

Path Analysis Of Situational Affective Characteristics On Conceptual Change Of Students Exposed To Discrepant Events Instruction In Sound Waves

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Abstract

This study developed a causal model for the explanation of the influence of situational affective characteristics on conceptual change of students exposed to discrepant events instruction in sound waves. A population of 5474 senior secondary II school students (SSII) formed the population, while a sample of 156 students was used for the study. Six instruments were used for data collection. The reliability of the instruments was obtained using Cronbach Alpha statistics. Data collected were analyzed using path analysis for the research questions, while the hypotheses were tested using Chi-Square Goodness of Fit Index (CGFI), Adjusted Goodness of fit (AGFI), and Root Mean Square Error of Approximation (RMSEA). The findings of the study showed that the causal model for explaining students' conceptual change is a model linking cognitive conflict, situational interest, self-efficacy, attention, and effort among others. It was recommended among others that teachers should ensure that students' attentions are activated during teaching which determines students' effort to learn meaningfully during teaching of physics concepts.

Keywords: Sound Waves, Conceptual Change, Discrepant Event, Situational Characteristics, Path Analysis.

Introduction

One of the branches of physics that has impacted greatly to life and makes life enjoyable and livable is acoustics. For instance, acoustics is applied in the area of entertainment (musical tones, harmonics, echoes and resonance), medicine (ultrasound), transportation (speed limit detector), architecture (echoes and reverberations), oil explorations (echoes) among others. Acoustics is the scientific study of sound waves, its properties and applications in the everyday life. It is the science of sound, production, transmission and effects. Sound is a form of energy produced by vibrating bodies. The vibrations cause the surrounding air to vibrate, hence producing a disturbance of the air (Anyakoha, 2013). The disturbance travels out from the source of vibration in the form of longitudinal waves (waves that travel in the same

direction or parallel with source of disturbance) (Anyakoha, 2013). Sound could also be defined as energy resulting from vibrations of two or more bodies in contact.

Reports have shown that sound wave is one of the topics in physics students easily misconceive. To this end, Chief Examiner's report (2015) of West African Examination Council' revealed that students were unable to differentiate between loudness and intensity (Chief Examiner's Report, 2015; p.393). However, intensity from the scientific viewpoint is the rate of flow of sound energy per second per unit area, while loudness is the magnitude of sensation of sound in the ears. Loudness depends on intensity, but they are not the same. Therefore, the students' inability to differentiate between loudness and intensity shows that students misconceive loudness to be intensity. Chief Examiner's Report (2015) suggested that to remedy the students' weakness, teachers should demand for explanations in order to know the extent of understanding of the concept, and teachers should insist on correct definitions during evaluations of candidates (p.394). Other studies have shown also that students misconceived sound waves. For example Pejuan, Jaén, and Bohigas, (2009) found that one of the misconceptions students have in sound waves is that students misconceived sound to consists of " sound particles " (different from air molecules) travelling among the particles or molecules of the transmitting medium. Similarly, students hold the belief that sound is propagated through the travelling of air particles, even in solids (Pejuan, Bohigas & Jaén, 2012). Other alternative conceptions held by students are that loudness and pitch of sounds are the same; sound can travel through empty space (a vacuum); sound cannot travel through liquids and solids; in wind instruments, the instrument itself vibrates (not the internal air column); sound waves are transverse waves (like water and light waves); and when waves interact with a solid surface, the waves are destroyed among others (Periago, Pejuan, Jaén & Bohigas, 2009). All these studies reviewed above are foreign based, though, students in Nsukka Education zone may possess the same or similar misconceptions in sound waves. Hence, the need to investigate the misconceptions students possessed in sound waves.

Misconception is prior knowledge that is in conflict with scientifically established knowledge (Chi, 2008). Misconceptions are false beliefs in one's mental model (Orji, 2013). Misconceptions are incorrect ideas about a concept or belief. Allowing students' misconceptions to persist could hinder understanding of topic(s) a teacher teaches and subsequently result to poor achievement in physics. This then suggests the need to remedy (correct) misconceptions once identified by the teacher through a process called conceptual change. According to Llinares and Krainer (2006) conceptual change is defined as learning that changes existing beliefs and knowledge. Conceptual change is a change or modification or rejection of one's conceptual beliefs when presented with anomalous situation (Madu & Orji, 2016). Conceptual change does not just occur but occurs when taught with teaching strategy that makes it possible. Example of such strategy is the use of discrepant event instruction. The contradictory information on students' beliefs is called discrepant event. According to Onzalez-Spada, Birriel and Birriel (2010), discrepant event is an event that amazes students because it is contrary to what they would expect to happen based on their background knowledge. Discrepant events are the catalyst for cognitive conflict (Orji, 2018). Discrepant events can be presented as a hands-on activity, a demonstration, a toy, an image or a video. During discrepant experiment, the students should have a mental model of what they expect to happen. An example of a discrepant event from physics instruction would be to use electric bell covered with bell jar placed on a vacuum pump and made airtight using grease. By pumping air into the jar using the pump, and switching on the bell, loud sound emits, but when the air is pumped out, the sound diminishes and dies down. But since the students believe that sound travels through a vacuum, the experiment is discrepant since it contradicts their belief. Another discrepant event is to use a tuning fork and hit it on a table and bring it near a still water, and notice a wave like movement of the water, showing that sound travels through a liquid like water. But, because the students already held the belief that sound do not travel through water, the event is discrepant among others. Discrepant event instruction has been found to promote conceptual change (Baser, 2006; Scharmann, Kang, & Noh, 2010; Orji, 2013; Madu & Orji, 2016). However, other studies have shown that discrepant events alone do not promote conceptual change without considering the learner's psycho-situational variables (Limón, 2001; Mason, 2001; Sinatra & Pintrich, 2003; Kang, Scharmann, & Noh, 2004; and Lin, 2007). Thus, in this study, attention, situational interest, effort, and self-efficacy of the learners were considered.

