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Research Paper

Effects of Inductive and Deductive Inquiry Teaching Approaches on Technical College Students Achievement in Metalwork

Muhammad Abubakar Uthman[1], Emmanuel Okafor Ede[2]
Abdullahi Muhammad Hassan[3*]

[1]Metalwork Technology Department, Niger State College of Education, Minna, Nigeria
[2]Department of Industrial and Technical Education, University of Nigeria, Nsukka, Nigeria
[3]Department of Industrial and Technology Education, Federal University of Technology, Minna, Nigeria

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Abstract

The impact of inductive and deductive teaching methods on metalwork proficiency was evaluated among technical college students. The purpose of study was designed to determine the effect of inductive and deductive inquiry teaching approaches to enhance students' cognitive achievement in Metalwork and to students' psychomotor achievement in Metalwork. The study, involving 115 students, employed a pre-test, post-test, non-equivalent control group design, with 56 students allocated to the Deductive Inquiry group and 59 to the Inductive Inquiry group. Data were collected using the Metalwork Achievement Test (MCAT) and the Metalwork Psychomotor Achievement Test (MPAT). The Pearson Product Moment Correlation produced a correlation coefficient of 0.83 for assessing the MCAT's reliability. The reliability of MPAT was determined using the scorer dependability technique. The inter-rater agreement was 0.82. Despite a non-significant ANCOVA result at the 0.05 level, the students in the experimental groups showed superior mean scores. In metalwork instruction, students who employed the inductive inquiry method earned higher average scores on both the cognitive and psychomotor tests. The mean scores were statistically significant. Given these findings, Metalwork teachers at technical colleges should employ an inquiry-based learning method.

Keywords: *Inductive, deductive, inquiry, teaching and achievement, student, colleges*

INTRODUCTION

The government and business sectors established special schools and technology institutions saddled with the responsibility of training and producing the necessary manpower to move the economy as awareness of the relevance of vocational and technology education to national development increased. In order to this goal, Atsumbe et al. (2014) claimed that the government of Nigeria, with the aim of functional and administrative distinction, has categorized technical education to encompass four different kinds and degrees of education: vocational education obtained at Technical Colleges and Vocational Centers, responsible for the role of producing craftsmen and master craftsmen; Technical education, obtained at Polytechnics/Monotechnics; Technical education, obtained at Polytechnics/Monotechnics; Professional education, obtained at University level and responsible for the role of producing professionals; and high level

Technical colleges are establishments where students are given instruction to obtain relevant information and skills in several professions for employment in the global business scene. Technical Colleges in Nigeria were founded, Besmart-Digbori (2011) said, to equip people to gain practical skills and fundamental scientific knowledge and attitudes needed by craftsmen and

Corresponding author's email: yabhass@yahoo.com

technicians at sub-professional level to meet the objectives of technical education. Metalwork is a subject available at the Nigerian technical college level.

Metalwork is a trade-related subject offered by students in Electronics, Motor vehicle mechanics, Auto Mechanics, Painting and Decorating, Furniture, and Radio and Refrigerating in Technical Colleges. The subject covers the study of processes in machine tools and operations, joining processes, mechanical fastening devices, bench work, and forging (National Board for Technical Education, 2001). Metalwork has been pivotal in the development of material culture. It plays key roles in the Nigerian economy, particularly in the manufacturing of consumer goods, equipment for the building and transport industries, producing almost all the equipment relevant in mining, petro-chemicals, iron, and steel, and providing hardware for modern technology.

The knowledge gained in Metalwork lays the groundwork for creating simple engineering solutions to common problems in homes, businesses, and schools. Therefore, the metalwork trade gives students the opportunity to acquire useful skills that will open a wide spectrum of jobs and productive activities. Duze (2011), however, noted that clear evidence of a declining grade of education and student quality, notably at the secondary school/technical college level, suggests that the current educational system in Nigeria appears not to be fulfilling the anticipated aims and objectives. Likewise, Eze et al. (2015) confirmed that the general claims of inadequate academic performance among technical college students in various trades demonstrate that technical institutions in Nigeria are not reaching the objectives of their founding. Every well-meaning Nigerian should be worried about this scenario. The internal and external tests clearly reflect this (Anyichie & Onyedike, 2012).

