Project Based Learning to Enhance Environmental Education through Automobile Mechanics

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Purpose: The purpose of the chosen project was to apply the principles of Problem-based Learning (PBL) to plans for curriculum renewal reliant on project-based learning events within the Cuban Vocational Training sector.
Methods: Examinations of the baseline and diagnostic assessments, lesson observations and the teaching experience of the authors revealed different perceived limitations in the initial education of Cuban skilled workers and technicians. There was a need to develop a novel approach to projects undertaken by students.
Results: Six implementation phases involved students identifying problems; analyzing human and other resources needed; proposing actions involving theoretical and practical action plans; execution of plans; presentation of results. Project evaluation was proposed: A variety of assessment methods were used such as self-assessment, peer assessment and group assessment where not only the results are assessed but also the whole process and development of skills, values and attitudes.
Conclusion: This curriculum renewal process reliant on PBL philosophy showcased an example of Work-integrated learning and provided insight on what can be done in terms of contributing to sustainable development at a school and community level. It involved engagement of teachers with some key elements of PBL pedagogy as an example of Automobile Mechanics Project based on the Cuban educational context. This approach ensured students acquired not only subject content knowledge but also skills and attitudes to meet complex demands in their chosen field.

Keywords: Sustainable development; Pollution; Project based learning; Automobile mechanics

Review Article

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INTRODUCTION

Developments within younger generations requires Technical and Vocational Education and Training (TVET) institutions create a competent, adaptable and innovative workforce, contributing to sustainable development. This is justified by the fact that those institutions prepare individuals for their initial entry into employment and provide upgrade training for the employed individuals. Learning in the 21st Century should ensure learners not only have knowledge and skills but the ability to meet complex demands by drawing on and mobilizing resources to solve professional problems in particular contexts. These issues led the authors to pose the following question:

How are learning activities taking place in the TVET institutions?

The results of the baseline and diagnostic assessments, as well as lesson observations within an evaluation project revealed different perceived limitations in the initial education of Cuban

skilled workers and technicians. The project was implemented as part of the teacher training and development program offered by Las Tunas University in partnership with Las Tunas Department of Basic Education to different TVET institutions. These limitations are:

- Teachers frequently present fragmented subject content that is decontextualized from real life situations.
- Teachers persistent use of traditional problems; this is not enough to promote the development of skills to approach novel situations and deal with real life problems.
- Occasionally, problems are solved and the field of application is not taken into consideration.
- During lessons, teachers do not draw attention to real life application of concepts. These limitations in approach of teachers negatively impact on students because:
- Students solve problems mechanically or without a deep understanding of theories.
- Students are unable to solve real life problems.

This situation shows contradictions between the demand for preparing a technically competent and skilled Cuban workforce and the preparation of TVET teachers.

Given the above, the following problem was identified: What would lead to improvements in the educational preparation of Vehicle Service Technicians who need to solve the diversity of professional problems they face in workshops?

Considering that most of Cuban vehicle and transport infrastructures are underdeveloped and have been used for more than 20 years this has had a significant impact on the environment (Cuesta Santos, et al., 2019). Vehicle Service Technicians were therefore taken as a priority to develop environmentally sound education projects.

PROJECT BASED LEARNING

This article looks at the problem outlined above through the lens of project-based learning (PBL) pedagogy. PBL engages students with learning and school through active exploration of real world problems and challenges. Students explore, make judgments, interpret, and synthesize information in meaningful ways (Harun, 2006). The authors provide an overview of how TVET teachers embraced some key issues regarding PBL pedagogy and an example of their efforts with PBL implementation based on the Cuban educational context.

To begin a literature review showed that the roots of PBL were in the progressive educational movement which promoted more student involvement and engagement (Peterson, 2012). It was recognized that William Heard Kilpatrick developed the ¨Project Method¨ inspired by the philosophy of John Dewey (Chipman & McDonald, 1980). Evidence also highlighted the concept of learning through projects that was developed in the 17th and 18th centuries (Knoll, 1997).

We then asked How is PBL defined? Research on this topic showed that PBL is defined in different ways. Some authors considered it as a pedagogy, while other authors considered it as a pedagogical approach, an active style of learning, a type of inquiry-based learning, or a method.

