

Development of intelligent tutor for enhancing Think-Pair-Share in learning of Electrical Machines in Colleges of Education (Technical) in North East, Nigeria

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ABSTRACT: This study developed an Intelligent Tutor for enhancing Think-Pair-Share in learning of Electrical Machines in Colleges of Education (Technical) in North East, Nigeria that will improve access to students and give them flexibility in learning. The study adopted a multi-method research design involving Research and Development (R & D) and Descriptive Survey research designs. The population of the study was 25 persons consisting of 10 lecturers of Electrical/Electronic Programme in Federal College of Education (Technical) Potiskum and Federal College of Education (Technical) Gombe, 15 industrial personnel, 5 each from Ashaka Cement, Bajoga, Savannah Sugar Plantation, Numan and Adama Beverages, Yola. Three research questions and three null hypotheses guided the study. The instruments were subjected to face and content validation by experts. The instrument, Intelligent Tutor Questionnaire for Electrical Machines (ITQEM) was then incorporated in the Intelligent Tutor (IT) for enhancing Think-Pair-Share in learning of Electrical Machines. Data collected from industrial personnel and lecturers' validation were analyzed using mean and standard deviation, two-tail t-test was used for test of significance between the responses of industrial personnel and Electrical/Electronic lecturers at 0.05 level of significance. The findings of the study showed that three topics and 60 items were found to be appropriate for inclusion in the Intelligent Tutor. It was recommended among others that, since Research grants such as TETFund NRF, Bench-work and PTDF should give priorities to scholars working on Intelligent Tutors and Artificial Intelligences in general to allow equal access for learners from all angles of the country which would in turn harnesses the untapped resourcefulness of the lecturers in Electrical Machines Principles of Operation.

Keywords: Colleges of Education, electrical machines, intelligent tutor, programming language, web-based instruction.

INTRODUCTION

Intelligent Tutoring System is an expert system that requires human expertise to be transferred to a computer, which involves an integration of human knowledge in a computer through the application of intelligence recognized as Artificial Intelligence (AI). According to Ramos *et al.* (2009), AI is the ability of computer-developed programmer to permit a computer to perform functions normally requiring human intelligence. The tool that performs functions of human beings in teaching and learning process is called tutor. According to Graesser *et*

al. (2007), tutors are software applications that use electronic technologies for personalized instructional delivery. While D'Mello *et al.* (2006) defined tutoring as an individualized one-on-one teaching and learning mechanism that uses AI technologies for instruction. AI attempts to simulate a teacher who guides the students' lesson flow (Keleş *et al.*, 2009). The learner interacts with the system through an interface system, receiving information, providing responses to questions, and even generating dialogue by asking questions which give them

feedback and hints on their answers either immediately or when they have finished entering all the steps (Moursund, 2006). When the correct instrument meet the right strategies, better results would be achieved.

Think-Pair-Share (TPS), on the other hand, is a cooperative learning process that encourages individual student's participation as they practices in the company of their peers. Gangne (2015) reported that students remember only 20% of what they hear, 30% of what they see, but remembers 90% of what they hear, see and practice cooperatively. This may be achieved with the use of IT and TPS learning process. The steps in TPS learning process according to Gana and Barnabas (2013) are: (a) Think: Students think independently about the lesson learnt; e.g. Electrical Machines troubleshooting, maintenance and repair, recollecting ideas on their own; (b) Pair: Students are grouped in pairs to discuss and practice their thoughts; and (c) Share: Students share their ideas and experiences with a larger group in accomplishing the tasks eg in Electrical Machines troubleshooting, maintenance and repairs. Thus, students' troubleshooting, maintenance and repair skills may become more refined through the three-steps learning process. Therefore, the integration of IT with TPS learning process may enable students to remember and reconstruct their learning experiences by practicing the troubleshooting, maintenance and repairs with real tools and instruments. Irrespective of the class size and the learner's age, McGregor (2006) maintained that TPS learning process is practicable with all category of learners and at the same time provides the learner with the needed technical skills.

Electrical/Electronic teachers in the Colleges of Education may be more updated with current trends in electronic technology than their counterparts in Technical Colleges due to their experience and expertise in research to solve problems in their subject area (Mayer, 2011). In the same vein, industrial personnel who often carry out the troubleshooting, repair and maintenance of the Electrical Machines may be more current concerning troubleshooting, repair and maintenance techniques.