The performance of technical students in the NABTEB examination is declining. Ogbuanya and Ogundola (2014) noted persistent reports of high failure rates among college graduates. According to NABTEB (2012), only 59,100 out of the 143,755 candidates who sat for the May/June 2012 examinations conducted by the board earned five credits. Thus, the figure represents 41.1% of the total candidates that were enrolled in the examination. The worst, as revealed by NABTEB are trade courses such as Metalwork. Evidence from NABTEB's metalwork results for 2008, 2009, 2010, 2011, 2012, and 201,3 (NABTEB, 2014 in Adio, 2016). Research studies powerfully link student academic achievement to teaching strategies chosen by instructors. Teacher-centered (Zakariyyau, 2003; Eze et al., 2015) are the often utilized approaches—lecture and demonstration.

An inquiry-based teaching method promotes active learning among students. The learning process is propelled by questioning and analytical thinking. Inquiry-based learning is a constructivist approach in which students act as scientists or researchers, taking ownership of their learning. (Sola & Ojo, 2007; Dutt-Doner & Grande, 2011). Students actively observe and question events, test hypotheses, interpret data, and construct models.

Inductive inquiry is an investigative learning strategy. Based on the argument that knowledge is mostly developed from a learner's experiences and engagement with events, the inductive inquiry teaching technique uses a technique called noticing (Bilash, 2009). Inductive teaching is a much more student-centered method. He said of children realizing something particularly important. This is a mental process in which the individual observes certain events, objects, or processes and then creates a specific pattern of ideas or associations, depending on these few encounters. Under an inductive learning style, teachers urge students to deduce from a collection of facts or data a conclusion, generalization, or pattern of connections (Orlich et al., 2007). According to Dutt-Doner and Grande (2011), the information-seeking process of the inductive inquiry method encourages students to identify facts, decide pertinent questions, create means to explore these questions, and construct answers. Students are encouraged to create and develop their own theories. Students go from particular facts and observations to conclusions through inductive inquiry, therefore experiencing the necessary mental processes. The instructor

chooses a collection of activities or resources for the class to help the students reach their goals. The pupil responds and attempts to create a significant pattern depending on his or her own observations and those of others. The instructor also invites students to express their opinions so that the whole class can gain from unique ideas. Thus, the inductive inquiry teaching and learning strategy is an educational method in which students are allowed to discover ideas or principles before the instructor involves them in one or another inquiry activity like exploration to assist them in grasping a concept or principle. Deductive inquiry is another type of inquiry teaching method. Another teaching method is deductive inquiry. It is predicated on the theory that students learn best from a highly regimented presentation of materials (National Institute- Landmark College, 2005). In a deductive inquiry classroom, the instructor introduces and clarifies ideas to the students and then expects them to complete assignments to hone the concepts (National Institute-Landmark College, 2005; Bilash, 2009). Based on the Art of Teaching Science, Dutt-Doner and Grande (2011) deductive inquiry teaching technique focuses on guiding students from a generic concept to particular cases that may be logically subsumed under generalizations. Under this method, the instructor provides significant ideas, topics, or hypotheses and coordinates the material. After that, students are actively learning generalizations, collecting data, and using it in relation to particular cases. Thus, the deductive inquiry teaching approach is an educational method in which the instructor delivers a generalization, principle, or idea and then involves the students in one or more inquiry activities to assist with understanding the subject. Academic success is the performance of a school topic as represented by a score on an achievement examination. Achieving is the result of education in which the learner determines their degree of achievement in activities, courses, or programs to which they are properly exposed (Atsumbe, 2013). Therefore, one may deduce from a student's behavior within a specific time range or at the conclusion of a given length of time achievement. Academic success in metalwork is the degree of knowledge and ability gained and maintained by students. A problem under discussion in education nowadays is students' performances in relation to instruction and the general success of learning results. This study will therefore determine whether the inductive inquiry approach to teaching or the deductive inquiry teaching approach will be better at enhancing students' cognitive and psychomotor achievement in Metalwork.

Purpose of the Study

This research aims to determine how inductive and deductive inquiry teaching strategies affect technical college students' metalwork performances. Specifically, the study was designed to determine the effect of:

1. Inductive and deductive inquiry teaching approaches to enhance students' cognitive achievement in Metalwork.
2. Inductive and deductive inquiry teaching approaches to students' psychomotor achievement in Metalwork.