For example, Bell defined PBL as "a student-driven, teacher-facilitated approach to learning because students pursue knowledge by asking questions that have attracted their natural curiosity" (Bell, 2010). On the other hand, "PBL is considered to be a particular type of inquiry-based learning where the context of learning is provided through authentic questions and problems within real-world practices" (Al-Balushi & Al-Aamri, 2014).

As stated by these two definitions, PBL is student-centered and it places students in the active role of problem solvers but it is seen as a learning approach based on the concept of inquiry-based learning.

For our context and project oriented purpose, the definition of PBL as a method was assumed.

"PBL is a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge" (Buck Institude of Education, 2018).

As stated by (Knoll, 1997) "The project is one of the standard teaching methods. It is generally considered a means by which students can (a) develop independence and responsibility, and (b) practice social and democratic modes of behavior".

Knoll definition reinforces the idea of PBL as a student-centered teaching method but it introduces other elements such as the development of attitudes and values.

PBL is student driven, (Bell, 2010) and that is why it usually begins with a driving question or real life problem which leads to the creation of an artifact (model, design, device, computer program, arts, etc.) by mean of completion a variety of tasks. The socialization aspects of the project are critical but enquiry processes involve written and oral ways of summarizing the procedure used to produce the product and present the outcomes. The following benefits of PBL were part of what we hoped to achieve:

- Provision of an integrated approach to understanding concepts and knowledge.
- Development of practice and research (evidence-based) skills.
- Facilitation of collaborative learning and team work.
- Facilitation of interdisciplinary work (connections across different subjects).

- Provision of stronger and more relevant preparation for practice.
- Improvement in learner engagement in school.
- Strengthening of learner motivation and interest.
- Making learning experiences more relevant and meaningful.
- Allowing teachers to assign projects for students with a diverse variety of interests, motivations, intelligences, learning styles, abilities, career aspiration and personal backgrounds.

Thus we posed another question: What must a project have in order to be considered PBL?

These are some design principles of PBL (Thomas, 2000).

- Centrality of core curriculum elements consistent with PBL methodology.
- Driving Questions: PBL methods are focused on real life questions and problems which catch student attention and "drive" students to propose solutions considering the central concepts of PBL and the principles underpinning a discipline.
- Constructive Investigations: PBL involves students in a constructive investigation, in this way, students are familiarized with the scientific method and current scientist activities.
- Autonomy: PBL methods are student driven and the teacher plays the role of facilitator or mentor.
- Realism: PBL events are not simple learning activities to be covered during a lesson. The approach enables students to look at real world challenges.

To implement PBL as a project different phases need to be considered (Tellez Lazo, 2005):

First phase: Identification of the problem or driving question. The problem can never be imposed by the teacher. The students are free to choose the problem to be investigated but it must be in accordance with the core curriculum elements and the needs of the school and the company in which it will be implemented.

Second phase: Analysis of necessary human and materials resources. It is important to analyze the availability of material resources to complete the project as well as the class in terms of diversity (Intelligence, learning styles and economic, educational and cultural backgrounds).

Third Phase: Design of action plan - These actions are planned from theoretical and practical points of view. PBL is student driven and that is why the teacher serves as a facilitator guiding this phase. Students would be more committed with the project if they have an active role in deciding activities (Harun, 2006).

Fourth Phase: Execution of designed actions. This is the longest phase. Here, individual and group work take places. The students socialize to achieve the results in collaborative ways. As the objectives of the project are achieved, professional and research skills are developed.

Fifth Phase: Presentation of results. Students write about and present the results. This is important to develop language skills.

Sixth Phase: Project evaluation. A variety of assessment methods are used such as self-assessment, peer assessment and group assessment. Not only the results are assessed but also the whole process and development of skills, values and attitudes.

These phases can be summarized in the Project Based Cycle (see Figure 1).

AUTOMOBILE MECHANICS EXAMPLE

Project overview

Pollution is a serious problem. Scientists are now worried about its influences in changing the Earth's atmosphere because of carbon dioxide emissions from cars and industry. If we do not do something quickly, the Earth's ecosystem, including its weather, might be quite different in the next centuries. Every year the burning of fossil fuels and tropical forests releases over ten billion tons of carbon into the atmosphere (UN, 2018).