According to Hassan *et al.* (2020), misunderstanding of the Principles of Operation of Electrical Machines may be one of the reasons for 'trial and error' type of troubleshooting among electrical/electronic graduates in Nigeria. Therefore, for efficient troubleshooting, repair and maintenance of the machines to be carried out by graduates, complex concepts must be clearly understood. Sorden (2015) asserted that visual analogy of complex processes can provide high level of content organisation, integration and assimilation among students. In other words, with the help of audio and visual elements as employed in IT, it may be easy to show complex processes that would otherwise need many words and other instructional aids to describe. In addition, combining the IT with TPS learning process may enhance individualised student's efforts in handling tools and instruments as against traditional method of teaching such

lecture where in most cases, students are passive learners (Slavin, 2011). The experiences students acquired from the IT are likely to be concretely internalized and when they are exposed to TPS learning, they may likely incorporate such experiences into already existing schemas of real life troubleshooting, repair and maintenance. In other words, combining words, pictures, animations and practice may be more effective in prompting deeper learning of Electrical Machines troubleshooting, repair and maintenance than the use of words alone.

Therefore, the software is designed to ensure that all aspects of the instruction conform to the needs of the intended users. An intelligent tutor has, however, prompted a parallel upsurge in the design and development of the software that symbolized learner's achievement. A learner's achievement is symbolized by his/her score or grade on a performance test in a particular subject. According to Fraenkel *et al.* (2012), achievement measures an individual's knowledge or skills in the given areas or subjects, while performance includes capacity to acquire and develop productive/manipulative skills based on the cognitive domain. Arroyo *et al.* (2004) pointed out that student achievement is dependent on several factors, including the instructional methods and learning environment. Hence, it is essential that electrical teachers should adopt teaching methods that allow active involvement in learning and provide a suitable learning environment to improve achievement, and performance of students in learning Electrical Machines principle of operation, troubleshooting, maintenance and repair. Therefore, the objective of this study is to develop intelligent tutor for enhancing Think-Pair- Share in learning of Electrical Machines in Colleges of Education (Technical) in North East, Nigeria.

Research questions

The following three research questions were answered in the study:

1. What are the appropriate contents of Principles of Operation of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share?
2. What are the appropriate contents of Troubleshooting of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share?
3. What are the appropriate contents of Repair and Maintenance of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share?

Hypotheses

The following three hypotheses were tested at the 0.05 level of significance.

H₀₁: There is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the Principles of Operation of Electrical Machines content necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.

H₀₂: There is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the appropriate contents in Troubleshooting Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share

H₀₃: There is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the appropriate contents in Repair and Maintenance of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.

Conceptual framework

The conceptual frame work for this study is as shown in Figure 1.

Models of intelligent tutor development

An Intelligent Tutor Software Development Life Cycle (SDLC) is a prescriptive characterization of the set of tools, methods and procedures that are expressed clearly to define a Software Development Life Cycle (Highsmith, 2000). The following are some of the SDLC: (1) CICD; (2) Spiral Model; (3) V-Model and (4). Waterfall Model

CICD-Model: Continuous Integration as well as Continuous Delivery/Continuous Deployment for the software at each stage of the development life cycle (Munassar and Govardhan, 2012).

The choice of adopting this model was due to the fact that it is a continuously progressive model as it appears with an infinity symbol. The main concepts attributed to CI/CD Model are Continuous Integration, Continuous Delivery/Continuous Deployment (Figure 2).

Procedure for design, development and implementation of the tutor

In designing the Intelligent Tutor, the target user, the language level, the purpose of and the pedagogical approach and appropriate use of technology was thoroughly considered. Design and implementation phase in this study considered as the phase for prototype development and it was built for the purpose of providing a deeper insight and better understanding of the problem and the system's requirements.

Design and implementation phase of Intelligent Tutor prototype was initiated within the following framework of sub-tasks:

1. Structure of the knowledge base for the tutor.
2. Construction or coding of the expert system.

Structure of the knowledge base for the tutor

The researcher, curriculum experts and Electrical Machine lecturers jointly designed the instruction for students to use to arrive at the structure of the knowledge base for the tutor. The software engineers and the researcher developed the program in expert module, and user interfaces to capture the knowledge of the following four sub headings/contents of Electrical Machine trade:

Student's interface: The student's interface is developed to store and update data about the student's performance in the subject domain. The system at the end create the certificate with a score: i) Personal data ii) Performance data and individual preferences iii) Learning history.

