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Transformation of Technology Education in Africa: The Development of New Ergonomic-Based Curriculum

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ABSTRACT

The purpose of this study was to examine the transformation of technology education in Africa in terms of the development of new ergonomic-based curriculum. Case study design was used in this study where selected Nigerian universities were involved. The theoretical framework in this study was based on several theories and models namely Maslow's needs theory, Billett's situational learning theory, Fullan's curriculum change theory and Wilson's mental model. The main variables in this study were: (a) awareness of ergonomics, (b) needs of ergonomics, (c) perception for the introduction of ergonomics, and (d) the constructs for ergonomics-based technology education curriculum. There were two phases in this study – phase one was the needs analysis and phase two was the modified Delphi technique. Participants in this case study were 119 lecturers of technology education from four selected Nigerian universities. Data were collected using a set of questionnaires, open-ended questions and interview protocol. Descriptive statistics such as frequency, percentage, means and standard deviation were used to describe the empirical data. The main result of the first phase of the study revealed that the respondents concurred that a new ergonomics-based curriculum was needed. In fact, the majority of the lecturers perceived the incorporation of ergonomics into technology education of the Nigerian universities was timely. Several factors were identified as the reasons for the needs of ergonomics-based technology education by lectures such as the incorporation of ergonomics would enhance employment opportunity for the graduates, broaden technology educators' knowledge and to produce competent graduates. It has been confirmed that ergonomics-based education technology would improve design skills, creativity, thinking skills as well as workplace safety awareness. In the second phase, the results of Delphi interview with 11 experts found that, in the final found (third-round), the experts achieved a final consensus on 18 topics, 42 sub-topics and 4 objectives. The elements listed in the final round were unanimously accepted based on 90% experts' agreement, and the mean of 4.18 and above, and the IQR ≤ 1. Thus, based on the empirical data, a new curriculum of ergonomics-based technology education for Nigerian universities was proposed.

Keywords: Needs analysis, curriculum development, ergonomics-based technology education, Africa, Nigeria

INTRODUCTION

Technology education in Africa

Africa is a large continent with varied educational models. In order to create "New Africa" in the Fourth Industrial Revolution and in a concerted effort to transform educational system as envisioned by the African Union and its 2063 Agenda, the African Union Commission has developed an Africa comprehensive ten-year continental education strategy [CES] (African Union Commission, 2015). To transform Africa's technical-vocational education and training (TVET) system, it is critical to embed the relevant knowledge, skills, competencies, attitudes, innovation and creativity into the new curriculum. CES comprised six guiding principles, 7 pillars and 12 strategies to serve as a guide the transformation. The six principles are (a) knowledge societies called for by Agenda 2063 are driven by skilled human capital, (b) equitable, inclusive and holistic education with effervescent conditions for lifelong learning is crucial for sustainable development, (c) dynamic leadership, good governance and accountability in education management are needed, (d) articulated education and training systems are essential for the realization of intra-Africa mobility and standardization through regional cooperation, (e) relevant and up-to-date education, training and research are key factors for scientific and technological innovation, creativity and entrepreneurship, and (f) a healthy mind in a healthy body – physically and socio-psychologically, and well fed. Next, the pillars of CES are more focused on political will of the governments to reform the education and training sector and to build and achieve good governance and civil society. The main strategy related to TVET is strategy number eight – to strengthen and expand TVET opportunities at both secondary and tertiary levels and strengthen linkages between the world of work and education and training system.

Historically, according to McGrath (2018), TVET system in Africa can be divided into three phases. The first TVET phase began around the period between colonialism and independence in the late 1950s and 1960s. The focus of the post-colonial states was to provide educational access to children to learn in formal schooling and to enhance economic development through industrialization (McGrath, 2018). Economists and politicians understood the importance of education – especially TVET to provide skilled human resources to work in local industries and to replace the highly skilled expatriates. Hence, the investment in public TVET in order to achieve industrialization was evident (Mustapha, 2017; Rostow, 1960).

The second phase of TVET focused on the providing relevant curriculum and infrastructure for TVET and enhancing linkage between vocational schools and industrial training. In addition, TVET has implemented well-publicized interventions designed to provide appropriate skills for rural and later urban informal sector settings (Van Rensburg, 1974, King 1977, Fluitman, 1988). The third phase of TVET in Africa focused on reforms that included new governance structures giving vocational schools and training institutions more autonomy on terms of curricula, training models, industrial partners and funding (Allais, 2003; McGrath & Lugg, 2012).

Overview of the concept of technology education

Technology education has different connotations for different people. It could also be confused with educational technology. Technology education and educational technology are two concepts often intertwined or misconstrued among the public despite the fact that both are entirely different concepts (Chedi, 2018). Technology education is the study of technology, in which students learn about the processes and knowledge related to technology (ITEA, 2000). On the other hand, educational technology is concerned with the use of technology as a tool to enhance the teaching and learning process across all subject areas (Brown & Brown, 2010).

Historically, technology education has evolved from an historical lineage of ideas which includes Bacon's realism, Pestalozzi's belief in the practical application of knowledge, Rousseau's naturalism, Herbart's sense of realism, Dewey's progressive and social reconstructionist thinking, as well as, the influence of vocationalism on technology education (Zuga, 1995). The origin of the formal technology education started at the Philadelphia Centennial Exposition of 1876 when Della Vos demonstrated a new approach to teaching the mechanical art that become a catalyst for vocational education in the United States (Finch & Crunkilton, 1999). Using this approach, Della Vos set up separate shops in the areas of wood work, joinery, blacksmithing and metal turning. Within several decades, technology education curriculum has evolved due to the work force demands and the needs of the labor market. The development and focus toward technology education improved immensely as the American Industrial Arts Association (AIAA) changed its name to the International Technology Education Association (ITEA) in 1986. Now the discussion would look into the definitions of technology education.

Before delving into the definition of technology education, it is timely to discuss about the definition of technology. In general, technology can be defined as the ways products, systems or processes are done or made (Society for the History of Technology, 2016). Also, in another definition, technology is a body of knowledge devoted to crating tools, processing actions and extracting of materials (Ramey, 2013). The term “technology” also refers to the design principles, guidelines, specifications, methods and tools that are developed in a discipline and used by its practitioners to accomplish a purpose (Hendrick, 2000). Next, technology education can be defined as the study of technology, in which students learn about the theory, process and application of technology. As a field of study, it covers the human ability to use technology to meet the human needs, by manipulating materials and tools with certain techniques (ITEA, 2000). Also, Pennsylvania Department of Education (PDE) defined technology education as a body of knowledge separate from but related to the sciences, with specific content, curriculum and specific certification requirements (Pennsylvania Department of Education, 2018). Subsequently, an elaboration about technology education in Africa is discussed.

Technology education in Africa

Technology education has been integrated into African education system especially at secondary and higher education. But the subject has been integrated differently from one country to the other. Since Africa is diverse, the nature and the mode of implementation of technology education in Africa are varied. For example, South African society is very complex. According to Ankiewicz (1995), South Africa is multicultural, multi-lingual, multi-ethnic and has elements of both first world and third world characteristics. This results in a population which operates at different levels of sophistication. Failure to introduce technology education in the curriculum would mean that the disadvantaged groups will become even more disadvantaged. In this study, the focus was on Nigeria. According to Chedi (2018), in Nigeria, the formal technology education institutions include (a) post-junior secondary schools consist of technical colleges and comprehensive colleges offering technical subjects, (b) polytechnics, monotechnics, and colleges of education technical, and (c) universities offering vocational and technology education programs. These institutions that offer technology education are discussed in the following sections:

Post-junior secondary schools

Technology education in Nigeria started back in 1932 with the establishment of Yaba College of Technology, with the three trade training centers located at Kaduna, Bukuru and Kano which later become Technical Colleges (Chedi, 2018). Then in 1952, additional three technical institutions were established at Zaria, Ibadan and Enugu. Also, the establishment of Polytechnics was another land mark in technology education development in the history of Nigerian education. Both federal and state governments have established several polytechnics.

The adoption of the new policy on education in Nigeria has resulted in the establishment of technical and vocational institutions such as technical colleges, colleges of education (technical), polytechnics, monotechnics, and universities of technology for the development of skilled workers at all levels (Dung-Gwom, 2010). According to the National Policy on Education (NPE, 2004), technology education institutions include post-junior secondary, post-secondary, and university. The institutions at post-junior secondary level are technical colleges and comprehensive secondary schools. A post-secondary level were polytechnics, monotechnics and college of education (technical).

The post-junior secondary schools include technical colleges and comprehensive secondary schools that offer courses leading to the award of the National Technical Certificate (NTC) and Advanced National Technical Certificate (ANTC) by National Business and Technical Examination Board (NABTEB) (NPE, 2004). Length of the program in technical college is three-year for NTC and one-year for ANTC. West African Examination Council (WAEC) and National Examination Council (NECO) also conduct examinations for technology education subjects/courses leading to the award certificate for Senior Secondary Certificate (SSC). However, the enrolment situation of technical colleges when compared with conventional secondary schools were unfavorable since the enrolment for technical colleges was less than 10% (NVQF, 2015).

Post-secondary schools

Polytechnics offered two-tier program of studies, *viz*, the National Diploma (ND) and Higher National Diploma (HND) with one-year period of industrial experience serving as one of the pre-requisites for the entry into the HND programs (Chedi, 2015b). Monotechnics are single-subject technology institutions for specialized programs such as surveying, mining, petroleum, and agriculture. According to NVQF (2015), a recent initiative is the introduction of the Innovation Enterprise Institutions and

Vocational Enterprise Institutions (IEIs and VEIs). These are private sector driven institutions that are designed to alleviate skills shortage in the industrial sector (Chedi, 2018). They provide industry-specific competencies in oil and gas, communication, automobile, construction, and welding. Table 1 displayed the numbers, types and ownership of the various TVET institutions in Nigeria, as at the beginning of 2010.

Table 1: TVET institutions offering accredited programs and their ownership structure

INSTITUTION	OWNERSHIP			
	Federal	State	Private	TOTAL
Polytechnics	20	37	18	75
Monotechnics Colleges of Agriculture	18	13	-	31
Colleges of Health Technology	6	6	1	13
Other Specialized Institutions	23	2	2	27
Innovation Enterprise Institutions	1	1	78	80
Subtotal	68	59	99	226
Technical Colleges	19	152	3	174
VEIs	1	1	10	12
Subtotal	20	153	13	186
Grand Total	88	212	112	412

Source: NVQF (2015)

College of Education (Technical)

College of Education (Technical) is an institution that awards Nigeria Certificate in Education Technical (NCE Tech) in different fields of technology education such as building technology, electrical/electronic technology, auto mechanics technology, metal work technology, and wood work technology (Chedi, 2018). According to NPE (2004), the minimum qualification for entry into teaching profession in Nigeria is the Nigeria Certificate of Education (NCE). Therefore, the responsibilities of NCE (Technical) holders are to teach technical/technology education subjects at Junior Secondary Schools, Technical Colleges and Senior Secondary Schools. NCE (Technical) holders can further their education by enrolling into universities under the faculty of technology education.

Technology education in Nigerian universities

Despite the existence of the conventional universities in Nigeria that offered undergraduate and post-graduate programs in technology education since 1970s, there were several Federal Universities of Technology (FUT) established in the period of 1980 - 1983 across the nation such as: FUT Bauchi (ATBU Bauchi), FUT Minna, and FUT Yola (Chedi, 2018). And these universities offered technology education programs at both undergraduate and post-graduate levels. As a result of the demand in technology education, various universities established the department of technical and vocational education under the faculty of technology education in which different programs were introduced at both undergraduate and post-graduate degree levels. The term “Technology Education” in this research refers to the three (3) vocational disciplines out of the twelve (12) vocational disciplines recommended by UNESCO (2004) at the International Meeting on Innovation and Excellence in TVET Teacher Education November 8-10, 2004 in Hangzhou, China (Chedi, 2018). The three vocational disciplines are (a) production and manufacturing, (b) civil engineering and electrical and electronics, and (c) information and communication technology. In Nigerian universities, the disciplines of technology education have several areas of specialization such as woodwork technology, drafting technology and so on. The vocational disciplines in this context of study refer to technology education and areas of specialization where shown in Table 2. The table showed that Nigerian universities classification of the areas of specialization is varied from the UNESCO-UNEVOC vocational disciplines.

Table 2: Technology education areas of specializations

UNESCO-UNEVOC vocational disciplines	Nigerian universities vocational disciplines	Areas of specialization
Production and Manufacturing	Mechanical Technology Education	Automobile Technology Metalwork Technology
Civil Engineering	Construction Technology Education	Building Technology Drafting Technology Woodwork Technology
Electrical and Electronics and Information and Communication Technology	Electrical and Electronics Technology Education	Electrical and Electronics Technology

In addition, the quality issue relating graduates of technology education is quite alarming. The need to reduce or eliminate dysfunctional barriers in the curricula, is critical in order to make technology education relevant (Chedi, 2018). According to Ogbuanya and Izuoba (2015), the present technology education curriculum is not relevant to the current situation in Nigeria. Consequently, the lacking of ergonomics in the technology education program in Nigerian is assumed to be a major hindrance in producing quality technology graduates. Therefore, this study was designed to develop a new curriculum of ergonomics-based technology education in Nigerian universities.