One needs to ask: Is life experience really better than it was a hundred years ago? It is certainly true that people live longer than they used to, travel faster than they could and own more things than they did. Humans have made great progress in industry, science, technology and medicine but we still have to tolerate noise and bad air which are critical challenges of modern life. Industry and modern life do not have to be enemies of beauty. Progress does not need to be aggressive. It does not have to destroy nature. We can have both beauty and progress if we really want this. We need clean rivers and open countryside just as much as a hundred years

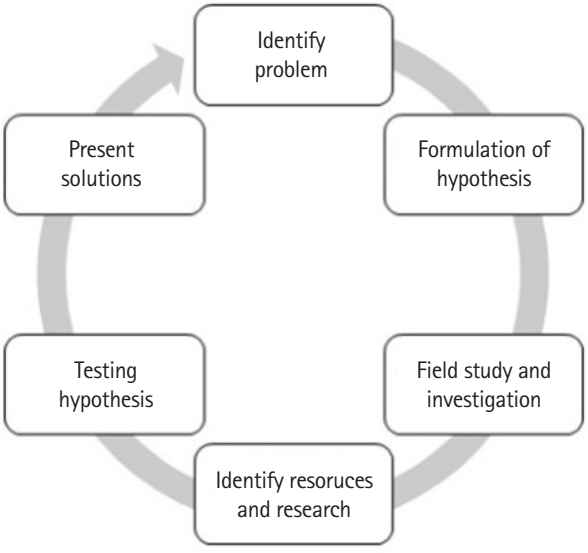

Figure 1. Project Based Learning Cycle

ago. Perhaps, in some ways, we need them even more. Things like open land, clean water and good air are becoming unusual and infrequent all over the world. These environmental changes have brought the international community to adopt global, regional, national and local measures to prevent and control its impacts (Statistics and Information National Office, 2015).

For these reasons, the following project was proposed; it takes place at the service workshop of the Municipal Transportation Company in Jobabo Municipality, Las Tunas province, in the Republic of Cuba. This Government Company is responsible for the urban and rural public transportation within the municipality and its workshop serves as a classroom to carry out the practical lessons of "Manifiesto de Montecristi" Technical and Vocational School and the place where learners develop their volunteer community service.

The staff of this workshop did not accomplish the Environmental Security Standards concerning oils, greases and residual fuels disposal during maintenance and reparation of the motor vehicles and they do not have the grease traps that are established protocols. Lubricants and fuels were spilled and spread out all over the ground and mixed with water, polluting the soil, underground and runoff waters. Any grease that enters to grease trap or interceptor is called 'brown grease'. This grease needs to be disposed of appropriately. This recovered grease is often suitable for recycling in to bio-diesel and thus it can have some value.

Driving Question/Problem

The key question was "How do practitioners improve achievement of the Environmental Security Standards, implement sustainable measures concerning oils, greases and residual fuels disposal during maintenances and reparations of motor vehicles?"

The project outlined provided students interested in sustainable development with the foundational concepts for engagement with the future sequence of courses such as those available to automobile mechanics, mechanics, other practitioners eg those involved with pollution, conservation, recycling, maintenance of safety and security rules.

Hypothesis

The following hypothesis was proposed:

If sustainable measures concerning oils, greases and residual fuels disposal during maintenance and reparation of motor vehicles are used, the Environmental Security Standards in the workshop area and the community would be improved.

General objective

Upon completion of this project, students should be able to use critical thinking processes to develop a system for maintenance and reparation of motor vehicles that incorporates basic ecological principles and sustainable management practices which contribute to the development of values such as love for nature, friendship and responsibility; under supervision of senior teachers and technicians.

Specific objectives

To develop enquiry and processing skills that will enable students to assume roles that enable them to:

- Identify the key principles of sustainable development.
- Describe several different models of sustainable development.
- Apply the principles of sustainable development and environmental friendly measures during reparation and maintenance of motor vehicles to keep them in good running conditions.
- Observe the global, regional, national and local environmental regulations.
- Examine vehicles to ascertain the nature and location of defects either by running engine or driving vehicles on road to prevent environmental damages during its operation.
- Dismantle partially or completely defective unit or parts of vehicle such as engine, gear box, rear axle, front axle, steering assembly, radiator, etc. according to nature of repairs to be done, using hoist, jack, pullers, hand tools and other devices applying safety and environmental friendly measures.
- Lubricate joints, tighten loose parts, test performance of vehicle by driving on road and make necessary adjustments to attain desired safety and national environmental standards.
- Execute techniques concerning oils, greases and residual fuels disposal during maintenances and reparation of motor vehicles.
- Explain how to avoid soil and water pollution arising from use of fuels and lubricants.
- Investigate the different chemical components of fuels and lubricants that pollute the water.
- Develop an environmental awareness.
- Examine, quantitatively and qualitatively, the amount of fuels and lubricants spilled during maintenances.
- Calculate the economic losses due to the spilling of the lubricants during maintenance.
- Socialize in projects in a way that results in collaboration with other community members and workers.