Domain/expert module: The expert module here represents the domain knowledge (set of concepts, training, texts, diagrams, pictures, simulations, audios and video clips among others along with their dependencies and other parameters) of the targeted concept or training. It is designed as a network of concepts or trainings.

Pedagogical or instructor module: The instructor module in the system controls the presentation of the instructional knowledge by selecting and sequencing the domain knowledge of the concept to be learned in Electrical Machines.

The user interface: A user interface was developed using Blazor Web Assembly to provide communications between the student and the website by typing and reading from the screen. The choice of the Blazor was due to the fact that it accepts both C# language and Hyper Text Markup Language (HTML). This will be so because most programs use non-vocal technique (that is, typing clicking on buttons and reading from the screen). Machines that can converse with students are clearly more flexible than those supporting more restrictive interactions. The three modules in collaboration deliver the contents of the subject matter to the student in a dynamic and personalized style. The dynamism in courseware presentations will be determined based on the previous interactions of the student with the tutor (recorded by the student model). The lessons will be presented to the student in the order specified by the teacher in the instructor module. The student will be said to have "completed" a lesson only after attaining the threshold specified by the teacher in the quiz of that particular lesson. In the context of this study, the passing criteria specified for each lesson is 40 marks in the

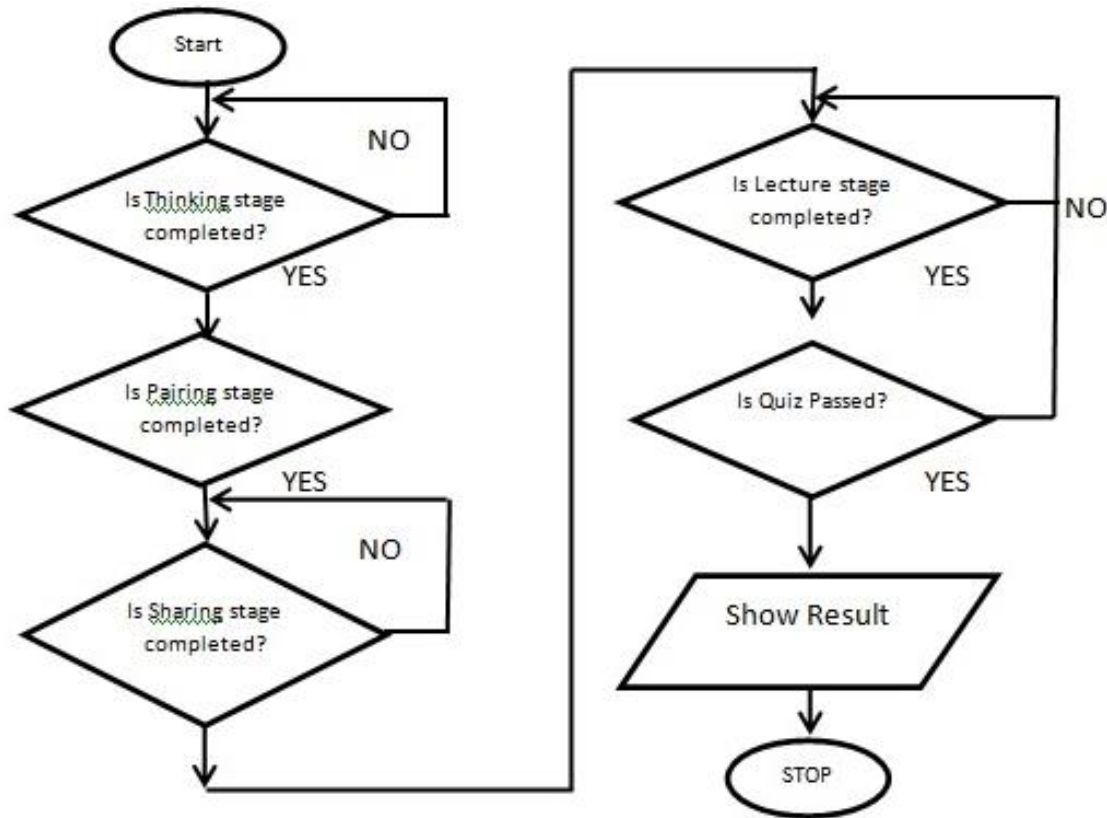


Figure 1. Concept of the intelligent tutor for enhancing Think-Pair-Share.