LITERATURE REVIEW

Awute et al., (2023) investigated at a Senior High School (SHS) in Ghana how the use of deductive and inductive approaches affected students' grammar. This study examines how the deductive approach affects the grammar performance of students and determines statistically significant variations between students taught using the deductive approach and those taught using the inductive technique. The research calls for one hundred students. There were two groups of 50 students each. The experimental group consists of a group; the control group is the other. Pre-tests and post-tests are the research tools used. Data from the control and experimental groups were analyzed using a quantitative method. The control group was taught the inductive method, whereas the experimental group was taught the deductive method. Both groups had a pre-test, and the

experimental group underwent four weeks of therapy. Data were collected and subjected to t-test analysis. This study revealed significant variations in the means of the two sets of student scores after the examination. The outcome favors the experimental group—that is, the group that uses the deductive method of instruction. Results showed that both groups had statistically significant variations in the mean-grade point average and other variances. It was advised that instructors should use suitable strategies to highlight their best features. Therefore, this research recommends the use of a logical methodology.

The study explored the impact of incorporating inductive, deductive, and interactive methods into GCE instruction on students' writing achievement and English language attitudes (Khlood and Najwa, 2023). Two null hypotheses and two research questions led the research. The investigation adopted an experimental research design. The study was conducted at all standard vehicle workshops in Benue State. A total of 203 people participated in the study, among them were 11 automotive lecturers, 30 autotropic experts, and 162 MVM artisans. The pretest was employed for equalizing purposes. Both groups completed the pretest. The experimental group's pre-test means had a standard deviation of 15.06 and a score of 37.00, while the control group's pre-test means had a standard deviation of 13.22 and a score of 38.76. With a degree of freedom of 58 and a significance level of 0.05, the calculated t-value of 0.483 is less than the corresponding tabular value of 2.00. Highly qualified and competent instructors are essential for effectively teaching grammatical competency. The text requires students to demonstrate inductive and interactive grammatical methodologies for enhancing their writing abilities. Middle and EFL instructors should be well-versed in grammatical techniques to enhance students' writing skills.

Kaur (2019). conducted research to determine how inductive and deductive approaches to instruction worked for secondary school science success. The aim of this research was to determine how well inductive and deductive approaches to instruction affected the scientific performance of secondary school pupils. One hundred youngsters from Ferozepur district were selected for this aim from different schools. For the control and experimental groups, a self-made achievement exam served as both a pre- and post-test basis. Data analysis revealed that the conventional group's accomplishment in science among secondary school pupils differed significantly from the inductive technique. The inductive approach helped the learner engage properly in the learning process and provided a more efficient interaction among the students. Regarding the science achievement of secondary school pupils, the logical approach and conventional technique differed greatly. For the students, the deductive approach is easy because they have a prepared key to address the pertinent issues. There is no appreciable variation in scientific performance among secondary school pupils when both deductive and inductive approaches are taught. Therefore, it was advised that instructors should embrace the inductive approach as it allows efficient interaction between students and helps learners to engage properly in the learning process.

Hypotheses

The following null hypotheses were developed to guide the study and were tested at a significance level of 0.05:

1. There was no significant difference between the effects of inductive and deductive inquiry teaching approaches on students' cognitive achievement in Metalwork.
2. There was no significant difference between the effects of inductive and deductive inquiry teaching approaches on students' psychomotor achievement in Metalwork.

RESEARCH METHOD

A quasi-experimental design was adopted in this study. This study was conducted in Niger. The specific population for this study was 115 Technical College (TC) II students offering

metalwork courses at four state government Technical Colleges in Niger State. The data was obtained from the Vice principal academic office of each technical college. Since they had studied metalwork in their first year and should have known the fundamental knowledge of metalwork terms, concepts, and methods, TC II students were chosen.

A simple random sampling technique was used to select four out of seven Technical Colleges in Niger State and assign them to experimental group 1 (deductive inquiry) and experimental group 2 (inductive inquiry). The colleges assigned to experimental group 1(deductive inquiry) are Minna and Kontagora, and the colleges assigned to experimental group 2 (inductive inquiry) are Bida and Suleja. All the TC II Metalwork students in the four Technical Colleges constitute the sample for the study because a quasi-experimental study according to Shadish et al. (2008) says that the researcher needs a random sample of participants to make the test as fair and unbiased as possible. Participants should be randomly selected from the population and then randomly assigned to either the control or experimental group.