Ergonomics

Ergonomics is a scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance (IEA Executive Council, 2000). Specifically, ergonomics as a field of study has unique focus such as on safety, educational ergonomics, office ergonomics, workstation design, control process, and human-computer interaction. Even some products have associated their names with ergonomics such as: ergonomics chair, ergonomics mouse and so on. At present, ergonomics is widely taught as a course or a program in universities and schools as well as in practice in the industries and offices in many countries (Karwowski, 2001; Žunjić et al., 2015).

In Nigeria, ergonomics subject is lacking in technology education programs in universities and higher education institutions (Ismaila, 2010). Hence, there is a need for empirical data to justify the urgency to integrate ergonomics into technology education curriculum. Adding or removing a program in educational system is a normal process as mentioned by Williams (2011). A new program can be added if there is a need. There are critical emerging issues in science and technology such as ergonomics which in one way or the other might have a vital role to play in technology education curriculum. According to Ismaila and Samuel (2014), ergonomics being the primary discipline for the scientific study of human interaction with any system has profound implications for training the current and future generations of technology educators if it is introduced into technology education curriculum. In addition, the technology education curriculum must be responsive to new development in the industry (Hardy & Barlex, 2013). Recent development has witnessed a rapid change in the industrial sector so there is a need to have a relevant and updated curriculum that meets the needs of the labor market.

Technology education field is faced with evolutionary transformation as a result of the rapid technological development and the changes of the program course contents due to the changing in demands in the era of the fourth industrial revolution (Chedi, 2018). Hence, there is a need for a relevant and updated curriculum that meets the need of the stakeholders. In the 1980s, technology education was introduced at Nigerian Junior Secondary School (JSS). Osami (2013) stated that Introductory Technology subject was introduced as a compulsory subject at the Junior Secondary Schools (JSS) in Nigeria. Also, since 1970s to date, the prominent awarding certificates in technology education in Nigeria are Bachelor of Technical/Technology Education (B. Tech) and National Certificate of Education Technical (NCE Tech).

However, despite the introduction of technology education in Nigeria for the past 50 years there were deficiencies in the contents of the program and substantial evidence in literature review showed that there was skills mismatch especially among technology education university graduates in Nigeria and it remained an alarming issue. Hence, there was a need to review the present curriculum. Moreover, there were several scholars who have called for the need to overhaul technology education program in Nigeria (Uwaifo, 2010; Pitan & Adedeji, 2012; Ebenehi & Baki, 2015). Furthermore, the changing demands of technology as a result of new technologies and the short supply of skilled workers have affected the types of graduates that universities have to produce (Bresnahan et al., 1999; Acemoglu & Autor, 2012; Wang, 2012). These factors constitute a strong rationale for this research to develop a new curriculum of ergonomics-based technology education in Nigeria.

PROBLEM STATEMENT

The technology education programs in Nigerian universities were characterized by various deficiencies, inadequacies and weaknesses (Chedi, 2015a; 2017; 2018). Current technology education curriculum is deficient in terms of the lacking of ergonomics in the technology education programs in the Nigerian universities. There is a disadvantage for technology educators if they lack ergonomics knowledge (Ismaila & Samuel, 2014). The inadequacy refers to inability of the technology education programs in Nigeria to integrate ergonomics in their programs. The slow pace of the technology education program in Nigerian universities to integrate ergonomics in their programs despite the fact that ergonomics is a compulsory subject in many universities in the world (Chedi, 2018). A number of universities in both developed and developing countries are offering ergonomics as a field of study such as in the USA, UK, Malaysia and China (Karwowski, 2005; Bridger, 2012; Dul et al., 2012; Zare et al., 2015). Nigeria is one of the countries that has not embarked on offering ergonomics as a field of study.

Another weakness is the incompetence of technology education graduates. They do not meet the needs of the labor market/industries (Barsky & Glazek, 2014). This weakness pinpoints the discrepancies in terms of course contents of technology education curriculum in Nigeria (Chedi, 2018). The lacking of ergonomics in the curriculum of technology education program of the Nigerian universities would affect the quality of Nigerian technology graduates (Chedi, 2018). It was also observed that the low pace of industrialization and technological growth in Nigeria could be attributed to the widening gap between science and technology as a result of the low quality of technology education graduates to adequately utilize the scientific ideas to produce new products and services. This suggests the need to overhaul technical education curricula in Nigeria (Ojimba, 2012). Naeini and Mosaddad (2013) observed that the inability of the technology education lecturers to teach ergonomics to their students is a major barrier among technology educators. Therefore, there is need for technology education graduates to learn ergonomics because it would be useful in their future employment.

In addition, there are deficiencies in the technology education program for Master degree in Nigeria despite periodic review of the programs. It is clear that the Master degree in technology education does not meet the needs of the current labor market and industries (Olajide, 2015). This could be due to lack of ergonomics knowledge among technology educators. Therefore, this study was aimed to fill the gap that exists as a result of the lacking of ergonomics in the technology education program. In response to this problem, this study was designed to develop a new curriculum of ergonomics-based technology education in Nigerian universities. Next, a conceptual framework is discussed to explain the related theories and models that are used as the bases for the present study.

CONCEPTUAL FRAMEWORK

The conceptual framework for this study was based on several relevant theories and models namely Maslow's Needs Theory (Maslow, 1970), Situational Awareness Theory (Endsley, 1995; Smith & Hancock, 1995; Winsen et al., 2015), Curriculum Change Theory (Fullan, 1991 & 2000; McNeil, 2009), Situated Learning Theory (Billett, 1994; 1996) and Mental Model (Wilson, 2000; Gentner, 2001; Trafton, 2004; Schaffernicht & Groesser, 2011). Specifically, Maslow theory explains that while people aim to meet basic needs, they seek to meet successively higher needs in the form of a pyramid. Maslow theory is relevant for the needs analysis in this study. The next theory is relevant to this study is situational awareness theory. Situational awareness theory is the invariant in the agent-environment system that generates the momentary knowledge and behaviors required to attain the goals specified by an arbiter of performance in the environment such as a workplace (Smith & Hancock, 1995). Situation awareness theory is used to guide in developing the ergonomics domains for the curriculum contents. Also, this theory is selected because it is related to the ergonomics domains such as movement, task, handling and design.

This study also focuses on curriculum development hence curriculum change theory (Fullan, 1991) is relevant. Curriculum change theory is defined as the substitution occurs when a new element substitutes another which is already present and alteration exists when new contents, items, materials, or procedures are added up into existing materials and programs (Fullan, 1991; McNeil, 2009). This definition seems to imply that if a new course is added such as ergonomics-based technology education into the existing program such as technology education; an alteration to the curriculum happens. In order to develop a new ergonomics curriculum, situated learning theory is selected because it lays emphasis on the technology education learning environment. Billett (1994) defines situated learning as workplace leaning in which job training and experience in real environment is important for the learners (Billett 1994;1996). In addition, mental model theory used in this study is defined as mental representations of humans, systems, artifacts, and situations formed by experience, observation, and training (Endsley, 1995; Wilson, 2000; Schaffernicht & Groesser, 2011). This mental model is relevant for the development of the ergonomics domains such as biomechanics, anthropometric, posture, work organization and human-machine interaction.

Based on the underlying theories and models presented in Figure 1, the study is concerned with four variables namely: awareness of ergonomics (Endsley, 1995; Smith & Hancock, 1995; Winsen et al., 2015), needs of ergonomics (Maslow, 1970; Anderson, 2014; McLeod, 2016), perception for introduction of ergonomics (Wilson, 2000; Gentner, 2001; Trafton, 2004; Schaffernicht & Groesser, 2011), and curriculum constructs (Fullan, 1991; McNeil, 2009). The conceptual framework is also guided by two phases. Phase one is the needs analysis and phase two is the modified Delphi technique. In phase 1, needs analysis variables were awareness of ergonomics, needs of ergonomics, and perception for introduction of ergonomics. The outcomes of the need analysis would lead to the application of modified Delphi technique which was the next phase of the research study. Next, phase 2 of the modified Delphi technique was a process to determine and to develop the domains needed for a new ergonomics-based curriculum based on the experts' agreement (Helmer, 1967; Linstone & Turoff 1975; Okoli & Pawlowski, 2005). Also, the modified Delphi technique was run for the three (3) rounds to obtain the experts consensus on the relevant ergonomics domains as shown in Figure 1. Furthermore, the draft of the new curriculum of ergonomics-based technology education would be documented and developed based on the Delphi experts' consensus. Finally, this study proposed new curriculum with the guide of the relevant theories and models. Basically, the final outcome of this study was the new curriculum of ergonomics-based technology education. In sum, the main contribution of this study was that it has put forward experts' consensus on the new curriculum of ergonomics-based technology education for Nigerian universities.

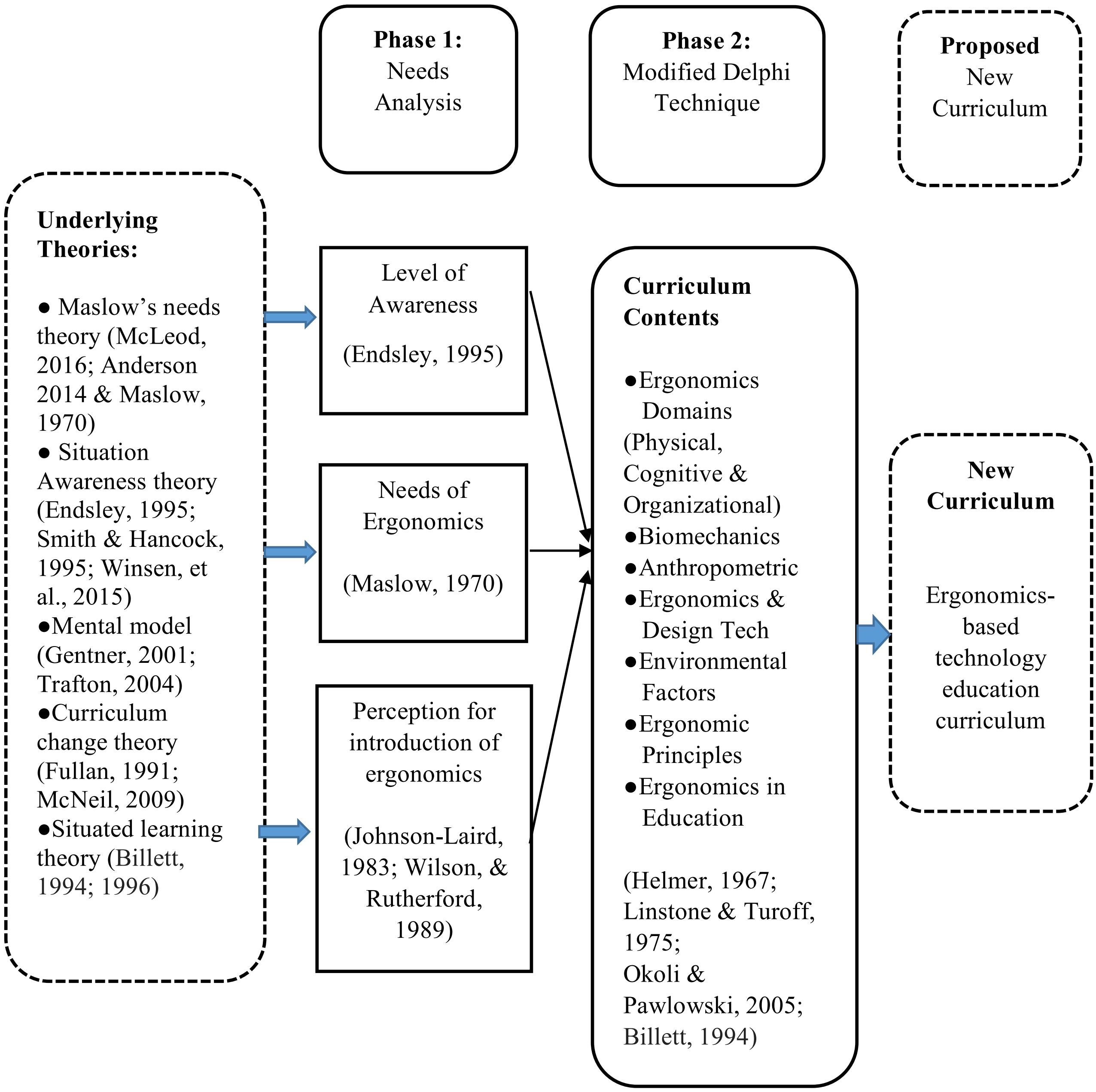

Figure 1: Conceptual framework of the study

PURPOSE AND OBJECTIVES OF THE STUDY

The purpose of this study was to develop a new curriculum of ergonomics-based technology for Nigerian universities using needs analysis to identify the needs of ergonomics to be integrated in a technology education program. Furthermore, this study would determine constructs or domains needed for the development of new curriculum of ergonomics-based technology education using experts' consensus through the application of modified Delphi technique. Specifically, the research questions of the study were as follows:

1. What is the ergonomics awareness among technology educators of the Nigerian universities?
2. What are the needs for the incorporation of ergonomics-based technology education into technology education programs of the Nigerian universities?
3. How do technology education lecturers perceive the introduction of ergonomics-based technology education in Nigerian universities?
4. What are the constructs needed for the development of new curriculum of ergonomics-based technology education in Nigerian universities.