Attention has been defined as the cognitive process of selectively concentrating on one aspect of the environment while ignoring other things. Attention is also defined as the allocation of processing resources (Anderson, 2004). Attention is one of the attributes of motivation that influences students' learning by making them focus on the figure (learning task) which is the main concept under discussion and disregards background (distractions) within the classroom (Orji, 2013). In teaching and learning, once the attentions of the students are not activated and sustained, every effort of the teacher to bring about meaningful learning and understanding will amount to time wasting (Orji, 2013). Also, attention has been reported to be stimulated when students experience cognitive conflict (Lee, 2000; Hidi, 2001; Hidi & Harackiewicz, 2000; Schraw & Lehman, 2001). Therefore, it is reasonable to consider attention as a factor that might influence conceptual change (Kang, Scharmann, Kang & Noh, 2010). Study by Kang, et al (2010) found that cognitive conflict-based instruction mediated by attention facilitates conceptual understanding. Kang, et al found a positive path coefficient between attention and cognitive conflict. Also, Orji (2013) found that cognitive conflict instruction triggers students' attention more than conceptual change pedagogy. Also, Limón (2003) opines that students focusing their attention on learning tasks facilitate their conceptual change.

Similarly, situational interest experienced by a student during teaching and learning could be potential factor that influence conceptual change. However, Interest is defined as an interactive relation between an individual and certain aspects of one's environments (Krapp, 1999). Individual interest is not the same as situational interest, thus individual interest is characterized by an intrinsic desire to understand a particular topic that persists over time, whereas situational interest is assumed to be transitory, environmentally activated, and context-specific (Kang, et al, 2010). Situational interest could be defined as eagerness invoked at an instant due to certain environmental uniqueness such as experiments, gadgets, stories and demonstrations (Orji, 2018). The study by Kang, Scharmann, Kang, and Noh (2010) study revealed that situational interest strongly influences conceptual change than cognitive conflict. Thus, situational interest might be one of the constructs that would be stimulated by discrepant events and a potential mediator that would influence conceptual change. Similarly study by Kang et al. (2010) further showed that situational interest promote conceptual change, as a result of the effort put during the learning process. Therefore, influence of effort on students' conceptual change was investigated in this study in sound waves.

Effort could be seen as level of commitment invested in a given task by the students. It has been found to be an essential component for students' academic success (Kang, et al, 2010). Also, study has shown that effort positively influence students conceptual change in density (Kang, et al., 2010). The empirical work on influence of effort on conceptual change was done only on density, but, in this study, influence of effort to learn by the students to enhance conceptual change was investigated in sound waves since conceptual change is domain and content specific (Orji, 2018). Similarly, situational interest of the learners could lead to enhanced effort that may influence their self-efficacy consequent conceptual change.

Self-efficacy is a person's belief in their ability to accomplish some specific goal or task (Frank, 2012). Self-efficacy is a self-belief construct that deals with the perception that one is capable of doing what is necessary to reach one's goals in terms of knowing what to do and being emotionally able to do it (Pajares & Schunk, 2001). Self-efficacy according to Bandura (1977) is the belief a student holds that he or she can succeed at a task in a particular context. Self-efficacy differs from self-concept and self-esteem since self-concept is a factual description of how you perceive yourself and self-esteem can refer to measures of components of self-concept (Huitt, 2011). That is to say that self-esteem is an evaluative component of self-concept (Olufemi, Tamilade & Olatoun, 2015). However, Hosey (2008) found that, students with higher self-efficacy performed only slightly better than low self-efficacy students but the difference was not statistically significant. In view of this Kang, et al, (2010) who worked on influence of non-cognitive variables on students conceptual change had suggested that the influence of self-efficacy on student's conceptual change be investigated. This necessitated the inclusion of self-efficacy in this study. The analysis of the influences and combined influence among cognitive conflict, situational interest, attention, effort to learn and self-efficacy on students' conceptual change could not be possible without using a statistical tool called path analysis.

Path analysis is an analytical method that estimates the magnitude and strength of effects within a hypothesized causal model (Christy, 2005). Path analysis is an alternative multi-variable technique that enables researchers to demonstrate model or models in complex systems by means of path diagrams showing causal connections with arrows and to predict the total amount of direct and indirect effects among the variables (Karadag,

2012). It is a methodological tool that helps researchers using quantitative data to disentangle the various causal processes underlying a particular outcome (Christy, 2005). According to Christy (2005) path analysis assesses the comparative strength of different effects on the outcome and hence, the relationship between variables in the path model are expressed in terms of correlations. Christy (2005) noted that path analysis cannot prove causation, but path models do reflect theories about causation and can inform researchers as to which hypothesized causal model best fits the pattern of correlations found within the data set. Karadag (2012) posited that path analysis allows researchers to break apart or decompose the various factors affecting an outcome into direct and indirect effects unlike ordinary correlational coefficient. With path analysis, effect of exogenous variables (independent variables) can be determined on the endogenous variables (dependent variables) unlike multiple-regression analysis (Karadag, 2012). Exogenous variables are explicit variables that bring about changes in other variables and their variation is external to the model, while endogenous variables are variables whose variation is explained by one or more variables within the model (Christy, 2005).

However, in an experimental study, effect of one independent variable on a dependent variable is studied at a time in order to reduce extraneous variable's influence on the dependent variable. But, with path analysis multiple causal influences can be studied at a time (Karadag, 2012). According to Christy (2005), variables play more than one role in path model. This means that an exogeneous variable can influence another exogeneous variable which in turn influence an endogenous variable. This equally means that a variable can be a dependent variable in one relationship and an independent variable in another. These variables are referred to as mediating variables. This provides a more effective and direct way of modeling mediation, indirect effects, and other complex relationship among variables (Christy, 2005). For instance, attention, effort and self-efficacy could mediate the influence of cognitive conflict on students' conceptual change. Hence, for the purpose of this study, the exogenous variables are cognitive conflict induced by discrepant events, situational interest, attention, effort to learn, and self-efficacy, while conceptual change is the only endogenous variable in the study.