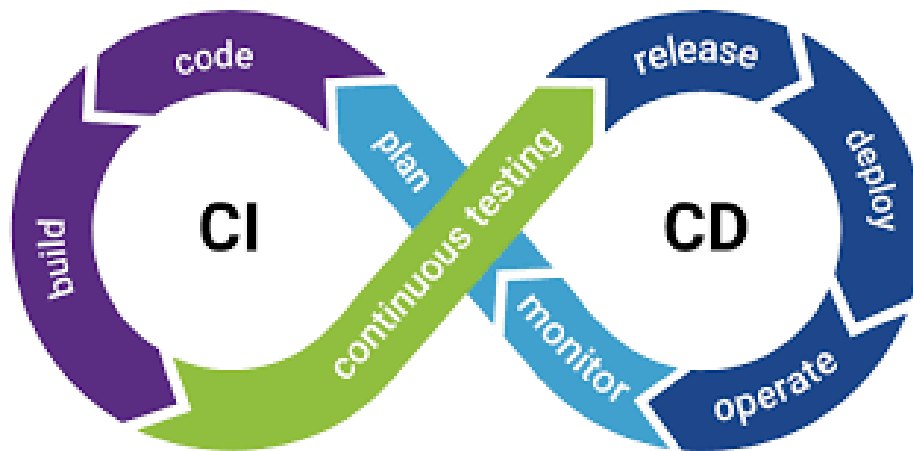


Figure 2. Continuous integration, continuous delivery/deployment, CI/CD-model.

corresponding quiz. The student is said to have 'completed' that lesson only if she/he obtained 40 marks or more in the quiz corresponding to that lesson. The purpose of this is to ensure that a student can attend a lesson only if she/he has a fair understanding of its prerequisite lesson.

Construction or coding of electrical machine intelligent tutor

This is the stage where detailed design specification is implemented as a source code. The software was constructed by coding (that is, programming) and by

assembling previously coded software components for use in the new application. The development team includes the researcher that captures the activities of Electrical Machine for inclusion in the tutor, Electrical Machine lecturers in the Colleges of Education and the software engineers. The researcher supplies all the information for the design as shown in Figure 1, while Electrical Machine lecturers and Industrial personnel provided the contents of the subject matter.

METHODOLOGY

The study adopted a multi-method research design involving Research and Development (R & D) and Descriptive Survey research designs. According to Janice (2003), multi-method research is used when two or more research methods are employed in one study. The study was carried out in North East Nigeria which consists of six states namely: Adamawa, Bauchi, Borno, Gombe, Taraba and Yobe States. The population of the study was 25 persons consisting of 5 lecturers of Electrical/Electronic Programme in Federal College of Education (Technical) Potiskum, 5 lecturers from Federal College of Education (Technical) Gombe and 5 respondents each from Savannah Sugar plantation Numan, Ashaka Cement and Adama Beverages Ltd, Yola, from the Maintenance Departments. This population was drawn using simple random sampling. The instrument for data collection was a structured questionnaire developed by the researcher titled "Intelligent Tutor Content Questionnaire for Electrical Machines (ITCQEM)". The items in the questionnaire were treated on a five-point rating scale using the following response options: Very Highly Appropriate (VHA) 5 points, Highly Appropriate (HA) 4 points, Moderately Appropriate (MA) 3 points, Fairly Appropriate (FA) 2 points and Not Appropriate (NA) 1 point.

The instrument was subjected to face and content validation by experts. The data for the study was collected by the researcher with the help of research assistants that were selected and trained for the purpose of the study from the selected Colleges of Education. The decision rule for answering the research questions was based on the real limit of numbers based on statistical consideration of Nunnally and Bernstein (2004), any expected technical skill operation with a mean score of 3.0 and above is considered "appropriate" for inclusion, while technical skill with a mean score below 3.0 is considered "inappropriate" for inclusion into the Intelligent Tutor.

RESULTS

Research question one: What are the appropriate contents of Principles of Operation in Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share?

Data analysis in Table 1 shows the Industrial Personnel

and Electrical/Electronic Lecturers' opinion on the appropriate contents of the IT for enhancing TPS in learning of the Principles of Operation of Electrical Machines. Based on the mean cut-off of 3.0 and above, the respondents rated all the contents of the IT as appropriate. The standard deviations which ranged from 0.99 to 1.46 indicated the closeness of the responses of the respondents in indicating the appropriateness of the items.

Research question two: What are the appropriate contents of Troubleshooting of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share?