The instruments that were used for data collection in this study are the Metalwork Cognitive Achievement Test (MCAT) and the Metalwork Psychomotor Achievement Test (MPAT). The items of the instruments were adopted from NABTEB General Metalwork Paper 1. Past questions on metal joining were used as MCAT and were used to test the students' cognitive achievement in Metalwork. The National Business and Technical Examination Board (NABTEB) has confirmed the contents of these items. Using topic experts and professional test developers, NABTEB sets its questions and subjects the produced items to many phases of validation and standardizing of tests. Furthermore, MCAT was conducted by professionals from the Department of Industrial Technical Education, University of Nigeria, Nsukka, and Federal University of Technology, Minna for face and content validation.

The MCAT's test-retest reliability was determined using Pearson Product Moment Correlation coefficient, and the result was 0.83. Two raters allow one to determine MPAT stability by applying Kendall's Coefficient of Concordance The inter-rater reliability was 0.82.

The research question data were analyzed via descriptive statistics using the mean, and the hypotheses were tested using ANCOVA, an inferential statistic. The research questions were answered using the means of the pretest, posttest, and retention learning test scores. The two groups (Inductive inquiry and deductive inquiry) were compared based on their pre-test and post-test mean gains to determine which performed better. At a significance level of 0.05, the hypotheses were tested using Analysis of Covariance (ANCOVA). ANCOVA adjusts for differences between groups in pre-test variables. ANCOVA is a suitable statistical method for analyzing experimental differences between treatment effects on dependent variables given that students remained in their original groups. If the calculated F value is less than or equal to the critical F value, the hypotheses are accepted. The hypotheses were not supported.

FINDINGS AND DISCUSSION

Table 1: Mean and Standard Deviations of Deductive and Inquiry Teaching Approaches' Means and Standard Deviations on Students' Cognitive Achievement in Metalwork

VARIABLES Group	N	Pre-test x	SD	Posttest $\bar{x}$	SD	Mean Gain
EXPERIMENTAL 1	56	41.46	7.066	68.59	6.237	27.13
EXPERIMENTAL 2	59	39.56	7.722	68.02	8.625	28.46

The results presented in Table 1 show the mean (□(x̄)) and standard deviation (SD) of achievement scores for experimental group1 (Deductive Inquiry Teaching Approach) and experimental group2 (Inductive Inquiry Teaching Approach). From the results, the pre-test mean and standard deviation of experimental group1 and experimental group2 are 41.46± 7.066 and 39.56± 7.722 respectively while the posttest mean and standard deviation of experimental group 1 and experimental group2 are 68.59± 6.237 and 68.02± 8.625 respectively. This gave a mean gain score of 27.13 and 28.46 for the groups, respectively, and the difference in the mean gain of the two groups was 1.33 in favor of experimental group 2 (Inductive Inquiry Teaching Approach). This indicated that experimental group 2, which was taught using the inductive inquiry teaching approach, had a slightly higher mean gain than experimental group 1, which was taught using the deductive inquiry teaching approach.

Table 2: Mean and Standard Deviations of Inductive and Deductive Inquiry Teaching Approaches' Means for Students' Psychomotor Achievement in Metalwork

VARIABLES Group	N	Pre-test $\bar{x}$	SD	Posttest $\bar{x}$	SD	Mean Gain
EXPERIMENTAL 1	56	49.26	7.912	69.10	9.106	19.84
EXPERIMENTAL 2	59	48.40	7.867	73.88	8.817	25.48

The results presented in Table 2 show that the pre-test mean and standard deviation of experimental group1 and experimental group 2 are 49.26 ± 7.912 and 48.40 ± 7.867 respectively while the mean (□(x̄)) and standard deviation (SD) of the psychomotor achievement scores for experimental group1 (Deductive Inquiry Teaching Approach) and experimental group2 (Inductive Inquiry Teaching Approach) are 69.10 ± 9.106 and 73.88 ± 8.817 respectively. This gave a mean gain score of 19.84 and 25.48, respectively, and the difference in the mean gain of the two groups was 5.64 in favor of experimental group 2 (Inductive Inquiry Teaching Approach). This indicated that experimental group 2, which was taught using the inductive inquiry teaching approach, had higher psychomotor achievement than experimental group 1, which was taught using the deductive inquiry teaching approach.