Finally, studies have shown that students in the area of the study possessed misconceptions in sound waves and by extension other areas of physics (Ugwuanyi, 2012; Orji & Madu, 2016; Orji, 2018). Thus, to change the misconceptions a conceptual change pedagogy was sought-discrepant event instruction. However, conceptual change like other learning outcomes is influenced by multiple variables both cognitive and non-cognitive (Kang et al, 2010). To this end influence of both cognitive (cognitive conflict) and non-cognitive (situational interest, attention, effort and self-efficacy) variables were investigated using path analysis. From the reviewed studies, path analysis is without doubt a good analytical tool for modeling the direct and indirect effect of exogenous variables on the endogenous variables. However, in all the studies reviewed none used anomalous data in the form of experiment as conceptual change intervention. Also, none carried out similar study in sound waves since conceptual change is content specific (Orji, 2018). Also, no study has investigated the influence of self-efficacy on students' conceptual change. This then means that no study has investigated the influence of these exogenous variables (cognitive conflict, situational interest, attention, effort and self-efficacy) on the endogenous variables (conceptual change). In the light of the gaps in the literature, the present study was deemed necessary for investigation. To guide the study, the following research questions were posed:

1. what is the most parsimonious causal model for explaining students' conceptual change based on the exogenous variables of the study (cognitive conflict, situational interest, attention, effort to learn, and self-efficacy)
2. what are the effects of cognitive conflict, situational interest, attention, effort and self-efficacy on students' conceptual change?
3. what are the directions and strength of causation of exogenous variables on students' conceptual change in sound waves?
4. what are the direct and indirect influences of exogenous variables on the students' conceptual change in sound waves?

Also, the following null hypotheses guided the study and were tested at 0.05 probability level.

1. There is no significant model fit for explaining students' conceptual change based on the exogenous variables of the study.
2. decomposed variables have no significant effect on students' conceptual change.
3. composite variables has no significant effect on students' conceptual change

Empirical Review

Several studies on path analysis has been carried out for example Adesoji and Olatunbosun (2008) investigated student, teacher and school environment factors as determinants of achievement in senior secondary school chemistry in Oyo state, Nigeria. Sample of 621 senior secondary III chemistry students and 27 Senior Secondary III chemistry teachers in Oyo State, Nigeria was used. Chemistry Achievement Tests (SACS), Teacher Attitude towards Chemistry Teaching Scale (TATCTS) and Laboratory Adequacy Inventory (LAI) were developed for data collection. Path analysis was used to analysis the data. The results revealed that 7.20% of the total effect on achievement in chemistry was accounted for by all the seven predictor variables when taken together among others. The two studies are related because path analysis was used in both studies, but they differ on the exogenous and endogenous variables investigated. Adesoji and Olatunbosun (2008) investigated student, teacher and school environment factors as determinants of achievement, while the present study, investigates influence of cognitive conflict, situational interest, attention, effort, and self-efficacy on students' conceptual change.

Similarly, Kang et al. (2010) carried out a study on influence of cognitive conflict and situational interest on students' conceptual change using 183 seventh graders from six middle schools in Seoul, Korea. A preconception test, a test of responses to a discrepant event, and a questionnaire of situational interest were administered as pretests. Computer-assisted instruction was given to the students as a conceptual change intervention. Questionnaires regarding attention and effort, and a conception test were administered as posttests. The conception test was administered once more as a retention test four weeks later. The results of path analysis indicated that both cognitive conflict and situational interest induced by a discrepant event respectively had an indirect effect on students conceptual understanding, which were mediated by attention and effort allocated to concept learning. Situational interest, however, was found to exert a stronger influence on conceptual change than cognitive conflict. This work of Kang et al, (2010) even though is related to the present work but differs with the present study because presents study used anomalous data inform of experiment as conceptual change intervention, while Kang et al (2010) used computer-Assisted instruction as conceptual change intervention. Also, Kang et al carried out their study on density whereas the present study was on sound waves. Also, self-efficacy was not considered in Kang et al work but instead suggested as one of the variables to be investigated by future researchers, but the present study fills that gap by including it in the study as one of the variables that could influence conceptual change.

Similarly, Ajayi, Ajayi, and Onabanjo, (2011) carried out a study on path-analytic study of students' home background, academic motivation, self-concept on attitude and achievement in senior secondary school mathematics in Ogun state, Nigeria. Two thousand four hundred students from 60 selected schools in nine local government areas within Ogun State, Nigeria were involved. Five research instruments namely, Attitude towards Mathematics Questionnaire; ($r = 0.73$), Self-concept Scale; ($r = 0.71$), Parents' Support Scale; ($r = 0.66$), Academic Motivation Scale; ($r = 0.85$) and Mathematics Achievement Test; ($r = 0.84$) were used. Four research questions were answered, and data analysed using path analysis technique. Findings showed that out of the seven predictor variables hypothesised, only one (parents' education), significantly exerted direct and indirect influence on students' attitude. The two studies differ on the variables investigated.

In the same vain, Orji (2013) investigated the effect of cognitive conflict instruction and conceptual change pedagogy on students' conceptual change in heat and temperature using 249 SSII students as sample. Students in two schools were taught using cognitive conflict instruction, and students in the other two schools were taught using conceptual change pedagogy. Thermal Concept Evaluation (TCE) and attention survey were instruments used for data collection. The research questions were answered using mean and standard deviation and hypotheses tested using

Analysis of Covariance (ANCOVA). Findings indicated that cognitive conflict instruction (CCI) fosters students conceptual change and attention more than conceptual change pedagogy (CCP) among others. This study differs with the present study in the area of design. The present study used correctional design whereas the previous study adopted quasi-experimental design. Thus, present study used path analysis in establishing cause effect unlike the previous study that used analysis of Covariance. ANCOVA. So, in effect the present study is more robust unlike the study of Orji (2013) because outcome variables like conceptual change are usually influenced by multiple variables and as such should be investigated simultaneously, not pair wise.

Similarly, Akobi (2014) carried out a study to examine the influence of parental socioeconomic status and home education environment on students' academic achievement using path analysis using 360 respondents. The instruments for data collection were questionnaire on home education and proforma. Analysis of Moment Structure (AMOS) was used to estimate the paths coefficients. The findings showed a significant relationship between parental socioeconomic status and students' academic achievement, and a significant relationship between students home education environment and students' academic achievement. Akobi study is similar with the present study on the analytical too employed (path analysis). However, the two study differ on the ground that all the variables (cognitive conflict, situational interest, attention and self-efficacy) of this study differ with the variables (parental socioeconomic status and home education environment on students' academic achievement) in Akobi's work.