Based on the analysis in Table 2, all the contents of the IT for enhancing TPS in learning of how to troubleshoot Electrical Machines scored above the mean cut-off of 3.0 and are therefore considered appropriate. The respective standard deviations which spanned 0.91 to 1.41 revealed the closeness of responses in terms of the appropriateness of the items.

Research question three: What are the appropriate contents of Repair and Maintenance of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share?

Table 3 present opinions of the respondents and based on the mean cut-off of 3.0 and above, all the contents of the IT were considered appropriate by the Industrial Personnel and Electrical/Electronic lecturers for enhancing TPS in learning of how to repair and maintain Electrical Machines. The standard deviations of 0.87 and 1.40 shows the closeness of respondents in their responses to indicate the appropriateness of the items.

Hypothesis H₀₁: There is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the Principles of Operation of Electrical Machines content necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.

The result presented in Table 4 shows t-calculated value for the mean ratings of industrial personnel and electrical/electronic lecturers with a significance of t-value at 0.13 which is greater than 0.05. This result shows that there is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the Principles of Operation of Electrical Machines content necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share. The null hypothesis is therefore accepted at 0.05 level of significance. Hence, there is no significant difference between the mean ratings of industrial personnel and

Table 1. Mean Responses on The Appropriate Contents of Principles of Operation of Electrical Machines Necessary for Inclusion in the Intelligent Tutor for Enhancing Think-Pair-Share ($N_{ip} = 15$; $N_l = 10$).

S/No	Item	Industrial Personnel		Lecturers		Remark	
		\bar{x}_{ip}	SD	\bar{x}_l	SD		\bar{x}_G
1.	Fleming's right-hand rule	3.27	1.44	3.90	1.10	3.52	A
2.	Newton's Law and power relationships	3.40	1.29	3.80	1.14	3.56	A
3.	The Magnetic field	3.47	1.41	3.90	0.99	3.64	A
4.	Magnetic Circuit with air gap	3.00	1.46	3.80	1.14	3.32	A
5.	Faraday's law	3.07	1.16	4.10	0.99	3.48	A
6.	Construction and its types	3.53	1.23	4.00	1.05	3.71	A
7.	Armature reaction	3.07	1.38	3.40	1.43	3.20	A
8.	Working characteristics of generator	3.53	1.25	3.60	1.43	3.55	A
9.	Losses and power flow diagram	3.07	1.33	3.80	1.23	3.36	A
10.	Voltage regulation and speed regulation	3.67	1.29	3.10	1.37	3.44	A

Key: \bar{x}_G = Grand Mean; \bar{x}_{ip} = Mean of Industrial Personnel; \bar{x}_l = Mean of Lecturers; SD = Standard Deviation.

Table 2. The Appropriate Contents of Troubleshooting of Electrical Machines Necessary for Inclusion in the Intelligent Tutor for Enhancing Think-Pair-Share ($N_{ip} = 15$; $N_l = 10$)

S/No.	Item	Industrial personnel		Lecturers		Remark	
		\bar{x}_{ip}	SD	\bar{x}_l	SD		\bar{x}_G
11.	Visual check of Fumes	3.47	1.30	3.80	0.91	3.60	A
12.	Proper Tools for Motor Troubleshooting	3.53	1.23	4.00	1.05	3.71	A
13.	Visual check of red hot metals	3.47	1.45	3.80	0.91	3.60	A
14.	Phase Unbalance	3.47	1.40	3.70	1.41	3.56	A
15.	Test and understand all components	3.67	1.29	3.70	1.41	3.68	A
16.	Promptness in starting a given task	3.53	1.23	4.00	1.05	3.71	A
17.	Visual check of red hot	3.47	1.41	3.91	0.99	3.64	A
18.	Check of sleeve bearings	3.67	1.17	3.20	1.22	3.48	A
19.	Burn-out insulation and binder yarns of the machine coil	3.47	1.45	3.80	0.91	3.60	A
20.	Visual checks and dimensional measurement of machine part such as bearings seats	3.53	1.25	3.60	1.43	3.55	A
21.	Visual checks and dimensional measurement of machine part such as fits	3.47	1.41	3.91	0.99	3.64	A
22.	Visual checks and dimensional measurement of machine part such as centering fits	3.53	1.23	4.00	1.05	3.71	A
23.	Visual checks and dimensional measurement of machine part such as bearing shells	3.47	1.41	3.91	0.99	3.64	A
24.	Visual checks and dimensional measurement of machine parts such as shaft ends	3.53	1.25	3.60	1.43	3.55	A
25.	Visual checks and dimensional measurement of all machine part such as keyways	3.47	1.40	3.70	1.41	3.56	A
26.	Visual check of speed is not up to expectation	3.67	1.29	3.70	1.41	3.68	A
27.	Belt wovelling	3.47	1.40	3.70	1.41	3.56	A
28.	Exposed cables	3.67	1.29	3.70	1.41	3.68	A
29.	Bulging capacitors	3.6	1.29	3.40	0.96	3.52	A
30.	Lose nuts or bolts	3.6	1.18	3.80	1.03	3.68	A
31.	Sound from the belts or bearing	3.47	1.40	3.70	1.41	3.56	A
32.	Sound from worn/collapsed bearings	3.67	1.29	3.70	1.41	3.68	A
33.	Sound from faulty commutator	3.47	1.12	3.00	1.15	3.28	A
34.	Loose stator core	3.2	1.32	3.80	1.47	3.44	A
35.	Worn, damaged or poorly lubricated bearing	3.6	1.29	3.40	0.96	3.52	A
36.	Rubbing of internal components	3.67	1.29	3.70	1.41	3.68	A
Group Mean							