Group project requirements

To organize the group work in a manner consistent with PBL, we proposed the following requirements:

- Groups of no more than five will be formed to complete the group portion of the project and ensure effective involvement.

- Each member of the group will be given an area of responsibility.
- In case of a group with less than four members, each member may have more than one responsibility.
- In PBL it is important to place the student in the actual roles of the practitioners in the workplace. The roles were as follows:

Project leader: This member gets information to absent students, meets deadlines, fills absent members in, coordinates the efforts of the entire group, ensures that group members understand the functions/tasks, ensures that group members perform all assigned duties efficiently, supports other group members and readily provides additional assistance if needed.

Engineer: Main design ideas would come from this person; she/he works with the leader in assigning the various functions/ tasks to group members. She/he adopts safety measures, personally, for the tools, job and environment.

Vehicle service technician: Provides maintenance and repair for motor vehicles observing the Environmental Security Standards established.

Manager: This member develops the budget, ensures group stays on budget, keeps financial records, builds components as assigned.

Speaker/Communicator: This is the person who writes the report and presents the results of the project to other students and professionals in different scenarios, local and national events organized by the Department of Basic Education.

Topics and concepts

This project facilitates interdisciplinary work. Concepts from different subjects were integrated in situations/scenarios that were part of learning activities. For example:

Mechanics of Motor Vehicles: Internal combustion engine; Petrol Engine Basics; Gasoline Engine Basics; Exhaust emission test of petrol and diesel engine; Acoustic emission testing; Leak testing: Bubble emission testing, Air leak testing.

Environmental Factors: Soil pollution and conservation; Water pollution and conservation; Air pollution and conservation; Noise pollution.

Chemical Factors: Hydrocarbons; Fuels and combustion; Chemical components of fuels and lubricants; Exhaust emission gasses.

Mathematical Factors: Calculation of areas and volumes; Statistics.

Physical Factors: Measurements and Measuring instruments; Work, energy and power; Hydrodynamic; Thermodynamics; Combustion engines.

Biological Factors: Ecosystems; Conservation.

Economic Factors: Cost; Economic losses.

Materials and Resources

Maintenances Observation Guide; Tools; Lubricants; Automotive Vehicles; Automobile parts; Manual of Mechanics of Automotive Vehicles; Rules of Usage of Fuels and Lubricants; Real life objects; Pictures and videos; Computers and stationery.

Time Line

The project was completed in four months, over the Christmas term from September to December. The first and second weeks were dedicated to diagnosing the relevant issues around environmental and working conditions within the workshop. During the third and fourth weeks a literature review on sustainable development practices was made. The second and third months the learners provide maintenance and repair motor vehicles and executed environmental friendly techniques concerning oils, greases and residual fuels disposal during maintenances and reparations. The last month learners evaluated the results. The presentation of results to other students was held at the end of the fourth month but the presentation of results to other professionals in different scenarios, local and national events organized by the Department of Basic Education was held after complexion of the project according to the academic year calendar.

RESULTS

The authors reflected on the benefits and challenges of project implementation.

Benefits

Upon completion of the project the following benefits can be summarized.

The project using Work-integrated learning consistent with PBL principles:

- Implemented sustainable development and environmental friendly techniques concerning oils, greases and residual fuels disposal during maintenances and reparations of motor vehicles which contributed to conserve the soil and water not only in the workshop area but the community as well.
- Promoted an environmental and production awareness at a School and Community level.
- Provided students with an integrated understanding of the concepts and knowledge on sustainable development.
- Developed practical and research skills, views and attitudes within the student group.
- Facilitated interdisciplinary work (connections across different subjects).
- Improved student motivation.

- Made learning experiences more relevant and meaningful.
- Facilitated student use of processes of Practice and Inquiry-Based Learning and PBL.

Challenges

As every human activity, the project implementation was not perfect; some challenges arose:

- Some Vehicle Service Technicians underestimated learners' preparation and motivation and refused to share experiences with them.
- The students faced some concerns since they have to learn outside of school (field and home) with adults who are not trained educators such as Vehicle Service Technicians and Workshop Skill Workers.

