKEEN	-.082[a]	-.324	.752	-.097	.999
	GAINENJOY	-.142[a]	-.564	.584	-.168	.992
	GAINANXIETY	-.074[a]	-.289	.778	-.087	.984
	GAINEFFORT	.098[a]	.290	.777	.087	.561

a. Predictors in the Model: (Constant), GAINATT

b. Dependent Variable: GAINTEST

4. Model: DV: GAINTEST; IV: Overall and Component Gained Scores in ATB (Females)

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	GAINKEEN	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

a. Dependent Variable: GAINTEST

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.291[a]	.085	.064	4.07430

a. Predictors: (Constant), GAINKEEN

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	67.539	1	67.539	4.069	.050[a]
	Residual	730.396	44	16.600		
	Total	797.935	45			

a. Predictors: (Constant), GAINKEEN

b. Dependent Variable: GAINTEST

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.926	.602		8.184	.000
	GAINKEEN	3.441	1.706	.291	2.017	.050

a. Dependent Variable: GAINTEST

Excluded Variables[b]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	GAINIMPT	-.093[a]	-.602	.550	-.091	.889
	GAININT	-.080[a]	-.548	.586	-.083	.999
	GAINTEACH	.159[a]	.999	.323	.151	.822
	GAINENJOY	-.155[a]	-.870	.389	-.132	.663
	GAINANXIETY	-.184[a]	-1.266	.212	-.190	.973
	GAINEFFORT	.012[a]	.078	.938	.012	.948
	GAINATT	-.188[a]	-1.311	.197	-.196	1.000

a. Predictors in the Model: (Constant), GAINKEEN

b. Dependent Variable: GAINTEST