Ugwuanyi (2016) developed a causal model for the explanation of the achievement of students in physics based on eight selected teacher and student's variables (qualification, professional development, and classroom practices, attitude to physics etc). The study was carried out in both Obollo-Afor and Nsukka Education Zone, of Enugu state, Nigeria using 630 respondents made up of 585 SSII students and 45 physics teachers. Data were three instruments, two questionnaire and one Proforma. Findings showed that the meaningful causal model for providing an explanation of the achievement of students in physics is the recursive model involving family background of students, qualification of teachers, students' attitude to physics, professional development and classroom practices. Although Ugwuanyi's study is similar with the present study but, differs on the ground that all the variables (cognitive conflict, situational interest, attention and self-efficacy) of this study differ with the variables (qualification, professional development, and classroom practices, attitude to physics) in Ugwuanyi's work.

Research Method

Correlational survey design was adopted for this study. According to Nworgu (2015) correlational study seeks to establish what relationship exists between two or more variables. Also, the adoption of Correlational survey is justified in this study because according to Christy (2005), the relationship between variables in a path model is expressed in terms of correlations. This means that since the study intends to use path analysis in the analysis of the data that were generated, the path coefficients that were obtained are correlational coefficients. Ezema et al. (2019), Gana et al. (2019), Okenyi et al. (2019), Achagh et al. (2020), Ugwuanyi et al. (2020) and Okenyi et al. (2021) have recently utilized this design in similar studies.

The study was carried out in Enugu State, Nigeria precisely Nsukka Education Zone which comprised of Uzo-Uwani L.G.A, Nsukka L.G.A and Igbo Etiti L.G.A. There are 58 government owned senior secondary schools in Nsukka Education zone, i.e. 30 in Nsukka L.G.A.; 12 in Uzo-Uwani; and 16 in Igbo-Etiti L.G.A. The population for this study was 5474 SS2 physics students in coeducational secondary schools that are government owned in Nsukka Education Zone. The breakdown includes 1371 SSII students in Igbo-Etiti L.G.A; 3395 students in Nsukka L.G.A; and 708 students in Uzo-Uwani. (Source: Academic Record unit of Post Primary School Management Board Nsukka {PPSMB}, 2017/2018). The choice of SS2 students was because the unit (sound waves) taught in this study is contained in SS2 scheme of work. The sample size for this study is all the 156 SS2 physics students in four intact classes. The sample size was drawn using two sampling technique. The first sampling technique employed was simple random sampling technique by means of flip chart method without replacement, used in selecting one local

government from the three local government areas in the zone. The second sampling technique employed was purposive sampling technique used in selecting four schools in the selected local government. The choice of purposive sampling technique was because only the schools with well-equipped laboratories especially apparatus in sound waves were selected for the study. Finally, simple random sampling was used in selecting four intact classes from the four selected schools one in each school.

Six (6) instruments were used for data collection. They are Sound Concept Test (SCT), Cognitive Conflict Induced by Discrepant Event Questionnaire (CCIDEQ), Situational Interest Questionnaire (SIQ), Attention Questionnaire (AQ), Effort to Learn Questionnaire (ELQ), and Self-efficacy Questionnaire (SEQ),

SCT was adapted from Eshach (2014) 20-item Sound Conception Inventory (SCI). The original version of the SCT has true or false response in each question of the instrument. But this was removed by the researcher as part of adaptation measure since true or false may not measure conceptual change well. Also, in the original version, certainty level (1=not sure at all) to (5=very sure) in answer was included in each question, but it was equally removed since adding it without using it during the analysis stage will amount to effort and time wasting on the part of the respondents and the researcher. Similarly, uniformity on the number of options in each question was not adhered to in the original version, but in the current version, the researcher streamlined the number of options into four (i.e a-d) in order to ensure uniformity. Three questions (6, 7, and 18) were deleted in the original instrument because they were not part of the topics covered. The three questions were replaced with new questions to take care of the topics treated in the study.

The second instrument CCIDEQ was adapted from Lee, Kwon, Park, and Kim (2003) Cognitive conflict level test. The instrument has twelve items originally structured on five point scale of Very true (VT=4) to Not at all true (NAT=0). The instrument has four components, namely cognitive contradiction, interest, anxiety and cognitive reappraisal. As part of the adaption, demonstration written in the original instrument was replaced with experiment and the five point scale was changed to four point ranging from very true (VT=4) to Not at all true (NAT=1) with somewhat true removed. Also, item six to eight were added making the total item to be fifteen.

SIQ was self-developed by the researcher to measure students' situational interest induced by discrepant events in the sound waves. It consists of 12-items structured on four-point Likert type scale of strongly agree (SA=4) to strongly disagree (SD=1). The fourth instrument- AQ, was readapted from Orji (2013) adapted version of Instructional Materials Motivation Scale developed originally by Keller (2006). Attention survey is one of sub scales of Instructional materials Motivation Scale. So, the researcher adapted this instrument to measure students' attention in lessons on sound waves. For the sake of this study, attention survey was adapted with slight modifications. For example, in the original instrument, item 11, reads -the quality of writing helped to hold my attention. This was modified to- the quality of the lesson helped to hold my attention. Also, the original instrument was rated on five points scale (i.e. 1= Not true, NT; 2= Slightly true, ST; 3= Moderately true, MT; 4= Most true, MT; and 5= Very true, VT). But the researcher changed it to four point scale (i.e. 1= Not true, NT; 2= slightly true, ST; 3= Moderately true, MT; and 4= Very true, VT). This was done in order to eliminate confusion that may arise between, moderately true (MT) and Most true (MT) when the students start responding to it. The fifth instrument-ELQ was as well, adapted from Tuan, Chin and Shieh (2005) Motivation Towards Science Questionnaire (MTSQ). The original version of the instrument consists of 35-item, but only 12-item was selected since only the 12-item (item 4-15) addresses effort to learn. The original version was structured on five-point Likert type of Strongly Agree, SA= 5; Agree, A=4, No Opinion, NO= 3; Strongly disagree, SD= 2; and Disagree, D= 1. Some minor modifications were carried out in the original version as part of the adaptation process. Firstly, no opinion was removed, thereby reducing the five points to four points Likert scale. Also, science written in the original version was removed and replaced with sound waves. Lastly, the researcher added item 1 and the last three items bringing up the number of items in the instrument to 16-item. Finally, the sixth instrument- SEQ just like other instrument for the study was also adapted from Academic Self-Efficacy subscale from Patterns of Adaptive Learning Scales (PALS) developed by Midgley et al. (2000). The instrument has five items structured on five-point Likert scale ranging from Very True, VT=5 to Not at all True, NAT= 1. As part of the adaptation process, the researcher removed somewhat true thereby reducing it to four-point scale.