Project valuation

This involved a range of appraisals of approaches to assessment and evaluation of the implementation of the project.

General rubric for project written reports

A rubric with seven indicators consistent with PBL to assess different levels of performance was proposed to evaluate the project written report (see Table 1).

General rubric for oral presentations of projects

A rubric with seven indicators and different levels of student performance was proposed to evaluate oral presentations of projects (see Table 2).

Table 1. General Rubric for Project written reports

Indicators	Levels of performance				
	Exemplary	Proficient	Satisfactory	Below standard	Unsatisfactory
Information sources	Used a variety of relevant sources (three or more different types and several of each type of source). Cited all sources.	Used many sources of two types. Cited all sources.	Used many sources of one type (e.g. textbooks, Internet, journals, magazines, questionnaire. Sources were referenced.	Two or three sources were used.	One source used and referenced.
Sources had data to support claims.	All sources (but one) had data to support claims.	Most sources had data to support claims.	Some sources had data to support claims.	One source had data to support claims.	No source had data to support claims.
Extracted relevant information.	All information extracted was relevant to the topic.	All information extracted was relevant to the topic. However, no information was given for one aspect.	Some relevant and some irrelevant information was extracted.	Little relevant information was extracted.	Little information was extracted; it was mainly irrelevant.
Paraphrased information.	All information extracted was paraphrased and well written.	Most information was paraphrased and well written.	Some information was paraphrased. However, copied portions were not indicated.	Most information was copied from sources.	All information was copied from sources.
Organized information.	Information was very clearly and sequentially organized. The position was logically stated with supporting data. Alternative points of view were included.	Information is clearly and sequentially organized. Logically stated position with supporting data.	Information was clearly and sequentially organized.	Information was sequentially organized.	Information was written haphazardly.
Synthesized	Project clearly and articulately showed: problem, hypothesis, method of research, literature reviewed, findings, analysis of findings, position.	Project showed: problem, hypothesis, method of research, literature reviewed, findings, analysis of findings, position.	Project showed problem, hypothesis, method of research, literature reviewed, findings, analysis of findings, position (one missing).	Project showed problem, hypothesis, method of research, findings.	Notes shown on aspects of the project.
Language	Write clearly and distinctly throughout the report, does not have writing errors.	Write clearly and distinctly throughout the report, have no more than two writing errors.	Write clearly and distinctly for most of the report, makes no more than two grammatical and writing errors.	Misuse key vocabulary, have more than two grammatical and writing errors.	Misuse key vocabulary, have more than ten grammatical and writing errors.
Grade	A 86 – 100	B 71 – 85	C 56 – 70	D 41 – 55	F 40 and lower

Table 2. General Rubric for oral presentations of projects

Indicators	Levels of performance				
	Exemplary	Proficient	Satisfactory	Below standard	Unsatisfactory
Preparedness	Completely prepared.	Seemed well prepared but could have spent more time rehearsing.	Somewhat prepared, but seems not to have rehearsed.	Did not seem prepared to present.	Appeared to have made no effort to prepare.
Time/length	Duration was for the required time.	Duration was longer or shorter than the time allotted by 0 – 20% of duration.	Duration was longer or shorter than the time allotted by 21 – 30% of duration.	Duration was longer or shorter than the time allotted by 31 – 40% of duration.	Duration was longer or shorter than the time allotted by 41 – 67% of duration.
Enthusiasm	Facial expressions and body language evoked a strong interest in and enthusiasm from the audience.	Facial expressions and body language sometimes evoked a strong interest in and enthusiasm from the audience.	Facial expressions and body language were used to spark interest and enthusiasm from the audience but the expressions seemed faked.	Very little use of facial expressions and body language. Did not evoke interest or enthusiasm from the audience.	Little enthusiasm was shown by the presenter(s).
Content information	Included the necessary information which was correct and current.	Included the necessary information which was correct.	Information included was correct. However, it included necessary as well as some unnecessary information.	Less than 50% of the required information was included.	Insufficient information was given, some of which was incorrect.
Language	Speaks clearly and distinctly throughout the presentation, does not mispronounce words.	Speaks clearly and distinctly throughout the presentation, mispronounced one and two words.	Speaks clearly and distinctly for most of the presentation, mispronounces key vocabulary or makes one or two grammatical errors.	Mumbles at one or two points, more than two grammatical errors.	Mumbles most of the presentation, mispronunciation and grammatical errors.
Effectiveness in making a point.	Song etc. was very effective in marketing its message.	Song etc. made a point strongly.	Song etc. made a point related to the topic.	Information in the song etc. was disjointed.	Lyrics did not portray a theme.
Creativity	A very high level of creativity shown.	A good standard of creativity shown.	Some creativity shown.	Creativity shown.	Little or no evidence of creativity is shown.
Grade	A 86 – 100	B 71 – 85	C 56 – 70	D 41 – 55	F 40 and lower