Key: \bar{x}_G = Grand Mean, \bar{x}_{ip} = Mean of Industrial Personnel, \bar{x}_l = Mean of Lecturers, SD = Standard Deviation.

Table 3. The Appropriate Contents of Repair and Maintenance of Electrical Machines Necessary for Inclusion in the Intelligent Tutor for Enhancing Think-Pair-Share ($N_{ip} = 15$; $N_l = 10$).

S/No	Items	Industrial personnel		Lecturers		Remark	
		\bar{x}_{ip}	SD	\bar{x}_l	SD		\bar{x}_G
37.	Record of performance data in log book	3.40	1.35	3.80	1.13	3.56	A
38.	Control of overall machine condition	3.60	1.29	3.70	1.41	3.64	A
39.	Checks of all machine parts and auxiliaries (such as external fans, speed detectors, brakes, sensors, etc.)	3.80	1.14	3.90	1.44	3.84	A
40.	Dismantling of machine	3.80	1.14	3.60	0.96	3.72	A
41.	Bearing check	3.53	1.40	4.00	1.05	3.71	A
42.	Cleaning of all machine parts and windings by special cleaning treatment including drying procedure by vacuum-oven treatment	3.40	1.29	3.90	1.44	3.60	A
43.	Change of antifriction bearings	3.67	1.23	3.90	0.99	3.76	A
44.	Change and replacement of all screws	3.67	1.34	3.80	0.91	3.72	A
45.	Change of nominal power	3.67	1.23	3.50	0.97	3.60	A
46.	Increase of efficiency	3.00	1.19	3.90	0.99	3.36	A
47.	Noise reduction	3.07	1.38	4.10	0.87	3.48	A
48.	Modification of bearing arrangement	3.67	1.23	3.50	0.97	3.60	A
49.	Replace Fans	3.47	1.40	3.60	1.07	3.52	A
50.	Replace Pumps	3.27	1.43	3.80	1.03	3.48	A
51.	A report with recommendations on the electrical machine parts in the log book	3.40	1.24	3.70	1.41	3.52	A
52.	Pulling out of the stator from the alternator	3.13	1.35	3.90	1.28	3.43	A
53.	Cleaned the generator parts	3.07	1.38	4.10	0.87	3.48	A
54.	The slots provided are insulation and the new coils are replaced	3.07	1.38	4.10	0.87	3.48	A
55.	The insulation and the auxiliary windings are placed	3.67	1.23	3.90	1.44	3.76	A
56.	The insulating layer is disposed in the immersion bench and the generator enters into the drying oven. This process is repeated a number of times	3.40	1.40	3.70	1.41	3.52	A
57.	Right connection/setting of the equipment/tools	3.53	1.24	3.70	1.41	3.59	A
58.	Identification of correct accessories needed for a job	3.07	1.38	4.10	0.87	3.48	A
59.	Identification of correct material/position to install a protective device	3.47	1.45	3.80	1.47	3.60	A
60.	Identifying grades of lubricants	3.67	1.23	3.70	1.05	3.68	A

Key: \bar{x}_G = Grand Mean, \bar{x}_{ip} = Mean of Industrial Personnel, \bar{x}_l = Mean of Lecturers, SD = Standard Deviation.

electrical/electronic lecturers in Colleges of Education on the Principles of Operation of Electrical Machines content necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.