METHODOLOGY

Participants

According to Piaw (2012), population is the entire group that will be studied. The population for this study comprised all the lecturers of technology education in four selected universities in Nigeria namely ATBU, MUT, FUTM and BUK. These universities were selected because they were the only federal universities from the northern Nigeria offering technology education. The population (N = 200) for the need analysis phase comprised all the lecturers of technology education in the four selected universities in Nigeria. Based on Krejcie and Morgan (1970) sample size table, a sample of 132 respondents was selected. The sampling for this study was a stratified sampling to select the technology education lecturers. In phase two, a Delphi technique was used to obtain experts' consensus on the domains of the new curriculum of ergonomics-based technology education. In this study, Delphi panel comprised eleven experts were selected based on certain criteria. A Delphi technique is a critical tool to obtain experts' agreement (Chedi, 2017).

Instrumentation and data collection

Multiple data collection tools were adapted in this study by using both quantitative and qualitative data collection instruments. The use of more than one instruments are advisable because they could enhance the validation process that is known as triangulation. Triangulation adds more credibility in the methodology and the use of multiple instruments in a research nowadays is preferable (Piaw, 2012). Therefore, the instruments included questionnaires, open-ended items and interview protocol. The data were gathered through questionnaire which consisted of three sections namely: (a) demography information, (b) the needs of ergonomics-based technology education, and (c) open-ended items. Roberts et al. (2014) asserted that open-ended responses could reflect a respondent's own thinking. Another instrument used in this research project was interview protocol. A semi-structured interview was developed and it was validated by experts from three different universities. Participants were selected based on the purposive sampling and interviewees were lecturers of technology education from the selected universities as earlier mentioned.

Data analysis

In this study, descriptive statistics such as frequency, percentage, means and standard deviation were used to describe the data where appropriate. Saunders et al. (2009) argued that data gathered have to be classified into groups before statistical analysis would be carried out. Interview protocol was one of the qualitative data collection instruments and qualitative data analysis would be used to analyze the data collected. McMillan and Schumacher (2014) defined the qualitative analysis as relatively systematic process of coding, categorizing, and interpreting data to provide explanations of single phenomenon of interest. In addition, Miles, Huberman, and Saldana (2014) view thematic analysis constitutes meaningful and parsimonious unit of analysis.

RESULTS

The population (N = 200) for the need analysis phase comprised all the lecturers of technology education in the four selected universities in Nigeria. A total of 132 questionnaires were distributed to the sample based on Krejcie and Morgan (1970) sample size table. The number of questionnaires returned were 119 (90.2%) out of 132 distributed and only 13 (9.8%) questionnaires were missing or not returned. The return rate is considered adequate for statistical analysis. Table 3 posited the demographic information of the respondents. In term of the years of teaching, about one-fourth of the respondents (24.4%) have between 10 to 15 years of teaching experience. Followed by a group of 3-5 years (20.2%) and those with 16-20 years of teaching experience (18.5%). Those with the lowest years of teaching experience were 1-2 years is only 4 individuals (3.4%). The nationality of all the participants for this study (100%) were Nigerian. With regards to gender, 110 lecturers (92.4%) out of 119 lecturers were males while only 9 (7.6%) were females. This shows that male lectures dominated the field of technology education profession in Nigerian universities. The age distribution of lecturers indicated that half of the lecturers (50.4%) were between 41 and 50 years old. The age group of 31-40 years of lecturers was 28.6% and only 14.3% of lecturers were in the group of 51-60 years.

In term of academic qualifications, out of 119 lecturers who took part in this study, 64 have Master's degree (53.8%), while 47 (39.5%) of the lecturers have doctoral degree, and only 8 lecturers (6.9%) possessed bachelor degree. The main area of specialization of the lecturers is electrical and electronics (21.0%) followed by building technology (18.5%), automobile technology (14.3%), metal technology (14.3%), agricultural education (13.4%), wood work technology (5.9%), and computer education (3.4%). However, the data show that the majority of the respondents (64.7%) are not aware of the ergonomics-based technology education.

Table 3: Demographic Information

	Variables	Categories	Frequency (f)	Percentage (%)
1.	Years of teaching in the field of Technology Education	1-2	4	3.4
		3-5	24	20.2
		6-9	21	17.6
		10-15	29	24.4
		16-20	22	18.5
		Over 20	19	16.0
2.	Gender	Male	110	92.4
		Female	9	7.6
3.	Age group	21-30	5	4.2
		31-40	34	28.6
		41-50	60	50.4
		51-60	17	14.3
		60+	3	2.5
4.	Highest Qualification	Doctoral Degree	47	39.5
		Master's Degree	64	53.8
		Bachelor Degree	8	6.7
5.	Area of Specialization	Automobile	17	14.3
		Technology	22	18.5
		Building Technology	25	21.0
		E/E Technology	17	14.3
		Metalwork	7	3.4
		Technology	4	13.4
		Woodwork	16	1.7
		Technology	11	9.3
		Computer Education		
		Agricultural Education		
		Others, please specify		
6.	Ergonomics awareness	Yes	42	35.3
		No	77	64.7

Needs analysis were used to answered questions one, two and three. The questions were answered through questionnaires, open-ended and interviews. The questionnaires comprised 12 items and were rated on a 5 -points Likert scale. The open-ended questions finding was used to provide an in-depth view of the respondents. Also, an interview was used to serve as complimentary or additional information for ergonomics-based technology education needs analysis questionnaires and open-ended questions. In the section B of the questionnaires, descriptive statistics such as means and standard deviations were used to describe the data where appropriate. Items 1 to 12 were analyzed and all items were rated on a 5-point Likert scale, with 1 = strongly disagree being as the lowest rating and 5 = strongly agree is the highest for the participants agreement on the items.

Research question one
What is the ergonomics awareness among technology educators of the Nigerian universities?

Items 1 through 4 in Table 4 from the questionnaire (NAQ1-4) and the Need Analysis Interview Questions 2 (NAIQ 2) were addressed in research question 1. Table 4 showed the overall mean and standard deviation (M= 4.40, SD = .40) which indicated the respondents strongly agreed that they were aware about the importance of ergonomics-based technology education in Nigerian universities. For items 1, the lecturers strongly agreed (M = 4.34, SD = .63) that ergonomics awareness is needed among technology-based educators. Moreover, in items 2, the respondents were very eager (M= 4.39, SD = .57) to know more about ergonomics field. The importance of ergonomics-based technology to enhance technology educators' knowledge was strongly agreed (M = 4.38, SD = .60) by most of the lecturers [items 3]. Item 4 shows the lecturers strongly believe (M = 4.49, SD = .55) that an ergonomics-based technology curriculum will enhance technology education programs. Generally, standard deviations in all items are relatively small which indicated the homogeneity in the agreement.

Table 4: Ergonomics awareness among technology educators

No.	Items	Mean	Standard Deviation	Interpretation (for the mean)
1.	Ergonomic awareness is needed among technology-based educators	4.34	.63	SA
2.	I will like to know more about ergonomics field	4.39	.57	SA
3.	Incorporation of ergonomics will increase technology educators' knowledge	4.38	.60	SA
4.	I believe the ergonomics-based technology curriculum will enhance technology education programs	4.49	.55	SA
	Total (Items 1 to 4) average	4.40	.39	

Besides quantitative data, this section also revealed the qualitative findings based on the interview. In order to examine the lecturer's perception with regards to ergonomics awareness, an interview question was posited in interview question (IQ) 1: What are your perception regarding the ergonomics awareness among technology educators in Nigeria?

Based on the interview data, three lecturers (L1, L5 and L7) were unanimously agreed that there was little or lack of ergonomics awareness among technology educators in Nigeria. To be specific, participant L1 concurred that ergonomics-based technology education is quite foreign to technology educators in Nigerian universities. Similarly, respondents L5 and L7 believed that most technology educators in Nigeria are not aware of ergonomics-based technology education. Thus, the lack of awareness among majority of technology educators is quite alarming. Some of these views were presented as follows:

> To be frank, ergonomics-based technology education is not an area that is known to technology educators. Right now, I don't think if technology educators were aware of ergonomics-based technology education (L1).
>
> The awareness status of ergonomics-based technology education, I think, most of technology educators are either totally unaware of this area (ergonomics) or less aware on this aspect (L5).
>
> There is little awareness, if any, about ergonomics-based technology education among technology educators (L7).

Research question two
What are the needs for the incorporation of ergonomics-base technology education into technology education programs of the Nigerian universities?

The research question two addressed the items 5 through 8 in Table 5 from the questionnaire (NAQ5-8), open-ended questions 1 through 3 (OQ 1-3) and the need analysis interview questions 2 through 5 (NAIQ3-5). The overall mean illustrates lecturers strongly agreed (M = 4.24, D = .45) on the needs to incorporate ergonomics into technology education programs in Nigerian universities. For item 5, respondents believed (M = 4.24, SD = .68) that ergonomics-based technology education is needed in order to produce competent technology education graduates. Also, lecturers concurred (M = 4.32, D = .62) that incorporation of ergonomics will improve their employment opportunity (item 6). For item 7, participants are convinced (M = 4.34, SD = .63) that the incorporation of ergonomics will broaden their technology educators' knowledge. In term of the quality of the technology education after incorporation of ergonomics-based technology education, most lecturers agreed (M = 4.05, SD = .6) that their graduates will be more marketable (item 8). Standard deviations were all within the range of below 1 (SD < 1) which shows the agreement among the respondents.

Table 5: Needs for the incorporation of ergonomics-base technology education

No.	Items	Mean	Standard Deviation	Interpretation (for the mean)
5.	The introduction of ergonomics-based technology education is needed to produce competent technology education graduates	4.24	.68	SA
6.	Incorporation of ergonomics will help technology educators' employment opportunity	4.32	.62	SA
7.	Incorporation of ergonomics will broaden technology educators' knowledge	4.34	.63	SA
8.	The introduction of ergonomics-based technology education is needed to produce marketable technology education graduates	4.05	.69	A
	Total (Items 5 to 8) average	4.24	.45	

The open-ended items 1 through 3 (OQ 1-3) of section C were presented to the respondents in order for them to provide qualitative input regarding the basis for the needs of ergonomics and to compliment questionnaire findings. The first open-ended item asked the participants to list three main reasons why ergonomics-based technology are needed in Nigerian universities. The three main reasons for the needs of ergonomics provided by lecturers were illustrated in Table 6. Based on thematic analysis, the lecturers' responses were categorized into themes such as: (i) improvement of productivity, efficiency and workstation organization; (ii) improvement of health and safety; and (iii) upgrading of quality graduates and marketability opportunity. Besides these top three reasons, there are other reasons such as the enhancement of ergonomics awareness and improvement of the quality of technology education curriculum. The themes were ranked by frequency which the most often cited is labelled as rank number one which is ergonomics can raise the productivity, efficiency and workstation organization. Followed by the improvement of health and safety as the second most important justification for ergonomics curriculum in Nigeria universities. The third dominant theme perceived by respondents as a basis for the integration of ergonomics is the improvement of quality graduates and marketability opportunity. Other themes emerged as reasons for ergonomics-based technology include enhancement of ergonomics awareness and the improvement of the quality of technology education curriculum.

The second open-ended item was posited to identify ways in which the introduction of ergonomics-based technology would enhance the technology education program in Nigeria. Table 6 showed the emerging themes as perceived by the participants. The theme was ranked as follows: (i) enhancement of the competence of the graduates; (ii) improvement of innovation and creativeness in design technology; (iii) enhancement of human-machine interaction, good work-habits and occupational health; and (iv) improvement of curriculum contents. The lecturers believe that ergonomics would enhance of the competence of the technology education graduates. In the same token, the new curriculum would improve of innovation and creativeness of the design students. Also, the participants believed that the enhancement of human-machine interaction, good work-habits and occupational health as the third most important factor in which ergonomics could improve technology education. Finally, ergonomics could improve the contents of the existing technology curriculum.