Again, class lesson was removed and replaced with sound waves, and on the final note the researcher added negative items alternating with the positive ones.

To ensure that all the instruments are valid and reliable, all the six instruments (SCT, CCIDEQ, SIQ, AQ, ELQ, SEQ) were subjected to face validity. Two experts in measurement and evaluation, one in educational Psychology, and two in Physics education (one physics secondary school's teacher and one physics educator), validated the instruments. All the experts except the physics teacher are in Faculty of Education University of Nigeria Nsukka. The researcher requested them to validate the instrument considering the following areas: ambiguity of the items of the instrument or otherwise, and the appropriateness of the items of the instrument.

The observations of the experts were used for the final modification, and selection of the items for the study. For instance, one of the experts suggested that "somewhat so" in SIQ be removed and replaced with better response option. This suggestion was taken and somewhat so was changed to "somehow so". Also, on SEQ instrument, one of the validators suggested that "somehow not true" be change to "somehow true". This suggestion was equally adhered to. Also, one of the validators equally suggested that personal data of the respondents be included in the instrument, and it was carried out in all the instruments. After the face validation, the six instruments (SCT, CCIDEQ, SIQ, AQ, ELQ, and SEQ) were trial tested on a sample of twenty (20) students. A school in Obollo Afor Education Zone that was not among the sampled schools in the sampled area of the study was used. This is to avoid biasness and test-wise effect on the subjects. After the trial testing, the reliability of the six instruments was determined using Cronbach Alpha formula. The choice of this reliability estimate was because the instruments are non-dichotomously scored items (Questionnaires), i.e. each item of the instrument has no preferred answer (right or wrong). The following reliability indices were gotten 0.82, 0.80, 0.94, 0.86, 0.79, and 0.76 for SCT, CCIDEQ, SIQ, ELQ, SEQ, and ASI. These reliability indices showed that the instruments are reliable.

Only four classroom teachers from the four intact classes were used as research assistants and they were trained and guided on the use of cognitive conflict instruction induced by discrepant events, using developed lesson plan made by the researchers. Photocopies of the lesson plan was made available to the teachers to use in their separate classrooms. The students in the four intact classes used for the study, were given only SCT as preconception test. The reason for this is to enable the researchers identify the students that have or possess alternative conceptions for inclusion in the study and, to help the researcher know the number of students that moved from naïve conception to sound conception after the post conception test. After the preconception test, the teaching using discrepant events instruction commenced using single groups which was taught sound waves using cognitive conflict induced by discrepant events. The teachers guided the students on how to fill their code number and that of the school code number in the provided spaces in the instrument (SCT). The students were given 45 minutes to respond to the instrument and their responses were collated and kept. Thereafter, their responses were analyzed in order to spot out the students that have misconceptions in the instrument. After the analysis of the students' preconception test, all the students with naïve conception were retained and used for the study. The treatment commenced and lasted for five weeks. Thereafter, the teachers administered the six instruments as conception test (posttest). The administration of the posttest lasted for three days, with SCT taken the first day and the rest, the remaining two days. This measure was taken to avoid boredom that may occur if all the six instruments were to be rated in a day. In all the administration of pretest, instructional treatment and posttest lasted for six weeks.

A special analytical package called Analysis of Moment Structure (AMOS) version 20 programme was used in running path analysis for the study. Research question 1 was answered using path diagram and path coefficients, while research question 2 was answered using regression coefficients from multiple linear regression. Research question 3 was answered using arrow headed lines in the path diagram and path coefficients and research question 4 was answered using parameter estimate of the path coefficients in the path diagram generated. Only path coefficient above 0.05 was accepted. This is because according to Kerlinger (1979), path coefficients that are below 0.05 should be deleted from the output path diagram.

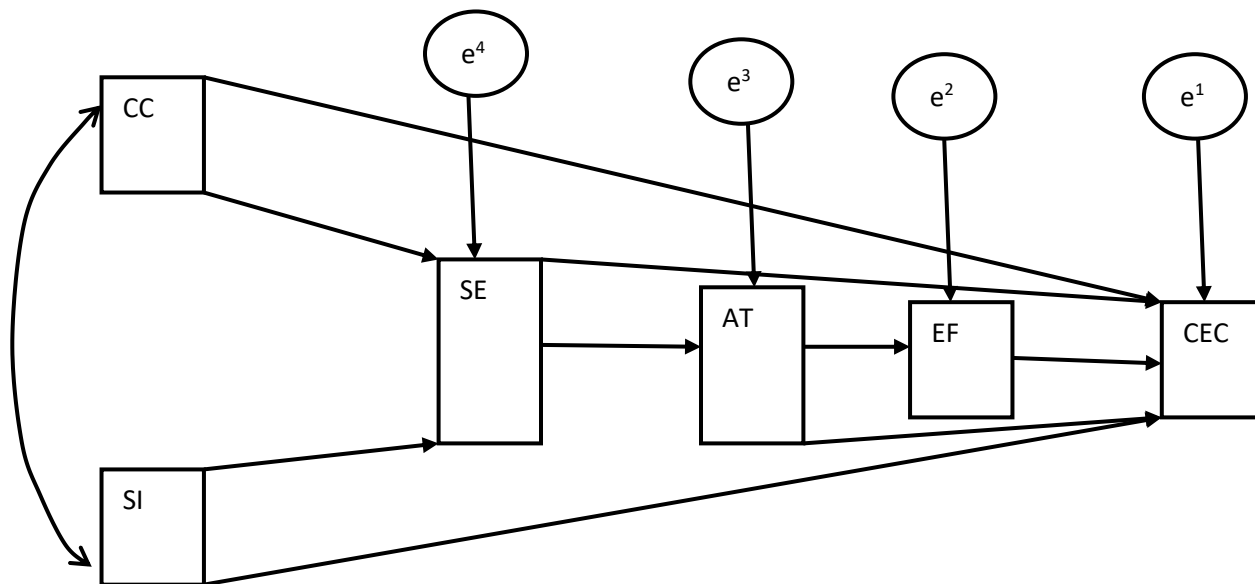
Hypotheses 1 was tested using Chi-square Goodness of Fit Index (CGFI), Root Mean Square Error of Approximation (RMSEA) and Adjusted Goodness-of-fit index (AGFI), while hypotheses 2, and 3 were tested using

2-way analysis of variance (ANOVA). Please note that only the posttest scores gotten from the students were used to answer the research question 1 to 4 and hypotheses.