Table 3: Summary of Analysis of Covariance (ANCOVA) on Students' Cognitive Mean ($\bar{x}$) Achievement in Inductive and Deductive Inquiry Teaching Approaches in Metalwork

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	24.590	2	12.295	.214	.808
Intercept	18091.758	1	18091.758	314.671	.000
Pretest	15.179	1	15.179	.264	.608
Group(Achievement)	12.554	1	12.554	.218	.041
Error	6439.358	112	57.494		
Total	542858.000	115			
Corrected Total	6463.948	114			

Table 3 shows that F = 0.218 caused by the influence on the achievement of experimental groups 1 and 2 has a significant value of 0.041. F is of great importance at any value below or equal to 0.05. Thus, from the table (P=0.041; p=0.05). Thus, the null hypothesis—that there is no appreciable difference in the impact of inductive and deductive inquiry teaching strategies on students' cognitive accomplishments in Metalwork—is disproved. Accepted as an alternative theory, students' cognitive performance in Metalwork differs significantly depending on the method of

inductive or deductive investigation.

Table 4: Summary of Analysis of Covariance (ANCOVA) on Psychomotor Mean ($\bar{x}$) Achievement of Inductive and Deductive Inquiry Teaching Approaches in Metalwork

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	655.796	2	327.898	4.043	.020
Intercept	18412.574	1	18412.574	227.007	.000
Pretest	1.189	1	1.189	.015	.904
Psychomotor Achievement	636.695	1	636.695	7.850	.006
Error	9084.326	112	81.110		
Total	596434.000	115			
Corrected Total	9740.122	114			

Table 4 shows that the influence on the psychomotor mean accomplishment of experimental group 1 and experimental group 2 generated F = 7.850, which was significant at 0.006. F is of great importance at any value below or equal to 0.05. Based on the table, (P=0.006; p=0.05), the null hypothesis—that there is no appreciable difference between the influence of inductive and deductive inquiry teaching styles on students' psychomotor success in Metalwork—is disproved. Accepted as an alternative theory, the influence of inductive and deductive inquiry teaching strategies on students' psychomotor success in Metalwork differs significantly.

Findings

1. Experimental group 2, which was taught using the inductive inquiry teaching approach, achieved a slightly higher achievement than experimental group 1, which was taught using the deductive inquiry teaching approach. The difference in students' cognitive achievement in Metalwork was found to be significant.
2. Experimental group 2, which was taught using the inductive inquiry teaching approach, achieved higher psychomotor achievement than experimental group 1, which was taught using the deductive inquiry teaching approach. The difference in students' metalwork psychomotor achievement was found to be significant

Discussion

Research question 1 was answered using the information in Table 1. According to the data, the inductive inquiry educational technique was more successful than the deductive inquiry one in raising students' cognitive performance; nevertheless, both approaches were successful. Mean scores exceeded those of students taught using a logical inquiry educational technique. Along the same lines, the examination of covariance applied to test the first hypothesis expressed in Table 3 Confirmed that the effects of inductive and deductive inquiry instructional approaches on the cognitive achievement of metalwork students were statistically significant. This result demonstrated that in terms of increasing the cognitive performance of metalwork students, inductive research is more successful than deductive research. The results of the research carried out by Ogbuanya and Owodunni (2013) to ascertain the effects of reflective (inductive) inquiry on students' achievement and interest in Radio Television and Electronics Work (RTVE) in Technical Colleges indicate that reflective (inductive) inquiry is more effective than the conventional (deductive) technique in improving students' achievement and interest in RTVE. Likewise, the results of the research agree with those of Pesek and Kirshner (2000) on investigative methods to learning and later student understanding indicate that when direct instruction comes before

investigation, students learn less and overlook significant conceptual connections. Students exhibit a considerably higher capacity to conceptualize the mathematics they are taught when exploratory opportunities take the front stage before direct teaching. In this sense, investigations should precede direct teaching so that students can create their own knowledge and draw significant links between what they are taught by the teacher and what they know from experience.