Table 6 illustrated the lecturers' feedback for item 3 in section C of the open-ended items. Item 3 asked respondents to discuss the expected barriers in integrating ergonomics-based technology into Nigerian universities. The most significant barrier that could impede incorporation of ergonomics curriculum were: (i) insufficient funding and financial constraints; (ii) lack of ergonomics awareness; (iii) inadequate infrastructure, equipment and materials; (iv) lack of experts or personals; (v) resistance to change and policy barrier; and (vi) difficulties in curriculum review and adaptation. The participants' responses were sorted according to the following themes: Lecturers cited inadequacy of funding and financial constraints as the first most important barrier to integrate ergonomics-based technology. The respondents also viewed lack of ergonomics awareness as the second most important barrier for incorporation of ergonomics. The third most frequent cited barrier by participants was inadequacy of infrastructure, equipment and materials. The lecturers viewed lack of experts or personals as another obstacle for the integration of curriculum of ergonomics and was ranked fourth. In addition, the resistance to change and policy barrier ranked fifth as a stumbling block for the ergonomics integration. While the last barrier was the difficulties in curriculum adaptation as the least hindrance for the incorporation of ergonomics into Nigerian universities.

Table 6: Open-ended questions

	items	Factors (n = 119)	f
1.	List three main reasons why ergonomics-based technology are needed in Nigerian universities.	Increase productivity, efficiency and workstation organization Improvement of health and safety Improvement of quality graduates and marketability opportunity Enhancement of ergonomics awareness	(91) (59) (58) (46)
2.	In what ways, the introduction of ergonomics-based technology would enhance the technology education program in Nigeria.	Enhancement of the competence of the graduates	(58)
		Improvement of innovation and creativeness in design technology	(34)
		Enhancement of human-machine interaction, good work-habits and occupational health	(29)
		Improvement curriculum contents	(25)
3.	Discuss the expected barriers of the plan to integrate ergonomics-based technology in Nigerian universities.	Inadequacy of funding and financial constraints	(44)
		Lack of ergonomics awareness	(38)
		Inadequacy of infrastructure, equipment & materials	(31)
		Lack of experts or personals	(27)

Apart from quantitative findings, qualitative data were also derived from the interview. In order to gather qualitative data to answer research question 2 regarding the needs to incorporate ergonomics-based technology education into technology education programs of the Nigerian universities, interview questions were asked to several participants.

An interview question 2 (IQ 2) was posted as: In your opinion, what are the reasons why ergonomics-based technology education are needed in Nigerian universities? Based on the interview data, four lecturers (L2, L5, L7, and L8) were in agreement that there is justification for the needs of ergonomics in Nigerian universities. To be specific, L2 argued that ergonomics intervention will improve design, safety and comfort. While L5 believed that ergonomics is lacking but the integration of ergonomics will improve innovation and skills acquisition of technology education students. Also, L7 observed that there is needs of ergonomics due to deficiency in the curriculum of technology education. Consequently, L8 complained that ergonomics is dormant in technology education program in Nigeria. Respondents' perspective was reported in details as follows:

> In reality, ergonomics intervention will improve design product, ensure safety and comfort. And technology educators are desperately in needs of this kind of skills (L2).
>
> In my opinion, we are lacking ergonomics and I believed ergonomics would facilitate innovation and enable students to acquire additional skills (L5).
>
> Ergonomics-based technology education is needed because is not there in the technology education curriculum of the Nigerian universities (L7).
>
> Reason is that ergonomics is silent in our system of education, it is dormant so far (L8).

Next, the researcher asked the lecturers regarding the benefits of ergonomics-based technology [IQ 3]: How do you perceive the benefits of ergonomics-based technology education into technology education curriculum of Nigerian universities? The respondents (L1, L5 and L9) opined that the benefits of ergonomics-based technology education were numerous. For example, one lecturer (L1) believed that ergonomics-based technology education would benefit technology education curriculum in the designing skills and productivity. Correspondingly, respondent L5 acknowledged that technology education curriculum of Nigerian universities would benefited from creativity and safety awareness that an ergonomic curriculum would offer. Furthermore, participant L9 argued that the advantage of ergonomics is that it would enable conducive environment and improve production. The participants' views were presented as follows:

> Yes, it is highly beneficial because one of the benefits of ergonomics is in the design aspect as well as for the curriculum [improvement]. It will help to identify exactly what are the areas to be considered while producing a product (L1).
>
> Graduates would benefit from enhanced creativity that the new curriculum would offer (L5).
>
> The benefits of ergonomics are many and diversified such it focuses on designing conducive environment, emphasizes safety procedures, and facilitates production (L9).

With regards to the barriers for incorporating ergonomics-based technology education an interview question was posted in IQ 4: In your opinion, what are the barriers in incorporating ergonomics-based technology education programs into the Nigerian universities? Varied reasons were given by several informants. In particular, L1 argued that technical know-how and curriculum were the stumble blocks for incorporating ergonomics-based technology education. Furthermore, another participant (L3) viewed leaders' misconception on ergonomics-based technology education as another impediment. Another informant (L6) stated that the barriers included lack of awareness and inadequate funding. Therefore, in general the main barriers were lack of awareness, inadequate funding, lack of technical know-how and insufficient facilities. These views were captured as follows:

> ... the barrier is the technical know-how, because (most) lecturers are not aware about what ergonomics-based technology education is... curriculum review is not an easy task, and also another barrier is the resistance from university's management due to their lack of understanding of ergonomics (L1).
>
> Most of our leaders have had their background in social sciences, and as such, every effort to bring ergonomics into the curriculum is seen as unnecessary (L3).
>
> Barriers included the low level of ergonomics awareness and lack of funding to equipped ergonomics lab, in particular (L6).

Research question three
How do technology education lecturers perceive the introduction of ergonomics-based technology education in Nigerian universities?

Qualitative and quantitative data were collected to address research question 3 which included items 9 through 12 (NAQ 9-12), open-ended questions 4 and 5 (OQ 4-5) and the need analysis interview questions 5 through 7 (NAIQ 5-7). Table 7 displayed the transcription of the lecturers' perceptions on the introduction of ergonomics-based technology education. In general, the results demonstrated that the respondents supported (M = 4.19, SD = .47) the introduction of ergonomics-based technology education in Nigerian universities. Regarding the participants' opinion on the introduction of ergonomics (item 9), they indicated strong agreement (M = 4.47, SD = .64) toward the integration of ergonomic-based technology curriculum. For item 10, on the incorporation of ergonomics-based technology, the lecturers concurred (M = 4.18, SD = .64) that it would make technology graduates more competitive. Also, the respondents acknowledged (M = 4.03, SD = .77) that they have interest to teach ergonomics in technology education program (item11). In addition, the lectures also agreed (M = 4.07, SD = .67) on the importance of making ergonomics as one of the areas of research interest. Generally, lecturers showed their positive perception with regard to the introduction of ergonomics-based technology education in Nigerian universities.

Table 7: Perception on the introduction of ergonomics-based technology education

No.	Items	Mean	Standard Deviation	Interpretation (for the M)
9.	In my opinion, it is now time to introduce ergonomics/human factor in technology education	4.47	.64	SA
10.	The incorporation ergonomics-based technology education is needed in Nigerian universities so they could become competitive	4.18	.64	A
11.	I am interested to teach ergonomics in technology education program	4.03	.77	A
12.	I would like to include ergonomics-based technology education as one the of areas of research interest	4.07	.67	A
	Total (Items 9 to 12) average	4.18		

The open-ended items 4 and 5 (OQ 4-5) of section C were put forward to participants in order for them to provide qualitative responses concerning factors that would speed up the development of the new ergonomics curriculum in the Nigerian universities. In the fourth open-ended item, respondents were asked to provide suggestions to expedite the development of a new curriculum of ergonomics-based technology in the Nigerian universities.

In responding to open-ended item 4, six themes emerged as stipulated in Table 8. Suggestions include: (i) promotion of the new curriculum; (ii) provision of awareness programs and workshops; (iii) provision of adequate funds; (iv) enhanced involvement of experts and stakeholders; (iv) publication of the research on new curriculum of ergonomics-based technology, and (vi) staff training. The coded themes were ranked by frequency. The first factor with the highest frequency perceived by participants that facilitates development of ergonomics was a promotion of the new curriculum. An aggressive promotion of a new curriculum is necessary to enhance the public awareness. The second factor supported the first theme with the emphasis on provision of awareness ergonomics program and workshop. The awareness program could accelerate the development of ergonomics curriculum. Likewise, provision of adequate funding is suggested by lecturers was the third most frequent theme that will promote ergonomics-based curriculum. In addition, the fourth suggestion was the active involvement of experts and stakeholders as opined by lecturers that would speed up the introduction of a new curriculum. Other suggestions that would expedite the development of a new curriculum of ergonomics are the publication of the research relating to ergonomics and the staff training to prepare for ergonomics-based technology education.

Table 8: Open-ended questions

No.	Items	Factors (n = 119)	(f)
4.	Provide suggestions to expedite the development of a new curriculum of ergonomics-based technology in Nigerian universities.	Promotion of the new curriculum	(35)
		Provision of awareness programs and workshops	(32)
		Provision of adequate funds	(31)
		Involvement of experts and stakeholders	(27)
5.	List any issues related to the needs to include ergonomics in technology-based education (if any):	Lack of ergonomics as a core course or elective and as an area of research	(32)
		Lack of awareness of ergonomics among university administrators and lecturers	(27)
		Staff overwork and shortage of regular training	(19)
		Lack of readiness in ergonomics-based technology education	(11)

To triangulate the quantitative data, an interview was conducted to provide richer data on the issue of the integrating ergonomics into technology-based education in Nigerian higher education institutions. Three interview questions 5 through 7 (NAIQ 5-7) were posited to the participants regarding the introduction of ergonomics-based technology education in Nigerian universities. An interview question 5 (IQ5) was posed to lecturers (L1, L3 and L6): How would you rate the present curriculum of master's degree program courses in technology education generally in term of their strengths and weaknesses? Interview data showed that three lecturers (L1, L3 and L6) acknowledged that the present technology education curriculum used in Nigerian universities were satisfactory in term of its strengths. However, in terms of the weaknesses of technology education curriculum, most respondents agreed that there was lacked of ergonomics-based technology education in Nigerian universities. Even though participant L1 perceived that present curriculum of technology education met the desirable skills needed, he [L1] lamented that lack of ergonomics is the main weakness. While L3 rated master's degree curriculum as an average but he testified that ergonomics is not in practice. Furthermore, L6 relatively satisfied with the curriculum but he is concerned with the facilities required for the ergonomics-based curriculum. Thus, they expressed their opinions as follows:

> In my view, the present curriculum has exposed students on how to conduct research and gain some desirable skills needed by the society while one of the weaknesses is the lack of ergonomics which will take care the aspect of human factors in technology education (L1).

> I will rate technology education curriculum of master's degree as an average in Nigeria, considering the input and focus of the program but ergonomics is not currently in our technology education curriculum (L 3).

> Generally, the present curriculum is relatively okay, however the aspect of ergonomics is lacking and it is one of the major weaknesses (L6).

Next, the researcher posed the interview question 6 (IQ 6): How do you perceive the roles of ergonomics-based technology education program in enhancing marketability of the graduates? The lecturers (L4, L6 and L8) generally agreed that ergonomics-based technology education would enhance marketability of the graduates. To be specific, L4 concurred that ergonomics-based technology education definitely would enhance marketability of the graduates. In the same token, L6 believed that ergonomics-based technology education would assist graduates to think out of the box, henceforth become innovative. Moreover, L8 believed that ergonomically graduates have more opportunities in getting job. The lecturers' views were presented as follows:

> Actually, the employers are looking for capable and best [graduates], definitely ergonomics would increase the marketability of the graduates (L4).

> The new ergonomics course will train the students to think out of the box, hence, they would acquire innovative skills (L6).

> Graduates [of the new curriculum] are expected to possess ergonomically conscious, safety conscious and ergonomics awareness. They would have more advantage in getting job than the graduates from the old curriculum (L8).

Finally, an interview question 7 (IQ7) was posited: Do you have any other suggestions or comments that you would like to add regarding the needs of ergonomics-based technology education? Based on the interview data, lecturers (L1, L4, L7 and L8) recommended that involvement of all the stakeholders in the ergonomics awareness as well as the publication of ergonomics related research were needed for the development of ergonomics curriculum. Specifically, participant L1 suggested that the university leaders should be aggressive in order to introduce ergonomics-based curriculum. Moreover, lecturer L4 argued the current curriculum should be enriched by adding the ergonomics to improve the present curriculum of technology education. Furthermore, informant L7 suggested that Nigerian ergonomics researchers should published more articles regarding the importance of ergonomics-based technology education in reputable journals. Similarly, L8 recommended that in order to create awareness among the academics and administrators more related research should be conducted. The participants' suggestions were presented:

> Those who want to bring this ergonomics-based technology education should persuade the stakeholders, industrial players, community, lecturers and parents in order to create awareness [about the importance of ergonomics] and … it is good to learn from other countries how to integrate ergonomics-based technology education (L1).