Results

In this sub-heading, the results of the investigation were presented in accordance with the research questions and hypotheses that guided the study

Research Question1: What is the most parsimonious causal model for explaining students' conceptual change based on the exogenous variables of the study?



NB: CC= Cognitive Conflict, SI=Situational Interest, AT=Attention, EF= Effort to Learn, SE= Self-efficacy, and CeC= Conceptual Change, e=error term

Fig 5: A Theoretical Causal Model for the Influence of Cognitive Conflict induced by discrepant event, Situational Interest, Self-Efficacy, Attention, and Effort to Learn on Students' Conceptual Change in Sound Waves

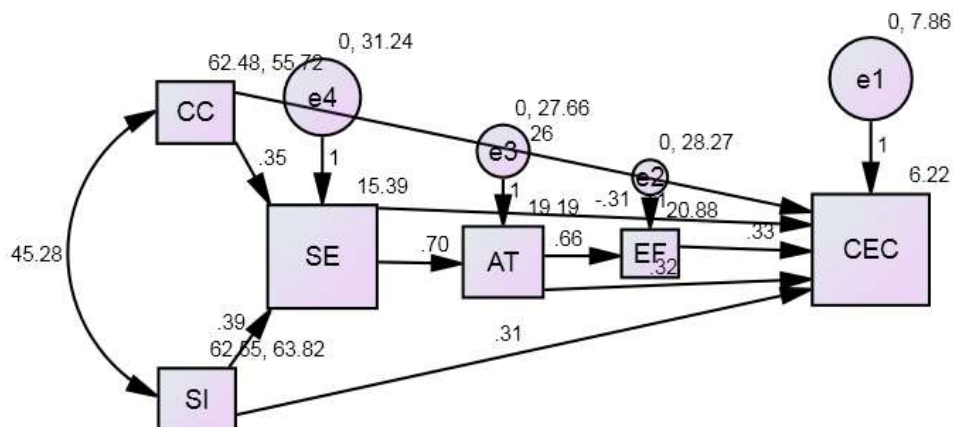


Figure 6: Observed Causal Model for Explaining the Influence of Cognitive Conflict induced by discrepant event, Situational Interest, Self-Efficacy, Attention, and Effort to Learn on Students' Conceptual Change in Sound Waves

A look at Figures 5 and 6 notices that the two diagrams are the same, figure 5 is the theoretical or hypothetical path diagram drawn in the AMOS program at the initial stage of the analysis, while figure 6 is the output path diagram or the observed path diagram after the analysis. After the analysis all the path coefficients were found to be greater than 0.05 as recommended by Kerlinger (1979), hence none of the variable was deleted. But it was observed that some of the exogenous variables influenced other exogenous variables. For example, cognitive conflict and situational interest influenced self-efficacy with path coefficients of 0.35 and 0.39 respectively. Self-efficacy influence attention and attention influenced effort with path coefficients of 0.70 and 0.66. Hence, this influence of cognitive conflict and situational interest on self-efficacy, self-efficacy on attention, and attention on effort, makes the observed model recursive. Therefore, the model that explains the causal influence of cognitive conflict, situational interest, self-efficacy, attention, and effort on students' conceptual change is a causal model.

Hypothesis 1: There is no significant model fit between the theoretical model and the observed model for explaining students' conceptual change based on the exogenous variables of the study.

Table 1: Chi-square Goodness of Fit-index model fit test based on the exogenous variables

Model	RMR	GFI	AGFI	PGFI
Default model	.888	.0.67	.894	.000
Saturated model	1.000		1.000	
Independence model	.000	0.93	.670	.677

Default model is a model that one or two paths has been trimmed or model found after testing; Saturated model is one just identified or one developed by the researcher without any deleted path; independence is one in which all paths has been deleted. Root mean square residual (RMR) is an index of measure of the extent by which estimated model differs from the observed model. The smaller the better (Ingram, Cope, Harju, & Wuensch, 2000). The Goodness of Fit Index (GFI) compares the model to the independence model rather than to the saturated model. A good model fit must exceed 0.9 (Bollen, 1989). AGFI (adjusted GFI) is an alternative GFI index in which the value of the index is adjusted for the number of parameters in the model. Also, PGFI(parsimony GFI) is an index used in adjusting the model by rewarding simple model and penalizing model that few path has been trimmed. From Table 1, the GFI, AGFI, and PGFI under independence model is 0.93, 0.67, and 0.677 which shows a good model fit. This

indicates that there is no significant difference in the model fit between the theoretical model and the observed model for explaining students' conceptual change based on the exogenous variables of the study

Table 2: Root Mean Square Error of Approximation (RMSEA) model fit test based on the exogenous variables

Model	RMSEA	LO 90	HI 90	PCLOSE
Default model	.329	.271	.391	.000
Independence model	.579	.545	.614	.000

The root mean square error of approximation (RMSEA) estimates lack of fit compared to the saturated model. A RMSEA of 0.05 or less indicates a good fit, and 0.08 or less an adequate fit (Hair, Anderson, Tatham, & Black, 1995). LO 90 and HI 90 are the lower and higher confidence interval of 90. According to Hair, Anderson, Tatham, and Black, (1995). PCLOSE is the p-value which tests that the RMSEA is no greater than 0.05 (Ingram, Cope, Harju, & Wuensch, 2000). In Table 2, it could be seen that RMSEA under saturated is 0.329 with Pclose of 0.00 showing that the model is good fit. This indicates that there is no significant difference in the model fit between the theoretical model and the observed model for explaining students' conceptual change based on the exogenous variables of the study. These two model fit tests established that the recursive causal model is the significant model for explaining students' conceptual change based on exogenous variables of this study.