Project evaluation questionnaire

A questionnaire was developed for feedback from teachers (see Table 3 and 4).

CONCLUSIONS

This project was an example of Work-integrated learning that provides insights on what can be done in terms of contributing to sustainable development at a school and community level. It involved TVET teachers in engagement with some key elements of PBL pedagogy as an example of Automobile Mechanics Project based on the Cuban educational context, in which one of the atmospheric and air pollution source is the transport infrastructure running with obsolete motor vehicles. This approach ensured students acquired not only subject content knowledge but also skills and attitudes to meet complex demands; the project was drawing on and mobilizing resources to solve professional problems in a particular context with an interdisciplinary perspective. The example provided increased students motivation, participation and engagement and at the same time it contributed to outcomes consistent with deeper and more meaningful learning than otherwise might have occurred when students are exposed to more passive experiences.

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Table 3. Question 1. Below are a series of statements. Please respond by circling the number you feel most reflects your opinion

Items	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree
Indicator 1: Project Content and Organization					
1. The project objectives were clear.	5	4	3	2	1
2. The project workload was manageable.	5	4	3	2	1
3. The project was well organized (e.g. timely access to materials, notification of changes, etc.)	5	4	3	2	1
Indicator 2: Student Contribution					
4. Student attendance was good during the whole project.	5	4	3	2	1
5. Students participated actively in the project.	5	4	3	2	1
6. Students behavior was appropriate during the whole project.	5	4	3	2	1
Indicator 3: Learning Environment					
7. The learning environment encouraged participation.	5	4	3	2	1
8. The learning environment was conducive to learning.	5	4	3	2	1
9. The learning environment was conducive to researching.	5	4	3	2	1
Indicator 4: Materials and Resources					
10. The availability of materials and resources was appropriate.	5	4	3	2	1
11. Learning materials and resources were relevant and useful.	5	4	3	2	1
12. The provision of learning resources on the Web was adequate and appropriate.	5	4	3	2	1
Indicator 5: Assessment					
13. The methods of assessment were reasonable.	5	4	3	2	1
14. Feedback on assessment was timely.	5	4	3	2	1
15. Feedback on assessment was helpful.	5	4	3	2	1

This questionnaire is a survey evaluating projects as part of the institutional self-evaluation of "Manifiesto de Montecristi" Technical and Vocational Education School. The survey provides you an opportunity to evaluate the projects you were involved in the previous academic year. You are kindly requested to give your opinion trough filling in the questionnaire provided.

Table 4. Question #2: Indicate the level of achievement during the project

Items	Excellent	Very good	Good	Fair	Poor
Indicator 6: Knowledge					
16. Mathematics, Science, Humanities and professional disciplines.	5	4	3	2	1
17. Problem formulation and solving skills.	5	4	3	2	1
18. Collecting and analyzing appropriate data.	5	4	3	2	1
19. Ability to link theory to practice.	5	4	3	2	1
20. Computer knowledge.	5	4	3	2	1
Indicator 7: Communications Skills					
21. Oral communication.	5	4	3	2	1
22. Report writing.	5	4	3	2	1
23. Presentation skills.	5	4	3	2	1
Indicator 8: Interpersonal Skills					
24. Ability to work in teams.	5	4	3	2	1
25. Leadership.	5	4	3	2	1
26. Independent thinking.	5	4	3	2	1
27. Motivation.	5	4	3	2	1
28. Reliability.	5	4	3	2	1
29. Appreciation of ethical values.	5	4	3	2	1
Indicator 9: Work skills					
30. Time management skills.	5	4	3	2	1
31. Judgment.	5	4	3	2	1
32. Discipline	5	4	3	2	1

Thank you for the time to answer all the questions.

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