> There is need to enrich the curriculum and the curriculum designer to organize committee at university or faculty or departmental level to articulate aspects of ergonomics so as the teachers would appreciate the benefits of ergonomics (L4).

> ... the researchers' [articles] on ergonomics should be published in reputable journals for the consumption of the public (L7).

> More research should be conducted on ergonomics and results should be published in journals so that it will create more awareness among academic's staff and policy makers (L8).

Research question four
What are the constructs needed for the development of new curriculum of ergonomics-based technology education in Nigerian universities as proposed by experts?

The research data were collected using semi-structured questionnaire, open-ended items and interview protocol to answer research question four. Research question four focuses on the verification of the relevant constructs for the development of new curriculum of ergonomics-based technology education in Nigerian universities.

In the first round, the semi-structured questionnaire was used to obtain the consensus among the eleven experts regarding the constructs. Based on the relevant review of literature, there were 19 topics and 38 sub-topics related to ergonomics that could be integrated in technology education curriculum. Table 9 indicated the frequency and percentage of experts' responses for Round 1. The criteria for the cut-off point for a construct that would be carried forward from Round 1 to Round 2 were more than 70% of experts' agreement on the construct. This is in line with the previous literature reviewed (Okoli & Pawlowski, 2005; Rana et al., 2017). The constructs presented in Table 9 displayed the experts' full agreement (100%) on the 18 topics and 29 sub-topics. However, there were sub-topics in which there are less than 100% agreement.

For sub-topic number 3.1 "An Introduction to Anatomy", nine experts agreed (81.8%) and only two experts disagreed (18.2%) with the proposed sub-topic. Similarly, for sub-topic 3.2 "An Introduction to Physiology" was disagreed by one expert [E9] while the rest agreed with the sub-topic hence it was accepted. Regarding sub-topic 5.1 "Body Size and Human Diversity" the majority (90.9%) of the experts accepted it as a sub-topic for Anthropometric with exception of E9 disagreed. For the topic number 8.0 Information and Operation, the sub-topic 8.2 "Hearing" and sub-topic 8.3 "Control for information" were approved by the experts but one expert rejected both sub-topics. Furthermore, the sub-topic 9.2 "Vibration" and sub-topic 9.3 "Illumination" were considered critical factors in ergonomics curriculum by most of the experts (90.9%) but one expert disagreed. Additionally, sub-topic 13.1 "Introduction to task" and sub-topic 13.2 "Time and Motion" were contested among the experts regarding their suitability to be put under "Task". However, majority of the experts contended that these sub-topics are relevant except one expert rejected the notion.

Finally, the last topic (number 19.0) was quite controversial because even though it was accepted by the majority of the Delphi panels, one expert (E4) argued that it was not appropriate as a topic. Considering the expert's [E4] reasonable argument that the topic number 19.0 is more appropriate as a special project (or term paper), thus it was dropped and not continued in the second round.

Table 9: Experts' responses on topics and sub-topics in Round 1

No.	Topics and sub-topics	Frequency (Percentage)		Decision
		Yes (%)	No (%)	
1.0	Introduction to Ergonomics	11(100)	0	Accepted
	1.1 Ergonomics definition	11(100)	0	Accepted
	1.2 Social and economics values	11(100)	0	Accepted
	1.3 Basic principles of ergonomics	11(100)	0	Accepted
2.0	Ergonomics Domains	11(100)	0	Accepted
	2.1 Physical ergonomics	11(100)	0	Accepted
	2.2 Cognitive ergonomics	11(100)	0	Accepted
	2.3 Organizational ergonomics	11(100)	0	Accepted
3.0	Anatomy and Physiology	11(100)	0	Accepted
	3.1 An introduction to anatomy	9(81.8)	2(18.2)	Accepted
	3.2 An introduction to physiology	10(90.8)	1(9.1)	Accepted
4.0	Basic Biomechanics	11(100)	0	Accepted
	4.1 An introduction to biomechanics	11(100)	0	Accepted
	4.2 Muscular work	11(100)	0	Accepted
		Yes (%)	No (%)	
5.0	Application of Anthropometric	11(100)	0	Accepted

	5.1 Body size and human diversity	10(90.9)	1(9.1)	Accepted
	5.2 Human reach	11(100)	0	Accepted
	5.3 Use of anthropometric data	10(90.9)	1(9.1)	Accepted
6.0	Posture	11(100)	0	Accepted
	6.1 Sitting posture	11(100)	0	Accepted
	6.2 Standing posture	11(100)	0	Accepted
	6.3 Hand and arm postures	11(100)	0	Accepted
7.0	Movement	11(100)	0	Accepted with modification
	7.1 Lifting	11(100)	0	Accepted
	7.2 Carrying	11(100)	0	Accepted
	7.3 Pulling and pushing	11(100)	0	Accepted
8.0	Information and Operation	11(100)	0	Accepted
	8.1 Visual information	11(100)	0	Accepted
	8.2 Hearing	10(90.9)	1(9.1)	Accepted
	8.3 Control: Fixed, wireless, remote	10(90.9)	1(9.1)	Accepted
9.0	Environmental Factors	11(100)	0	Accepted
	9.1 Noise: Guidelines, reduction, and hearing conservation	11(100)	0	Accepted
	9.2 Vibration: Guidelines and prevention	10(90.9)	1(9.1)	Accepted
	9.3 Illumination: Light intensity, brightness and color	10(90.9)	1(9.1)	Accepted
	9.4 Climate: Thermal comfort, heat and cold and climate control	11(100)	0	Accepted
	9.5 Ventilation	11(100)	0	Accepted
10.0	Design of Workplace	11(100)	0	Accepted
	10.1 Workstations for computers	11(100)	0	Accepted
11.0	Design of Industrial Workplaces	11(100)	0	Accepted
	11.1 Workshop workstation	11(100)	0	Accepted
	11.2 Utilization of space	11(100)	0	Accepted
12.0	Work Organization	11(100)	0	Accepted
	12.1 Flexible form of organization	11(100)	0	Accepted
	12.2 Autonomous groups	11(100)	0	Accepted
13.0	Tasks	11(100)	0	Accepted
	13.1 Introduction to tasks	10(90.9)	1(9.1)	Accepted
	13.2 Time and motion	10(90.9)	1(9.1)	Accepted
	13.3 Job design	11(100)	0	Accepted
14.0	Prevention of Occupational Injuries	11(100)	0	Accepted
	14.1 Traumatic injuries	11(100)	0	Accepted
	14.2 Stress/strain injuries	11(100)	0	Accepted
15.0	The Ergonomics Approach	11(100)	0	Accepted
	15.1 Project management	11(100)	0	Accepted
16.0	Ergonomics and Design technology	11(100)	0	Accepted
17.0	Ergonomics in Education	11(100)	0	Accepted
18.0	Ergonomics Checklist	11(100)	0	Accepted with modification
19.0	An in-depth study of topics of special interest in Ergonomics and human factors (Semester Paper)	10(90.9)	1(9.1)	Accepted with modification

Also, in Round 1 the first open-ended was put forward to the experts in order for them to provide qualitative responses regarding additional topics or sub-topics of the proposed constructs of a new ergonomics-based technology education curriculum. Table 10 illustrated experts' suggestions on additional topics or sub-topics. Four additional sub-topics were suggested by E8 which include "Medical and Rehabilitation", "Biomechanics in Ergonomics", "Biomechanics of Gait and its Analysis in Ergonomics" and "Effective Utilization of Assistive Devices in the Workplace". All these proposed topics were forwarded to Round 2 for another validation by Delphi experts. Another suggestion was offered by E10. He proposed the change of topic 7.0 [in Table 9] from "Movement" to the "Principles of Manual Material Handling". Hence, the suggestion was accepted where both topics were merged together under a new proposed topic which is "Movement and Principles of Manual Material Handling" as presented in Table 12.

Moreover, E6 suggested that sub-topic 8.2 "Hearing" should be under Environmental Factors, however the suggestion was not accepted because topic 8.0 Information and Operation has to do with electronics devices while topic 9.0 Environmental Factors has to do with surrounding such as machines and tools as indicated in Table 9. Therefore, "Hearing" was maintained under topic 9.0. In addition, suggestions were proposed by experts for additional four sub-topics (see Table 10), namely (1) medical and rehabilitation domain, (2) biomechanics in ergonomics, (3) biomechanics of gait and its analysis in ergonomics, and (4). In sum, the suggested sub-topics (2.4, 4.2, 4.3, and 7.4) were forwarded to the Round 2 in order for the experts to reevaluate their opinion as shown in Table 12.

Table 10: Experts suggested additional sub-topics in Round 1

No.	Sub-topics	Decision
1.	Medical and rehabilitation domain	Accepted
2.	Biomechanics in ergonomics	Accepted
3.	Biomechanics of gait and its analysis in ergonomics	Accepted
4.	Effective utilization of assistive devices in the workplace	Accepted

In the context of module objectives, the experts' agreement was indicated in Table 11. Objectives 1 to 3 scored 100% while the objective 4 scored 90.9%. However, in objective 4, expert (E4) suggested to reframe the objective, and the researcher reframed as follow "to gain an understanding of ergonomics in education" (refer to Table 12). Furthermore, E4 suggested that the term "provide" in item 1 of Table 11 would be replaced with the term "understanding". The suggestions were accepted and forwarded to the next round (Round 2) in order for the experts to revalidate the new constructs.

Table 11: Experts' responses on module objectives in Round 1

	Module objectives	Frequency (Percentage)		Remarks
		Yes (%)	No (%)	
1.	To provide basic principle of ergonomics	11(100)	0	Accepted
2.	To identify the ergonomics application in design technology	11(100)	0	Accepted
3.	To identify the risk factors and preventive measure in the five (5) distinct environments, namely - office, classroom/lecture theatre, studio/laboratory, workshop, and fields.	11(100)	0	Accepted
4.	To enable to gain an understanding of ergonomics in education	10(90.9)	1(9.1)	Accepted with modification

In summary, the outcomes of Round 1 showed that topic number 19 [see Table 9] was dropped due to wide disagreement among the experts and it was not forwarded to Round 2. Additional four sub-topics suggested by experts were forwarded to Round 2. The sub-topics were numbered 2.4, 4.2, 4.3, and 7.4 (refer to Table 12). Also, based on experts' suggestions, two topics 7.0 and 17.0 in Table 9 were modified in Table 12. Moreover, all of the four objectives were accepted, objectives 2 and 3 without any modification while objectives 1 and 4 with minor modification as recommended by the experts (refer to Table 11). Therefore, 18 topics, 42 sub-topics and 4 objectives and a total of 64 items were forwarded to Round 2 in order for the experts to review again their decision.

Delphi Round 2

In the second round of Modified Delphi technique, panel members' received results of the Round 1, as well as Round 2 questionnaire. Throughout the process of Round 2, follow-ups were made via mobile phone and email simultaneously to the experts as a reminder for the returning of their questionnaires. Experts were asked to rate their agreement or disagreement for the items of the proposed elements of a new ergonomics-based technology education curriculum. The scale to rate topics and sub-topics was 5-point Likert scale as being used in the previous structured questionnaire.

Experts' responses in the Round 2 were mainly quantitative in nature and were therefore, analyzed using SPSS software version 23. Accepted consensus was based on the cut-off point for the items' agreement of more that 70 percent consensus (Okoli & Pawlowski, 2005; Rana et al., 2017). Also, the mean score should be above 3.41 on the Likert scale. Thus, the cut-off ($M \geq 3.41$) as it was used by Sakhnini and Blonder (2015). The interquartile range (IRQ) should be less than or equal to 1.5 ($IQR \leq 1.5$) and the standard deviation (SD) must be less than or equal to 1 ($SD \leq 1$) in line with the literature reviewed (Rossett & Sheldon, 2001; Martin & Ritz, 2012).

For the second round (Round 2), the structured questionnaire contained 18 topics and 42 sub-topics as compared 19 topics and 38 sub-topics in Round 1. Also, four objectives were developed for the new curriculum of ergonomics-based technology education in Nigerian universities. Table 12 illustrated the experts' agreement on all the items presented. The statistical results of the Round 2 showed that experts reached 100% consensus on the four topics [15.0, 16.0, 17.0, and 18.0].

Table 12 also showed that all of the 18 topics gained high means of 4.18 and above. It can be interpreted that the experts strongly agreed on the topics based on the relevant items. In addition, the 18 topics have a standard deviation of less than 1 indicated a strong consensus and consistency among the experts. The only sub-topic with lowest mean ($M = 4.18$) was sub-topic 3.1 "An Introduction to Anatomy" with standard deviation 0.874 ($SD < 1$). The sub-topic, nevertheless, was forwarded to Round 3.

Interquartile range (IQR) also called spread and dispersion index was also computed and the results were displayed in Table 12 for both topics and sub-topics. The results indicated a strong agreement among experts as all the 18 topics and 42 sub-topics had the IQRs for those constructs were below 1 ($IQR \leq 1$). The IQR results indicated panel member of experts had strong agreement and therefore consesus was considered to have been achieved. The results of IQR were displayed in Table 12.