Research Question2: What are the influences of cognitive conflict, situational interest, attention, effort and self-efficacy on students' conceptual change?

Table 3: Multiple correlation coefficient of combined influence of exogenous variables on students' conceptual change

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.901 ^a	.812	.806	2.859

a. Predictors: (Constant), AT, SI, EF, CC, SE

In Table 3 it was shown a correlation of 0.90 among the predictor variables (cognitive conflict, situational interest, self-efficacy, attention and effort) and the criterion variable (conceptual change). The correlation coefficient(R=0.90) revealed a high relationship among the exogenous and endogenous variables. Also, the coefficient of determination (R square=0.81) revealed that cognitive conflict, situational interest, self-efficacy, attention and effort together accounted for 81.2% of variations in students' conceptual change. This means that 81.2% of variations in students' conceptual change could be attributed to cognitive conflict, situational interest, self-efficacy, attention and effort put together.

Table 4: Multiple Regression coefficients and t-test of individual influence of exogenous variables on students' conceptual change

Coefficients ^a						
Model		Unstandardized Coefficients		Standardized	t	Sig.
		B	Std. Error	Coefficients Beta		
1	(Constant)	6.224	2.287		2.722	.007
	CC	.259	.051	.300	5.113	.000
	SI	.310	.048	.383	6.447	.000

EF	.327	.057	.370	5.764	.000
SE	-.308	.060	-.370	-5.099	.000
AT	.323	.045	.378	7.111	.000

a. Dependent Variable: CEC

In Table 4 it was indicated that cognitive conflict has 0.259 positive relationships with conceptual change, situational interest has 0.310, effort has 0.327, self-efficacy has -0.308 and attention has 0.323 positive relationships with conceptual change. This means that apart from self-efficacy that has negative relationship with conceptual change, other predictor variables cognitive conflict, situational interest; attention and effort have positive relationship with conceptual change each. The positive relationship implies that every change in the conceptual change is as a result of the values change in the exogenous variables (cognitive conflict, situational interest, attention, effort and self-efficacy).

Hypothesis 2: There is no significant influence of decomposed variables on students' conceptual change.

In Table 4, t-test analysis showed that probability values were all less than 0.05 level of significance, an indication that all the exogenous variables have significant influence on conceptual change. This means that there is significant influence of cognitive conflict, situational interest, self-efficacy, attention and effort on students' conceptual change. Therefore, the null hypothesis is rejected.

Hypothesis 3: There is no significant influence of composite variables on students' conceptual change.

Table 5: ANOVA analysis of influence of composite variables on students' conceptual change

ANOVA ^a						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	5289.019	5	1057.804	129.408	.000 ^b
	Residual	1226.128	150	8.174		
	Total	6515.147	155			

a. Dependent Variable: CEC

b. Predictors: (Constant), AT, SI, EF, CC, SE

In Table 5, the ANOVA value (F-ratio=129.41) with probability value (sig.=0.00) is less than level of significance of 0.05. This indicates that all the exogenous variables combined has significant influence on students' conceptual change. Therefore, there is significant influence of composite variables on students' conceptual change,

Research Question3: What are the directions and strength of causation of exogenous variables on students' conceptual change in sound waves?

Table 6: path estimate showing the strength of causation of exogenous variables on students' conceptual change

			Estimate
SE	<---	CC	.352
SE	<---	SI	.392
AT	<---	SE	.699
EF	<---	AT	.662
CEC	<---	CC	.259
CEC	<---	SI	.310
CEC	<---	SE	-.308
CEC	<---	AT	.323

CEC	<---	EF	.327
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In Table 6 it is revealed that a positive path exists between cognitive conflict and conceptual change, with a path coefficient of 0.26. also, a positive path exist between situational interest and conceptual change with 0.31 path coefficient; self-efficacy has a negative path with conceptual change with -0.31 path coefficient, attention has a positive path with 0.32 path coefficient, and effort has also a positive path with 0.33 path coefficient. This implies that as cognitive conflict of the learners increases by 1, their conceptual change increases by 0.26. Also, as situational interest of the students increases by 1, their conceptual change increases by 0.31, and as student's self-efficacy increases by 1, their conceptual change decreases by 0.31. Also, as students' attention increases by 1, their conceptual change increases by 0.32, and as students' effort increases by 1, their conceptual change increases by 0.33. This means that the effort, and attention students put in during learning exert greater influence on students' conceptual change more, so also the interest generated by the use of discrepant events.

Also, it was revealed in Table 6, that cognitive conflict influences self-efficacy with a positive path coefficient of 0.35. This means that as students experience cognitive conflict by 1, their self- efficacy increases by 0.35. Also, it was shown that situational interest influences students' self-efficacy with a positive path coefficient of 0.39. This indicates that as students' situational interest increases by 1, their self- efficacy increases by 0.39. It was shown also that self-efficacy influences students attention with a positive path coefficient of 0.69 indicating that as students' self-efficacy increases by 1, their attention increases by 0.69. Finally, it was indicated also in the Table 3, that attention influences effort with a positive path coefficient of 0.66, equally indicating that as attention increases by 1, that student's effort to the task increases by 0.66. It could be observed that self-efficacy has the highest influence on students' attention, same applied to attention on effort.

Research Question4: what are the direct and indirect influences of exogenous variables on the students' conceptual change in sound waves?

Table 7: Path coefficients showing the direct influences of exogenous variables on the students' conceptual change

	SI	CC	SE	AT	EF
SE	.392	.352	.000	.000	.000
AT	.000	.000	.699	.000	.000
EF	.000	.000	.000	.662	.000
CEC	.310	.259	-.308	.323	.327

From Table 7 it was shown that situational interest has direct influence with self-efficacy and conceptual change with path coefficients of 0.39 and 0.31 respectively. Also, cognitive conflict has direct influence with self-efficacy and conceptual change with path coefficients of 0.35 and 0.26. In the same way, self-efficacy has direct influence with attention and conceptual change with path coefficients of 0.69 and -0.31. Similarly, attention has direct influence with effort and conceptual change with path coefficients of 0.66 and 0.32; and effort has only direct influence with conceptual change with path coefficient of 0.33.