Consequently, the treatment offered to the students in the inductive inquiry group determines the outcome of this research in terms of their cognitive performance. The results could be justified by the fact that teachers' adoption of several instructional strategies (such as active learning, cooperative learning, and self-assessment) in the inductive and deductive classrooms appealed to the students' different intelligence and engaged them in the learning process, which enhanced their memory and increased their motivation to learn. The results could also be explained by the fact that giving students the opportunity to participate actively in the class through free interaction with the teacher and their peers and allowing them to learn in groups and assess their performance themselves improved their ability to explore issues and articulate their own ideas. This, in turn, improved their learning and thinking abilities, leading to a deeper understanding of the difficult technology concepts and principles associated with Metalwork. This implies that students in the inductive approach remembered and applied more of their learning than the other group of students that were taught through the deductive approach.

The analysis of the results of the psychomotor test presented in Table 2, which provided answers to research question 3, showed that students who were taught with the inductive inquiry instructional approach had a higher mean score than those who were taught using the deductive inquiry instructional approach in the psychomotor achievement test. The analysis of covariance presented in Table 7 confirmed that the difference in the mean scores of the students between the two groups was significant. The finding is similar to the finding of Suryanmysih (2011), which found that adoption of a guided inquiry instructional approach in the teaching of chemistry improved students' psychomotor achievements, among other achievements, than modified direct instruction. The effectiveness of the inductive inquiry instructional approach compared to the deductive inquiry instructional approach may probably be due to the fact that students are able to do with minimal guidance from teachers after their introduction to the basic concepts underlying the performance of such tasks. Moreover, deductive inquiry students were more passive than their guided peers because these students were initially led by their teachers.

CONCLUSIONS

This research was intended to determine how an inquiry-based learning method affected technical colleges' metalwork students' performances. The method of inquiry-based learning used in this research significantly influenced students' metalwork learning process. The cognitive and psychomotor performance of the students revealed this.

In other words, the study revealed that both deductive and inductive inquiry educational strategies were successful at increasing metalwork student performance. Nevertheless, the inductive inquiry strategy was better than the deductive one. The study also revealed notable variations in the performance of pupils taught using inductive versus deductive inquiry. When students were allowed to actively engage in classroom teaching and learning by engaging with instructors, learning environment, and peers while working and learning together in groups, their attention was raised, they studied metalwork, and they gained psychomotor skills better. Students also retained their knowledge for a longer period when they were allowed to consider many answers to a problem while working together on practical projects using actual tools, equipment, and machinery. If inquiry-based learning is taken into account in the teaching and learning of Metalwork in the Technical Colleges, craftsmen trained will graduate from the Colleges with

knowledge, psychomotor skills, strong problem-solving skills, creative thinking, collaborative work, and independent decision-making skills, which will make them adaptable to the present and envisaged changes in the metalworking industry occasioned by technological advancement. Consequently, the artisans created using an inquiry-based learning method would be able to advance their education and pass their NABTEB tests with higher marks, thereby contributing to the industrial growth of Nigeria and acting as employers of labor instead of job seekers.

LIMITATION AND FURTHER RESEARCH

The possible variation in teaching quality across teachers limits this research and might influence the use and success of inductive and deductive inquiry teaching strategies. Furthermore, the particular setting of technical institutions in Niger and the sample size might limit the generalizability of the results to other areas or technical disciplines, therefore confining the outcomes of the research. The results could also be influenced by variations in students' previous knowledge, drive, and learning style as well as by limited resources and tools accessible for metalwork practice.

Suggestions for further studies

Based on the findings of the study, the following topics were suggested for further study:

1. The effects of inductive and deductive inquiry teaching approaches on metalwork achievement were compared across regions or states in Nigeria.
2. Conducting longitudinal studies to examine the long-term impact of inductive and deductive teaching approaches on students' retention of metalwork concepts and their practical skill development would provide valuable insights into the sustained effectiveness of these methods.

RECOMMENDATIONS

These suggestions were developed based on the results of this research:

- Technical College Teachers should use an inquiry-based learning strategy in their metalwork instruction.
- The National Board for Technical Education should consider reviewing the curriculum for Metalwork with a view to incorporating an inquiry-based learning approach into the teaching of Metalwork;
- Governments and industries should provide the tools, machines and consumable materials needed to teach the state–of – the arts Metalwork in the Technical Colleges;
- Science and technical schools boards and administrators of Technical Colleges should organize seminar, conferences and capacity building workshops.

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