Table 12: Frequency, mean, standard deviation, and Interquartile Range (IQR) for Round 2

No.	Topics and sub-topics	Frequency (Percentage) (Likert scale 4 - 5)	Mean	Standard Deviation	IQR
1.0	Introduction to Ergonomics	10(90.9)	4.55	.688	1
	1.1 Ergonomics definition	10(90.9)	4.64	.674	1
	1.2 Social and economics values	10(90.9)	4.55	.688	1
	1.3 Basic principles of ergonomics	10(90.9)	4.73	.647	0
2.0	Ergonomics Domains	10(90.9)	4.73	.647	0
	2.1 Physical ergonomics	10(90.9)	4.55	.688	1
	2.2 Cognitive ergonomics	10(90.9)	4.45	.688	1
	2.3 Organizational ergonomics	10(90.9)	4.45	.688	1
	2.4 Medical and rehabilitation ergonomics	10(90.9)	4.45	.688	1
3.0	Review of Anatomy and Physiology	9(81.8)	4.36	.809	1
	3.1 An introduction to anatomy	8(72.8)	4.18	.874	2
	3.2 An introduction to physiology	9(81.8)	4.36	.809	1
4.0	Basic Biomechanics	10(90.9)	4.55	.688	1
	4.1 An introduction to biomechanics	11(100)	4.45	.522	1
	4.2 Biomechanics in ergonomics	11(100)	4.82	.405	1

	4.3 Biomechanics of gait and its analysis in ergonomics	10(90.9)	4.45	.688	1
	4.4 Muscular work	10(90.9)	4.36	.924	1
5.0	Application of Anthropometric	10(90.9)	4.55	.688	1
	5.1 Body size and human diversity	9(81.8)	4.36	1.055	1
	5.2 Human reach	10(90.9)	4.36	.924	1
	5.3 Use of anthropometric data	9(81.8)	4.45	.820	1
6.0	Posture	10(90.9)	4.64	.647	1
	6.1 Sitting posture	10(90.9)	4.64	.674	1
	6.2 Standing posture	10(90.9)	4.64	.674	1
	6.3 Hand and arm postures	10(90.9)	4.64	.674	1
7.0	Movement and Principles of Manual Material Handling	10(90.9)	4.55	.688	1
	7.1 Lifting	10(90.9)	4.55	.688	1
	7.2 Carrying	10(90.9)	4.64	.674	1
	7.3 Pulling and pushing	10(90.9)	4.55	.688	1
	7.4 Effective utilization of assistive devices in the workplace	10(90.9)	4.55	.688	1
8.0	Information and Operation	10(90.9)	4.55	.688	1
	8.1 Visual information	10(90.9)	4.55	.688	1
	8.2 Hearing	10(90.9)	4.36	.674	1
	8.3 Control: Fixed, wireless, remote	10(90.9)	4.27	.647	1
9.0	Environmental Ergonomics	10(90.9)	4.55	.688	1
	9.1 Noise: Guidelines, reduction, and hearing conservation	9(81.8)	4.36	.809	1
	9.2 Vibration: Guidelines and prevention	10(90.9)	4.55	.688	1
	9.3 Illumination: Light intensity, brightness and color	10(90.9)	4.55	.688	1
	9.4 Climate: Thermal comfort, heat and cold and climate control	10(90.9)	4.55	.688	1
	9.5 Ventilation	10(90.0)	4.64	.467	1
10.0	Design of workplace	10(90.9)	4.55	.688	1
	10.1 Workstations for computers	10(90.9)	4.64	.674	1
11.0	Design of Industrial Workplaces	10(90.9)	4.55	.688	1
	11.1 Workshop workstation	10(90.9)	4.55	.688	1
	11.2 Utilization of space	10(90.9)	4.64	.674	1
12.0	Work Organization	10(90.9)	4.55	.688	1
	12.1 Flexible form of organization	10(90.9)	4.36	.674	1
	12.2 Autonomous groups	11(100)	4.45	.522	1
13.0	Tasks	10(90.9)	4.55	.688	1
	13.1 Introduction to tasks	10(90.9)	4.73	.647	0
	13.2 Time and motion	11(100)	4.36	.505	1
	13.3 Job design	11(100)	4.82	.405	0
14.0	Prevention of Occupational Injuries	10(90.9)	4.45	.688	1
	14.1 Traumatic injuries	10(90.9)	4.45	.688	1
	14.2 Stress/strain injuries	10(90.9)	4.55	.688	1
15.0	The Ergonomics Approach	11(100)	4.64	.505	1
	15.1 Project management	10(90.9)	4.45	.688	1
16.0	Ergonomics and Design technology	11(100)	4.82	.405	0
17.0	Ergonomics Assessment tools and Ergonomics Checklist	11(100)	4.64	.505	1
18.0	Ergonomics in Education	11(100)	4.82	.405	0

Table 13 illustrated the frequency, mean (M), standard deviation (SD), and Interquartile Range (IQR) for module objectives in Round 2. For Objective 1, all the experts agreed (100%) that understanding of principles of ergonomics is important as one of the module objectives (M = 4.82, SD = .405, IQR = 0). The experts also believed (M = 4.55, SD = .688, IQR = 1) that Objective 2 was proper for ergonomics-based technology education curriculum. For Objective 3, the experts reached the consensus that it was relevant (M = 4.73, SD = .647, IQR = 0). Finally, the panel experts considered Objective 4: to gain an understanding of ergonomics in education was appropriate to be included as the final module objective (M = 4.82, SD = .405 and IQR = 0).

Table 13: Frequency, mean, standard deviation, and Interquartile Range (IQR) for module objectives in Round 2

No.	Module Objective	Frequency (Percentage) (Likert scale 4 – 5)	Mean	Standard Deviation	IQR
1.	To understand basic principles of ergonomics	11(100)	4.82	.405	0
2.	To identify the ergonomics application in design technology	10(90.9)	4.55	.688	1
3.	To identify the risk factors and preventive measure in the five (5) distinct environments namely - office, classroom/lecture theatre, studio/laboratory, workshop, and fields.	10(90.9)	4.73	.647	0
4.	To gain an understanding of ergonomics in education	11(100)	4.82	.405	0

Delphi Round 3

In Round 3 (see Table 14), the results of the second round were sent to each of the 11 Delphi's panel members. In the third round, experts were asked to re-evaluate all the feedback of the second round to form a final evaluation for topics, sub-topics and module objectives of a new ergonomics-based technology education curriculum. The experts evaluated and refined the lists of topics and sub-topics and rated them using the 5-point Likert scale. Hence, the ratings were similar as in the second round. Round 3 instruments were sent for the experts to measure their agreement on the topics, sub-topics and module objectives. Despite some of the experts' prompt responses prior to the date line, still follow-up contact was made with experts via mobile phone and email. The purpose of Round 3 was to draw further consensus among the expert panel members as a final round of the modified Delphi technique. The panel experts should reach a final consensus on the topics, sub-topics and module objectives for the new ergonomics-based technology education curriculum.

The results of the third round of the modified Delphi technique maintained 18 topics, 42 sub-topics and 4 module objectives as there was no additional topics or sub-topics suggested by the experts. In round 2, most of the topics have a frequency/percent agreement of 10(> 90%), mean of >4.18 as illustrated in Table 12.

In Round 3, the empirical data posited that the highest mean for topics was 4.91 and the lowest mean for topics was 4.45 in all 18 topics. The standard deviation of the topics was below 1 (SD < 1). The IQR ≤ 1 shows convergent consensus has been achieved. Table 13 also displayed analysis results for the sub-topics. The total items for sub-topics were 42 items in Round 3, each item scored more than 90% agreement while the sub-topic highest mean was 4.82 and lowest mean was 4.45. This showed a strong agreement of experts has been achieved regarding the topics and sub-topics. Also, standard deviation of all the sub-topics of 42 items were below 1 (SD < 1). Hence, the SD index indicated a convergent consensus has been attained. Also, experts reached consensus since all the final sub-topics have shown IQR was 1 or less (IQR ≤ 1) indicated a high level of agreement among the experts.

Table 14: Frequency, mean, standard deviation, and Interquartile Range (IQR) in Round 3

No.	Topics and sub-topics	Frequency (Percentage) (Likert scale 4 – 5)	Mean	SD	IQR
1.0	Introduction to Ergonomics	11(100)	4.91	.302	0
	1.1 Ergonomics definition	11(100)	4.82	.405	0
	1.2 Social and economic value	11(100)	4.73	.467	1
	1.3 Basic principle of ergonomics	11(100)	4.82	.405	0
2.0	Ergonomics Domains	11(100)	4.82	.405	0
	2.1 Physical ergonomics	11(100)	4.82	.405	1
	2.2 Cognitive ergonomics	11(100)	4.82	.405	1
	2.3 Organizational ergonomics	11(100)	4.82	.405	1
	2.4 Medical and rehabilitation ergonomics	11(100)	4.55	.522	1
3.0	Review of Anatomy and Physiology	11(100)	4.73	.467	1
	3.1 An introduction to anatomy	11(100)	4.73	.467	1
	3.2 An introduction to physiology	11(100)	4.73	.467	1
4.0	Basic Biomechanics	11(100)	4.64	.505	1
	4.1 An introduction to biomechanics	11(100)	4.55	.522	1
	4.2 Relevance of biomechanics in ergonomics	11(100)	4.55	.522	1
	4.3 Biomechanics of gait and its analysis in ergonomics	10(90.9)	4.45	.688	1
	4.4 Muscular work	10(90.9)	4.73	.647	0
5.0	Application of Anthropometric	10(90.9)	4.73	.647	0
	5.1 Body size and human diversity	10(90.9)	4.64	.674	1
	5.2 Human reach	10(90.9)	4.64	.674	1
	5.3 Use of anthropometric data	10(90.9)	4.64	.674	1
6.0	Posture	10(90.9)	4.73	.647	0
	6.1 Sitting posture	10(90.9)	4.73	.647	0
	6.2 Standing posture	11(100)	4.82	.405	0
	6.3 Hand and arm postures	10(90.9)	4.73	.647	0
7.0	Movement and Principles of Manual Material Handling	10(90.9)	4.73	.647	0
	7.1 Lifting	10(90.9)	4.73	.647	0
	7.2 Carrying	10(90.9)	4.64	.674	1
	7.3 Pulling and pushing	10(90.9)	4.64	.674	1
	7.4 Effective utilization of assistive devices in the workplace	11(100)	4.55	.405	0
8.0	Information and Operation	11(100)	4.73	.467	1
	8.1 Visual information	11(100)	4.64	.505	1
	8.2 Hearing	11(100)	4.64	.505	1
	8.3 Control: Fixed, wireless, remote	11(100)	4.64	.505	1
9.0	Environmental Ergonomics	11(100)	4.82	.405	0
	9.1 Noise: Guidelines, reduction, hearing and conservation	11(100)	4.82	.405	0
	9.2 Vibration: Guidelines and prevention	11(100)	4.82	.405	0
	9.3 Illumination: Light intensity, brightness and color	11(100)	4.82	.405	0
	9.4 Climate: Thermal comfort, heat and cold and climate control	10(90.9)	4.64	.674	1

	9.5 Ventilation	11(100)	4.73	.467	1
10.0	Design of Workplace	11(100)	4.64	.505	1
	10.1 Workstations for computers	11(100)	4.73	.467	1
11.0	Design Industrial Workplaces	11(100)	4.73	.467	1
	11.1 Workshop workstation	11(100)	4.82	.405	0
	11.2 Utilization of space	11(100)	4.73	.467	1
12.0	Work Organization	11(100)	4.82	.405	1
	12.1 Flexible form of organization	11(100)	4.64	.505	1
	12.2 Autonomous groups	11(100)	4.64	.505	1
13.0	Tasks	11(100)	4.45	.522	1
	13.1 Introduction to tasks	10(100)	4.45	.688	1
	13.2 Time and motion	10(90.9)	4.45	.688	1
	13.3 Job design	10(90.9)	4.55	.688	1
14.0	Prevention of Occupational Injuries	11(100)	4.64	.505	1
	14.1 Traumatic injuries	10(90.9)	4.45	.934	1
	14.2 Stress/strain injuries	11(100)	4.82	.405	0
15.0	The Ergonomics Approach	11(100)	4.55	.522	1
	15.1 Project management	11(100)	4.55	.522	1
16.0	Ergonomics and Design Technology	11(100)	4.64	.505	1
17.0	Ergonomics Assessment Tools and Ergonomics Checklist	11(100)	4.64	.505	1
18.0	Ergonomics in Education	11(100)	4.64	.505	1

Table 15 displayed frequency, mean, standard deviation and Interquartile Range (IQR) data on the module objectives in Round 3. The empirical data indicated that experts agreed (100%) on the first objective that was to understand the basic principles of ergonomics as an integral of the curriculum (M = 4.91, SD = .302, IQR = 0). The second objective was to identify the ergonomics application in design technology and the experts (100%) have considered it as pertinent as a module objective (M = 4.82, SD = .405, IQR = 0). Then, for the third objective which was to identify the risk factors and preventive measure and the experts reached (100%) consensus that it was an important module objective for the new proposed ergonomic curriculum (M = 4.64, SD = .505, IQR = 1). Finally, the fourth objective was to gain an understanding of ergonomics in education and the experts were strongly agreed (M = 4.82, SD = .405, IQR = 0).