Hypothesis H₀₂: There is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the appropriate contents of Intelligent Tutor for enhancing Think-Pair-Share in Troubleshooting of Electrical Machines

The result presented in Table 5 shows t-calculated value

for the mean ratings of industrial personnel and electrical/electronic lecturers with a significance of p at 0.698 which is greater than 0.05. This result shows that there is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the appropriate contents of Intelligent Tutor for enhancing Think-Pair-Share in troubleshooting Electrical Machines. The null hypothesis is therefore accepted at 0.05 level of significance. Hence, there is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the appropriate contents of Intelligent Tutor for enhancing Think-Pair-Share in troubleshooting Electrical Machines.

Table 4. Two-tail t-test of difference between industrial personnel and electrical/electronic lecturers in Colleges of Education on the principles of operation of Electrical Machines.

Respondents	N	\bar{X}	SD	SE	t-cal	p-value	Decision
Industrial personnel	15	3.31	0.242	0.076	3.09	0.013	Accepted
Lecturers	10	3.74	0.299	0.095			

Significant at $t < .05$; Key: SE = Standard Error.

Table 5. Two-tail t-test of difference between industrial personnel and electrical/electronic lecturers in Colleges of Education on Troubleshooting of Electrical Machines.

Respondents	N	\bar{X}	SD	SE	t-cal	p-value	Decision
industrial personnel	15	3.46	0.167	0.033	0.392	0.698	Accepted
Lecturers	10	3.48	0.278	0.055			

Significant at $P < .05$; Key: SE = Standard Error.

Table 6. Two-tail t-test of difference between industrial personnel and electrical/electronic lecturers in Colleges of Education on Repair and Maintenance of Electrical Machines.

Respondents	N	\bar{X}	SD	SE	t-cal	P. value	Decision
Industrial personnel	15	3.44	0.251	0.051	4.59	0.00	Accepted
lecturers	10	3.76	0.174	0.095			

Significant at $P < .05$; Key: SE = Standard Error.

Hypothesis H₀₃: There is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers Colleges of Education on the appropriate contents of Intelligent Tutor for enhancing Think-Pair-Share in Repair and Maintenance of Electrical Machines

The result presented in Table 6 shows t-calculated value for the mean ratings of industrial personnel and electrical/electronic lecturers with a significance of t-cal at 4.59 which is greater than 0.05. This result shows that there is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the appropriate contents of Intelligent Tutor for enhancing Think-Pair-Share in Repair and Maintenance of Electrical Machines. The null hypothesis is therefore accepted at 0.05 level of significance. Hence, there is no significant difference between the mean ratings of industrial personnel and electrical/electronic lecturers in Colleges of Education on the appropriate contents of Intelligent Tutor for enhancing Think-Pair-Share in Repair and Maintenance of Electrical Machines.

Findings of the study

The following findings emerged based on the data collected and analysed:

1. The contents appropriate for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share in learning of the Principles of Operation of Electrical Machines include: Fleming's right-hand rule, Faraday's law, the magnetic field, circuit with air gap, armature reaction, working characteristics of generator.
2. The contents of troubleshoot in Electrical Machines were found to be appropriate for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.
3. The contents of repair and maintenance in Electrical Machines were found to be appropriate for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.
4. There is no significant difference between the mean ratings of industrial personnel and Electrical/Electronic lecturers in Colleges of Education (Technical) on the Principles of Operation of Electrical Machines content necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.
5. There is no significant difference between the mean ratings of industrial personnel and Electrical/Electronic lecturers in Colleges of Education (Technical) on the Troubleshooting of Electrical Machines content necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share.
6. There is no significant difference between the mean ratings of industrial personnel and Electrical/Electronic lecturers of Colleges of Education (Technical) on the Repair and Maintenance of Electrical Machines content necessary for inclusion in the Intelligent Tutor

for enhancing Think-Pair-Share.

DISCUSSION

The discussions of the findings of the study were in accordance with the questions raised for the research. The findings to research question one revealed that the appropriate contents of Principles of Operation of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share are: Fleming's right-hand rule, Newton's Law and power relationships, The Magnetic Field, Magnetic Circuit with air gap, Faraday's Law, Construction and its types, Armature reaction, Working characteristics of generator, Losses and power flow diagram, Voltage regulation and speed regulation. This finding implies that both industrial personnel as well as electrical/electronic lecturers in the colleges of education and universities share the same opinion in terms of Principles of Operation that were included in the IT. This finding is in agreement with the content of NCCE (2012) Minimum Standards for NCE Electrical and Electronics Programme.