Table 8: Path coefficients showing the indirect influences of exogenous variables on the students' conceptual change

	SI	CC	SE	AT	EF
SE	.000	.000	.000	.000	.000
AT	.274	.246	.000	.000	.000
EF	.181	.163	.463	.000	.000
CEC	.027	.024	.377	.217	.000

In Table 8 it was revealed that situational influence has indirect influence on attention (0.27), effort (0.18) and conceptual change (0.03). This implies that situational interest mediates with attention and effort to influence conceptual change, but as low as 0.03 path coefficient. Also, cognitive conflict has indirect influence on attention (0.25), effort (0.16) and conceptual change (0.02). This equally implies that cognitive conflict mediates with attention and effort to influence conceptual change but as low as 0.02 path coefficient. Also, it was shown that self-efficacy indirectly influences effort (0.46) and conceptual change (0.38). This means that the mediation between self-efficacy and effort to influence conceptual change is high. Finally, attention has indirect influence on conceptual change with 0.27 path coefficient and effort has no indirect influence on conceptual change as evident in the path diagram.

Discussion of the Findings

The findings of the study showed that the causal model for explaining students' conceptual change is the model linking cognitive conflict, situational interest, self-efficacy, attention and effort. This means that both cognitive and affective variables should be considered when thinking about conceptual change. This finding goes to support an age long practice in education of considering the three educational domains of the learner during instruction and assessment. The findings equally revealed that cognitive conflict, situational interest, self-efficacy, attention and effort together accounted for 81.2% of the variations in the students' conceptual change. This implies that some unobserved variables or error terms could influence conceptual change of the students. These unobserved variables accounted for 18.8% of students' conceptual change. One of the variables could be students' state of mind, locus of control, personality, teachers' pedagogical skills, and classroom control among others. This is because a student with unstable state of mind may not be challenged by the presence of discrepant event, or even pay attention and make reasonable efforts in a learning encounter. Also, a student who attributes failure to external forces instead of attributing it to his effort, attention, and interest may not witness conceptual change meaningfully. The supportive hypothesis equally revealed that cognitive conflict, situational interest, self-efficacy, attention and effort have significant influence on students' conceptual change.

These findings are in agreement with the findings of Ugwuanyi (2016) who found that the most meaningful model for the explanation of students' achievement is the recursive model involving path analysis of family background, teachers' qualification, students' attitude, teachers' professional development and classroom practice. The only difference was that Ugwuanyi's finding centred on achievement, while the present study centred on conceptual change. This equally agreed with the findings of Akobi (2014) who found that parental education and socioeconomic status explain students' achievement.

Findings also indicated that cognitive conflict and situational interest influence students' conceptual change. This finding showed that cognitive conflict and situational interest promote conceptual change and as such should be considered during instructional setting. Finding also showed that cognitive conflict and situational interest influence self-efficacy, attention and effort. This finding agreed with the findings of Orji (2013) who found that cognitive conflict influences attention of the learners. The agreement of the findings of the present study with Orji (2013) findings could be partly due to the fact that the two studies were carried out in same locality sharing similar characteristics. The findings also corroborated with findings of Kang et al. (2010) who found that cognitive conflict and situational interest induced by a discrepant event respectively had an indirect effect on students conceptual understanding, which were mediated by attention and effort allocated to concept learning. Findings of Kang et al. (2010) equally revealed a positive path coefficient between attention and cognitive conflict, agreeing equally with the

findings of the study. This agreement could be due to the use of the same instructional conceptual change pedagogy (discrepant event) by the two studies.

Similarly, findings showed that self-efficacy has a negative relationship with conceptual change. This suggests that high self-efficacy of a learner may not result to any meaningful conceptual change, but could result to decrease in conceptual change of the learner. This is so because self-efficacy is the perception that one can do something, not the skill in doing something. It therefore means that emphases on self-efficacy should be on its influence on other variables such as attention that could in turn have influence on conceptual change. The finding disagrees with the finding of Fencel and Sheel (2005) and that of Hosey (2008) who variously found that self-efficacy is linked with students' success. This disagreement could be attributed to other conditions that are imperative in different studies. This finding agreed with findings of Lee, Cawthon and Dawson (2015) who found that self-efficacy did not predict conceptual change. Finding showed also that self-efficacy influences attention and effort which influence conceptual change. This finding could be so because when one believes that he/she can do something, it may make the person to pay attention and put more effort in the learning task. Also, it could be because paying attention indicates serious effort to succeed or achieve a particular task.

Also, findings of the study revealed that the effort and attention students put in a learning task exert greater influence on students' conceptual change than cognitive conflict and situational interest. This suggests that effort and attention students put in a learning task foster conceptual change, more than the conflict and interest generated during the learning task. This finding disagreed with the finding of Kang et al. (2010) who found that situational interest exerts strong influence on students' conceptual change more than cognitive conflict and attention. The reason for the contradiction could be largely due to students' pattern of response and location. Findings equally revealed that attention influences effort students put during lesson. This also means that attention of the learner during teaching and learning makes the learner to put more effort for meaningful conceptual change. Findings also showed that attention and effort mediate the influence of situational interest on students' conceptual change, and that effort mediates the influence of self-efficacy on students' conceptual change. This finding once more agreed with the fact that attention and effort are important for meaningful conceptual change to occur.

Conclusion

Based on the findings and discussions of this study, it was concluded that conceptual change is explained by cognitive factor (cognitive conflict) and affective factors (situational interest, self-efficacy, attention and effort). This means that for a meaningful conceptual change to occur, that the teachers should expose students to discrepant events and take the students' cognitive conflict, situational interest, self-efficacy, attention, and effort into consideration. Also, that cognitive conflict alone does not induce conceptual change, but does it when it interacts with other affective factors like situational interest, attention, effort, and self-efficacy. Again, that self-efficacy has negative influence on students' conceptual change and as such should not be considered when teaching for conceptual change instead its influence on other variables that may in turn influence conceptual change should be put to consideration. Finally, when teaching for conceptual change, attention and effort students put into learning task should be prioritized more than cognitive conflict and situational interest.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. Teachers should ensure that students' attentions are activated during teaching by using discrepant events instructions.
2. Teachers should place emphases on students' effort during teaching and learning.

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