Table 15: Experts' agreement on the module objectives in Round 3

No.	Module Objectives	Frequency (Percentage) (Likert scale 4 – 5)	Mean	SD	IQR
1.	To understand basic principles of ergonomics	11(100)	4.91	.302	0
2.	To identify the ergonomics application in design technology	11(100)	4.82	.405	0
3.	To identify the risk factors and preventive measure in the five (5) distinct environments namely - Office, Classroom/Lecture theatre, Studio/Laboratory, Workshop, and fields.	11(100)	4.64	.505	1
4.	To gain an understanding of ergonomics in education	11(100)	4.82	.405	0

Consensus on topics and sub-topics in Round 3

Delphi experts' changed agreement between Round 2 and Round 3 was illustrated in Table 16. Out of 18 topics, 12 topics have shown an increased in agreement but 6 topics remained unchanged. Similarly, of the 42 sub-topics, 32 sub-topics were shown an increased in agreement, 8 sub-topics did not change. While two sub-topics "Time and Motion" and "Job Design" have shown a reduced in percentage of agreement. Generally, there were negligible changes in the descriptive statistics for the experts' rating between round two and three. In sum, the changes in agreement among experts in Round 3 regarding topics and sub-topics are as follows: Out of 60 constructs, there was an increase of agreement of 44 constructs (12 topics and 32 sub-topics), while 14 constructs (6 topics and 8 sub-topics) unchanged and 2 constructs (2 sub-topics) have shown a decreased agreement.

Table 16: Changes in agreement among Delphi experts in Round 3

No.	Topics and sub-topics	Round 2 n (%) (Likert scale 4 -5)	Round 3 n (%) ((Likert scale 4 -5)	Increased agreement	Uncha-nged	Decreased agreement
1.0	Introduction to Ergonomics	10(90.9)	11(100)	✓		
1.1	Ergonomics definition	10(90.9)	11(100)	✓		
1.2	Social and economic value	10(90.9)	11(100)	✓		
1.3	Basic principle of ergonomics	10(90.9)	11(100)	✓		
2.0	Ergonomics Domains	10(90.9)	11(100)	✓		
2.1	Physical ergonomics	10(90.9)	11(100)	✓		
2.2	Cognitive ergonomics	10(90.9)	11(100)	✓		
2.3	Organizational ergonomics	10(90.9)	11(100)	✓		
2.4	Medical and rehabilitation ergonomics	10(90.9)	11(100)	✓		
3.0	Review of Anatomy and Physiology	9(81.8)	11(100)	✓		
3.1	An introduction to anatomy	8(72.8)	11(100)	✓		
3.2	An introduction to physiology	9(81.8)	11(100)	✓		
4.0	Basic Biomechanics	10(90.9)	11(100)	✓		
4.1	An introduction to biomechanics	11(100)	11(100)	✓		
4.2	Relevance of biomechanics in ergonomics	11(100)	11(100)	✓		
4.3	Biomechanics of gait and its analysis in ergonomics	10(90.9)	10(90.9)	✓		
4.4	Muscular work	10(90.9)	10(90.9)	✓		
5.0	Application of Anthropometric	10(90.9)	10(90.9)	✓		
5.1	Body size and human diversity	9(81.8)	10(90.9)	✓		
5.2	Human reach	10(90.9)	10(90.9)		✓	
5.3	Use of anthropometric data	9(81.8)	10(90.9)	✓		
6.0	Posture	10(90.9)	10(90.9)		✓	
6.1	Sitting posture	10(90.9)	10(90.9)		✓	
6.2	Standing posture	10(90.9)	11(100)	✓		
6.3	Hand and arm postures	10(90.9)	10(90.9)		✓	
7.0	Movement and Principles of Manual Material Handling	10(90.9)	10(90.9)		✓	
7.1	Lifting	10(90.9)	10(90.9)		✓	
7.2	Carrying	10(90.9)	10(90.9)		✓	
7.3	Pulling and pushing	10(90.9)	10(90.9)		✓	
7.4	Effective utilization of assistive devices in the workplace	10(90.9)	11(100)	✓		
8.0	Information and Operation	10(90.9)	11(100)	✓		
8.1	Visual information	10(90.9)	11(100)	✓		
8.2	Hearing	10(90.9)	11(100)	✓		
8.3	Control: Fixed, wireless and remote	10(90.9)	11(100)	✓		
9.0	Environmental Ergonomics	10(90.9)	11(100)	✓		

9.1	Noise: Guidelines, reduction, hearing and conservation	9(81.8)	11(100)	✓		
9.2	Vibration: Guidelines and prevention	10(90.9)	11(100)	✓		
9.3	Illumination: Light intensity, brightness, color	10(90.9)	11(100)	✓		
9.4	Climate: Thermal comfort, heat and cold, climate control	10(90.9)	10(90.9)	✓		
9.5	Ventilation	10(90.0)	11(100)	✓		
10.0	Design of workplace	10(90.9)	11(100)	✓		
10.1	Workstations for computers	10(90.9)	11(100)	✓		
11.0	Design Industrial Workplaces	10(90.9)	11(100)	✓		
11.1	Workshop workstation	10(90.9)	11(100)	✓		
11.2	Utilization of space	10(90.9)	11(100)	✓		
12.0	Work Organization	10(90.9)	11(100)	✓		
12.1	Flexible form of organization	10(90.9)	11(100)	✓		
12.2	Autonomous groups	11(100)	11(100)		✓	
13.0	Tasks	10(90.9)	11(100)	✓		
13.1	Introduction to tasks	10(90.9)	11(100)	✓		
13.2	Time and motion	11(100)	10(90.9)			✓
13.3	Job design	11(100)	10(90.9)			✓
14.0	Prevention of Occupational Injuries	10(90.9)	11(100)	✓		
14.1	Traumatic injuries	10(90.9)	10(90.9)		✓	
14.2	Stress/strain injuries	10(90.9)	11(100)	✓		
15.0	The Ergonomics Approach	11(100)	11(100)		✓	
15.1	Project management	10(90.9)	11(100)	✓		
16.0	Ergonomics and Design Technology	11(100)	11(100)		✓	
17.0	Ergonomics Assessment Tools and Ergonomics Checklist	11(100)	11(100)		✓	
18.0	Ergonomics in Education	11(100)	11(100)		✓	
Total	Topics			12	6	2
	Sub-topics			32	8	---

As stipulated in Table 17 for the four (4) module objectives, there were two increased agreement and two remained the same. This result indicated that the final four module objectives were accepted by the experts.

Table 17: Consensus on module objectives

No	Module Objectives	Round 2 n (%) (Likert scale 4 - 5)	Round 3 n (%) (Likert scale 4 - 5)	Increase agreement	Un-changed	Decrease agreement
1.	To understand basic principles of ergonomics	11(100)	11(100)		✓	
2.	To identify the ergonomics application in design technology	10(90.9)	11(100)	✓		
3.	To identify the risk factors and preventive measure in the five (5) distinct environments namely - Office, Classroom/Lecture theatre, Studio/Laboratory, Workshop, and fields.	10(90.9)	11(100)	✓		
4.	To gain an understanding of ergonomics in education	11(100)	11(100)		✓	
	Total			2	2	--

Stability of the mean responses between Round 2 and Round 3
Delphi literature shows that stability is a measure as the percentage change in the projection distribution from round to round. Scholars suggested that a 15% change or lower in any two distributions was considered a stable situation (Franchak, Dessy & Norton, 1984; Hsu & Sandford, 2007; Gracht, 2012; Halim et al., 2017). Table 18 illustrated the mean and percentage difference for each topics and sub-topics rated during Round 2 and Round 3. Average percentage change for topics was 3.64% and 4.50% for the sub-topics; both were less than 15%.

Table 18: Topics and sub-topics mean change between Round 2 and 3

No.	Topics and sub-topics	Mean			
		Round 2	Round 3	Difference	% Change
1.0	Introduction to Ergonomics	4.55	4.91	+0.36	7.91
1.1	Ergonomics definition	4.64	4.82	+0.18	3.88
1.2	Social value and economics value	4.55	4.73	+0.18	3.96
1.3	Basic principle of ergonomics	4.73	4.82	+0.09	1.9
2.0	Ergonomics Domains	4.73	4.82	+0.09	1.9
2.1	Physical Ergonomics	4.55	4.82	+0.27	5.93
2.2	Cognitive Ergonomics	4.45	4.82	+0.27	8.31
2.3	Organizational Ergonomics	4.45	4.82	+0.27	8.31
2.4	Medical and rehabilitation Ergonomics	4.45	4.55	+0.1	2.25
3.0	Review of Anatomy and Physiology	4.36	4.73	+0.37	8.49
3.1	An introduction to Anatomy	4.18	4.73	+0.55	13.16
3.2	An introduction to Physiology	4.36	4.73	+0.37	8.49
4.0	Basic Biomechanics	4.55	4.64	+0.09	1.98
4.1	An introduction to Biomechanics	4.45	4.55	+0.1	2.25
4.2	Relevance of Biomechanics in Ergonomics	4.82	4.55	-0.27	5.6
4.3	Biomechanics of gait and its analysis in ergonomics	4.45	4.45	0.00	0.00
4.4	Muscular work	4.36	4.73	+0.37	8.49
5.0	Application of Anthropometric	4.55	4.73	+0.18	3.96
5.1	Body size and human diversity	4.36	4.64	+0.28	6.42
5.2	Human reach	4.36	4.64	+0.28	6.42

5.3	Use of anthropometric data	4.45	4.64	+0.19	4.27
6.0	Posture	4.64	4.73	+0.09	1.94
6.1	Sitting Posture	4.64	4.73	+0.09	1.94
6.2	Standing Posture	4.64	4.82	+0.18	3.88
6.3	Hand and Arm Postures	4.64	4.73	+0.09	1.94
7.0	Movement and Principles of Manual Material Handling	4.55	4.73	+0.18	3.96
7.1	Lifting	4.55	4.73	+0.18	3.96
7.2	Carrying	4.64	4.64	0.00	0.00
7.3	Pulling and Pushing	4.55	4.64	+0.09	1.98
7.4	Effective utilization of assistive devices in the workplace	4.55	4.55	0.00	0.00
8.0	Information and operation	4.55	4.73	+0.18	3.96
8.1	Visual information	4.55	4.64	+0.09	1.98
8.2	Hearing	4.36	4.64	+0.28	6.42
8.3	Control for information: Fixed, Wireless, Remote etc.	4.27	4.64	+0.37	8.67
9.0	Environmental Ergonomics	4.55	4.82	+0.27	5.93
9.1	Noise: Guidelines, reduction, hearing conservation etc.	4.36	4.82	+0.46	10.55
9.2	Vibration: Guidelines and prevention	4.55	4.82	+0.27	5.93
9.3	Illumination: Light intensity, brightness, color etc.	4.55	4.82	+0.27	5.93
9.4	Climate: Thermal comfort, heat and cold, climate control	4.55	4.64	+0.09	1.98
9.5	Ventilation	4.64	4.73	+0.09	1.94
10.0	Design of workplace - Office	4.55	4.64	+0.09	1.98
10.1	Workstations for computers	4.64	4.73	+0.09	1.94
11.0	Ergonomic principles to design industrial workplaces	4.55	4.73	+0.18	3.96
11.1	Workshop workstation	4.55	4.82	+0.27	5.93
11.2	Utilization of space	4.64	4.73	+0.09	1.94
12.0	Work organization	4.55	4.82	+0.27	5.93
12.1	Flexible form of organization	4.36	4.64	+0.28	6.42
12.2	Autonomous groups	4.45	4.64	+0.19	4.27
13.0	Task	4.55	4.45	0.00	0.00
13.1	Introduction to task	4.73	4.45	-0.28	5.92
13.2	Time and motion	4.36	4.45	+0.09	2.06
13.3	Job Design	4.82	4.55	-0.27	5.6
14.0	Prevention of occupational injuries	4.45	4.64	+0.19	4.27
14.1	Cumulative trauma injuries,	4.45	4.45	0.00	0.00
14.2	Stress/strain injuries	4.55	4.82	+0.27	5.93
15.0	The Ergonomics Approach	4.64	4.55	-0.09	1.94
15.1	Project management (Phases)	4.45	4.55	+0.1	2.25
16.0	Ergonomics and Design technology	4.82	4.64	-0.18	3.73
17.0	Ergonomics Assessment tools and Ergonomics Checklist	4.64	4.64	0.00	0.00
18.0	Ergonomics in Education (educational ergonomics) – Schools, Class rooms, students etc.	4.82	4.64	-0.18	3.73
	Average percent change for both topics & sub-topics				4.24
	Average percentage change for topics				3.64
	Average percentage for sub-topics				4.50

Table 19 portrayed the module objectives rated by Delphi experts in Round 2 and Round 3. The average mean percentage change for module objectives was less than 15%. As discussed by Halim et al. (2017) and Gracht (2012), stability is achieved based on the percentage change of mean response between Round 2 and Round 3.