Research question two revealed the appropriate contents of Troubleshooting of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share which are: Check of sleeve bearings, Burn-out insulation and binder yarns of the machine coil, Visual checks and dimensional measurement of machine part such as bearings seats, Visual checks and dimensional measurement of machine part such as fits, Visual checks and dimensional measurement of machine part such as centering fits, Visual checks and dimensional measurement of machine part such as bearing shells, Visual checks and dimensional measurement of machine parts such as shaft ends, Visual checks and dimensional measurement of all machine part such as keyways, Visual check of speed is not up to expectation, Belt wovelling, Exposed cables, Bulging capacitors, Lose nuts or bolts, Sound from the belts or bearing, Sound from worn/collapsed bearings, Sound from faulty commutator, Loose stator core, Worn, damaged or poorly lubricated bearing, Rubbing of internal components.

The findings to research question three revealed that the appropriate contents of Repair and Maintenance of Electrical Machines necessary for inclusion in the Intelligent Tutor for enhancing Think-Pair-Share that were valid are: Record of performance data in log book, Control of overall machine condition, Checks of all machine parts and auxiliaries (such as external fans, speed detectors, brakes, sensors, etc.), Dismantling of machine, Bearing check, Cleaning of all machine parts and windings by special, cleaning treatment including drying procedure by vacuum-oven treatment, Change of antifriction bearings, Change and replacement of all screws, Increase of efficiency, Noise reduction, Modification of bearing

arrangement, Replace Fans, Replace Pumps, A report with recommendations on the electrical machine parts in the log book, Pulling out of the stator from the alternator, Cleaned the generator parts, The slots provided are insulation and the new coils are replaced, The insulating layer is disposed in the immersion bench and the generator enters into the drying oven. This process is repeated a number of times, Right connection/setting of the equipment/tools, Identification of correct accessories needed for a job, Identification of correct material/position to install a protective device, Identifying grades of lubricants respectively.

Conclusion

The present study developed a complete teaching package in form of an Intelligent Tutor for enhancing Think-Pair-Share in learning of Electrical Machines. The findings revealed that the contents appropriate for inclusion into the Intelligent Tutor which are the Principles of Operation, Troubleshooting and Repair and Maintenance for enhancing TPS in learning of Electrical Machines were all found to be appropriate. The Intelligent Tutor will not only serve as a bridge filling the gap during unscheduled school closures in the study region, but as a mechanism for conveying the much-needed skills necessary for employment amongst graduates of electrical/electronic programme and for national development.

Recommendations

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

1. Research grants such as TETFund NRF, Bench-work and PTFDF should give priorities to scholars working on Intelligent Tutors and Artificial Intelligences in general to allow equal access for learners from all angles of the country which would in turn harnesses the untapped resourcefulness of the lecturers in Electrical Machines Principles of Operation.
2. An intervention in form of Academic Staff Training/Development programme should be initiated by the Colleges of Education (Technical) in the North East, Nigeria to train existing Electrical/Electronic lecturers on the use of the Intelligent Tutor for enhancing TPS in learning of Troubleshooting of Electrical Machines.
3. Federal Ministry of Education should provide the needed support in terms of facilities and equipment for the planning, inclusion and implementation in the use of Intelligent Tutor for enhancing TPS in learning of Repair and Maintenance of Electrical Machines.
4. Relevant agencies such as National Board for Technical Education should provide the needed policy to incorporate Intelligent Tutor into the teaching and

learning of Principles of Operation of Electrical Machines in Colleges of Education (Technical) in Nigeria.

5. Relevant agencies such as National Board for Technical Education should provide the needed policy to incorporate Intelligent Tutor into the teaching and learning of Troubleshooting of Electrical Machines in Colleges of Education (Technical) in Nigeria.
6. Relevant agencies such as National Board for Technical Education should provide the needed policy to incorporate Intelligent Tutor into the teaching and learning of Repair and Maintenance of Electrical Machines in Colleges of Education (Technical) in Nigeria.
7. General usability of Intelligent Tutor in practical Electrical Machines troubleshooting, maintenance and repair should be undertaken by the Colleges of Education (Technical) in North East, Nigeria.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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