Table 19: Means differences and percentage change between Rounds 2 and 3

No.	Module Objectives	Round 2	Round 3	Difference	% Change
1.	To understand basic principles of ergonomics	4.82	4.91	+0.09	1.87
2.	To identify the ergonomics application in design technology	4.55	4.82	+0.27	5.93
3.	To identify the risk factors and preventive measure in the five (5) distinct environments namely - Office, Classroom/Lecture theatre, Studio/Laboratory, Workshop, and fields.	4.73	4.64	-0.09	1.9
4.	To gain an understanding of ergonomics in education	4.82	4.82	0.00	0.00
	Average				2.43

Comparison between Round 2 and Round 3

The reduction of standard deviation indicated a more convergence agreement among the Delphi experts. In the final round, standard deviation (SD) reduction for almost all the topics and sub-topics except sub-topics 4.2, 14.1, 15.0 and 16.0 as showed in Table 19. This generally indicated movement toward increased in the experts' consensus in Round 3. In addition, convergence was identified by a decrease in average SD between Round two (R2) and Round three (R3). Round two (R2) has an average SD of 0.655 while R3 has an average SD of 0.504. Thus, the average SD decrease by 0.151 between Round 2 and Round 3. Therefore, this has indicated a convergence of the experts' consensus regarding topics and sub-topics.

Table 19: Comparison of standard deviations between Round 2 and Round 3

No.	Topics and sub-topics	Round 2	Round 3	Difference
1.0	Introduction to Ergonomics	.688	.302	-0.386
1.1	Ergonomics definition	.674	.405	-0.269
1.2	Social and economic value	.688	.467	-0.221
1.3	Basic principle of ergonomics	.647	.405	-0.269
2.0	Ergonomics Domains	.647	.405	-0.269
2.1	Physical ergonomics	.688	.405	-0.283
2.2	Cognitive ergonomics	.688	.405	-0.283
2.3	Organizational ergonomics	.688	.405	-0.283
2.4	Medical and rehabilitation ergonomics	.688	.522	-0.166
3.0	Review of Anatomy and Physiology	.809	.467	-0.342
3.1	An introduction to anatomy	.874	.467	-0.407
3.2	An introduction to physiology	.809	.467	0.342
4.0	Basic Biomechanics	.688	.505	-0.183
4.1	An introduction to biomechanics	.522	.522	0.000
4.2	Relevance of biomechanics in ergonomics	.405	.522	+0.117
4.3	Biomechanics of gait and its analysis in ergonomics	.688	.688	0.000
4.4	Muscular work	.924	.647	-0.277
5.0	Application of Anthropometric	.688	.647	-0.041
5.1	Body size and human diversity	1.055	.674	-0.381
5.2	Human reach	.924	.674	-0.25
5.3	Use of anthropometric data	.820	.674	-0.146
6.0	Posture	.647	.647	0.00

6.1	Sitting posture	.674	.647	-0.027
6.2	Standing posture	.674	.405	-0.269
6.3	Hand and arm postures	.674	.647	0.000
7.0	Movement and Principles of Manual Material Handling	.688	.647	-0.041
7.1	Lifting	.688	.647	-0.041
7.2	Carrying	.674	.674	0.000
7.3	Pulling and pushing	.688	.674	-0.041
7.4	Effective utilization of assistive devices in the workplace	.688	.405	-0.269
8.0	Information and Operation	.688	.467	-0.041
8.1	Visual information	.688	.505	-0.183
8.2	Hearing	.674	.505	-0.169
8.3	Control: Fixed, wireless and remote	.647	.505	-0.142
9.0	Environmental Ergonomics	.688	.405	-0.283
9.1	Noise: Guidelines, reduction and hearing conservation	.809	.405	-0.404
9.2	Vibration: Guidelines and prevention	.688	.405	-0.283
9.3	Illumination: Light intensity, brightness and color	.688	.405	-0.269
9.4	Climate: Thermal comfort, heat and cold, and climate control	.688	.674	-0.014
9.5	Ventilation	.467	.467	0.000
10.0	Design of Workplace	.688	.505	-0.283
10.1	Workstations for computers	.674	.467	-0.207
11.0	Design of Industrial Workplaces	.688	.467	-0.221
11.1	Workshop workstation	.688	.405	-0.283
11.2	Utilization of space	.674	.467	0.207
12.0	Work Organization	.688	.405	-0.283
12.1	Flexible form of organization	.674	.505	-0.169
12.2	Autonomous groups	.522	.505	-0.017
13.0	Tasks	.688	.522	-0.166
13.1	Introduction to tasks	.647	.688	-0.041
13.2	Time and motion	.505	.688	-0.183
13.3	Job Design	.405	.688	0.0283
14.0	Prevention of Occupational Injuries	.688	.505	-0.183
14.1	Traumatic injuries	.688	.934	+0.246
14.2	Stress/strain injuries	.688	.405	-0.283
15.0	The Ergonomics Approach	.505	.522	+0.017
15.1	Project management	.688	.522	-0.166
16.0	Ergonomics and Design Technology	.405	.505	+0.100
17.0	Ergonomics Assessment Tools and Ergonomics Checklist	.505	.505	0.000
18.0	Ergonomics in Education	.405	.505	-0.099
	Average	0.655	0.504	0.151

In term of module objectives, the changes of standard deviation between Round 2 and Round 3 as illustrated in Table 20. The standard deviations for the all of the four module objectives have shown a reduction. This generally indicating movement toward increased in the experts' consensus in Round 3. In addition, convergence was identified by a decrease in average SD between Round 2 and Round 3. Round two has an average SD of 0.536, while R3 has an average SD of 0.404. Hence, the average SD decreased by 0.132 between Round 2 and Round 3. Therefore, this showed a convergence of the experts' consensus regarding the module objectives.

Table 20: Comparison between Round 2 and Round 3 regarding module objectives

No.	Module Objectives	Round 2	Round 3	Difference
1.	To understand basic principles of ergonomics	.405	.302	-0.103
2.	To identify the ergonomics application in design technology	.688	.405	-0.283
3.	To identify the risk factors and preventive measure in the five (5) distinct environments namely - Office, Classroom/Lecture theatre, Studio/Laboratory, Workshop, and fields.	.647	.505	-0.142
4.	To gain an understanding of ergonomics in education	.405	.405	0.000
	Average	0.536	0.404	

DISCUSSION

The research findings were discussed and presented in this section. There were two phases in data collection – needs analysis phase and modified Delphi technique phase. The purpose of this study was to develop a new curriculum of ergonomics-based technology education in the technology education program of the Nigerian universities. This study was designed to answer four research questions. Three research questions with regard to phase one and one research question for phase two. Needs analysis revealed that the ergonomics awareness among technology educators in the Nigerian universities was quite low. The empirical data have indicated that most of the lecturers agreed regarding the introduction of ergonomics into technology education curriculum in Nigerian universities. They also believe that it will enhance employment opportunity and competency of the graduates.

The modified Delphi technique was employed in the phase two and the contents of the curriculum were identified using questionnaires, open-ended questions and interview. Based on the panel of experts (n = 11) consensus in the three rounds, the final round has shown that the experts have reached consensus regarding the new ergonomics-based technology education curriculum by confirming the final constructs – 18 topics, 42 sub-topics and 4 module objectives. The topics and sub-topics were accepted based on a strong agreement (> 90%), mean of >4.18, standard deviation of topics items was below 1 (SD < 1) and IQR was 1 or less (IQR ≤ 1).

Furthermore, consensus on topics and sub-topics between Round 2 and Round 3 indicated changes in agreement among Delphi experts' such that out of 60 constructs, there was an increase on agreement of 44 constructs, while 14 constructs unchanged and two constructs showed decreased agreement. With regard to the four module objectives, the data indicated two objectives gained an increased agreement and the two objectives remained the same. Therefore, a strong agreement regarding the objectives and the constructs of the new curriculum was obtained. In addition, the stability of the mean responses was measured as the percentage change in the projection distribution between Round 2 and Round 3 was 4.24% – less than the 15% required for stability. Finally, when comparing the standard deviations of all the constructs, the average standard deviation (SD) was decreased by 0.151 between Round 2 and Round 3. Therefore, this also indicated a convergence of the experts' consensus on the topics and sub-topics of the new ergonomics-based technology education curriculum.

CONCLUSION

The main contribution is that the study identified a gap that is the lack of ergonomics in the technology education program in the Nigerian universities. Both experts and lecturers agreed on the needs of an ergonomics-based technology education in Nigerian universities. Hence, the solution to this existing gap is to introduce ergonomics-based technology education which lecturers and experts suggested as a way to bridge the gap. Empirical data in this study showed that the technology education lecturers were low in their knowledge about ergonomics. However, they were eager to learn more about ergonomics field. They also agreed that the ergonomics-based technology education should be introduced in the

Nigerian technology education programs at university level. In addition, the respondents believed that the new ergonomics-based technology education curriculum would enhance the employment opportunity, increase technology educators' knowledge and produce competent graduates. It has been suggested that ergonomics-based education technology would improve design technology, creativity, thinking skills as well as occupational safety and health competence.

To determine constructs needed for the development of new curriculum of ergonomics-based technology education in Nigerian universities, a modified Delphi technique with 11 experts was conducted. After consecutive round one to three, the experts achieved a final consensus on 18 topics, 42 sub-topics and 4 objectives. The elements listed in the final round (round-three) were unanimously accepted based on the frequency/percent agreement of 11 experts (> 90% agreement), means of 4.18 and above, the average standard deviation was SD < 1 and IQR ≤ 1. Further analysis to examine the changes in percentage agreement rating between round one and round two showed a total of 44 items out of 60 items and 14 items unchanged making the total acceptable items were 58 items.

The theoretical implication that can be derived this study is that the empirical data support and confirm the theories and model used in this study such as situational awareness theory, curriculum change theory, situated learning theory and mental model. Specifically, situational awareness theory is the invariant in the agent-environment system that generates the momentary knowledge and behaviors required to attain the goals specified by an arbiter of performance in the environment such as a workplace. Situation awareness theory also can be used to guide in developing the ergonomics domains for the curriculum contents. Also, this theory is selected because it is related to the ergonomics domains such as movement, task, handling and design.

Curriculum change theory is defined as the substitution occurs when a new element substitutes another element which is already present and alteration exists when new contents, items, materials, or procedures are added up into existing materials and programs. This definition seems to imply that if a new course is added such as ergonomics-based technology education into the existing program such as technology education – an alteration to the curriculum happens. In order to develop a new ergonomics curriculum, situated learning theory is selected because it lays the foundation of the technology education learning environment. In situated learning theory, workplace leaning in which job training and experience in real environment is important for the learners. In addition, mental model theory used in this study is defined as mental representations of humans, systems, artifacts, and situations formed by experience, observation, and training. This mental model is relevant for the development of the ergonomics domains such as biomechanics, anthropometric, posture, work organization and human-machine interaction.

The practical implications are several. First, the respondents believe that application of ergonomics-based technology education in technology education programs is appropriate in enhancing students of technology education knowledge and to be able to become more competent. As Mustapha (2017) observed that one of the biggest challenges of the twenty-first century is the creation of jobs. Since the benefits of ergonomics are quite clear, the development of a new curriculum is deemed necessary. Hence a concerted effort should be made to incorporate ergonomics-based technology education into Nigerian universities.

Additional implication that can be deduced from this finding is in terms of safety which will lead to a greater enhancement of health and serve as preventive measure for accident and injuries in workplace as compared to a curriculum without ergonomics-based technology education. In general, a new curriculum – the ergonomics-based technology education is expected to provide the students a comprehensive exposure to demands of technology changes, industries and labor market. In other words, the future students who follow a new ergonomics-based technology education curriculum are expected to have more advantages in job opportunity in the industries.

In addition, the implication of this study for industries as employers of technology education graduates is that when ergonomics is introduced there could be improvement in the quality of the future graduates' job performance in the workplace. Also, industries will benefit significantly in the reduction of cost implication, reduce accident and improve safety as Zare et al. (2015) observed that integration of an ergonomics approach in the manufacturing production system could reduce defects and improve quality in the production process. For the policy makers, the findings imply that a new benchmark for technology education in Africa. Thus, the key finding shows there is an urgent need to propose a new curriculum of ergonomics-based technology education in Nigerian universities.

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