Application of Cues, Prompts, Probes, Questions and Gestures (CPPQG) in Physics Teaching and Learning

Ugwumba Augustine Okoronka¹, Kodjo Donkor Taale²,*

¹Department of Science Education, Adamawa State University, Mubi, Nigeria
²Department of Physics Education, University of Education, Winneba, Ghana
*Corresponding author: ktaale@yahoo.com

Received January 28, 2015; Revised March 03, 2015; Accepted March 18, 2015

Abstract This study was an action research using cues, prompts, probes, gestures and questioning strategy to remediate some learning difficulties of students in some physics concepts. This was done by collecting both quantitative and qualitative data using teacher constructed test. Pre-test, was used to assess students’ prior knowledge and post-test to determine the final state of the learners. A sample of 40 Level 200 Geography Education students of the Department of Science Education, Modibbo Adama University of Technology, Yola, Nigeria, participated in the study. The data collected were analysed using descriptive statistics, percentages, paired sample t-test and the correlation statistic. The results obtained showed an improvement in students’ understanding of basic concepts in optics, heat and mechanics. Students performed relatively better in optics (80% of the students) scoring 45% and higher; followed by thermal physics (heat) (70 %) and mechanics (50%). The post-test mean score was higher than the pre-test. Also, paired sample t-test was significant at 0.05 alpha level and df of 39. Similarly , a moderately high and significant correlation coefficient of 0.70 was calculated between the pre and post test scores. Based on the findings, it is recommended that teachers should integrate CPPQG into all forms of physics instruction in today’s changing world of technologies. This is a major way to make its learning “interesting” to the average learner who ordinarily may not be able to make the kind of “connections” expected in maximizing physics teaching and learning.

Keywords: cues, prompts, probes, gestures, Instructional Decision Making Tree, Transactional Model of Direct Instruction, physics teaching and learning


1. Introduction

Over the last two decades, trends in science pedagogy have focused on methods and techniques which tend to emphasize Science as an inquiry that is activity based, learner centred and socially contextualised [1,2]. The extent to which students are allowed to engage actively in the learning process determines both the quantity and quality of learning. Academic performance and achievement of students is by inference highly dependent on the approach of presenting information and how it is received by the students. The need for the learner’s active engagement in the learning process (personal construction of knowledge) is the hallmark of the theory of constructivism. This is with a view not only to arouse interest and inculcate positive attitude towards Science but also to improve students’ performance as well as create better understanding [3]. These ideas are in consonance with [4]’s principle of meaningful learning as opposed to the old order of rote learning. [5] had long identified three learner characteristics which account for about 25% of variance in school achievement attributable to the quality of instruction which students receive as cues, reinforcement and participation. Also, a primary purpose of providing quality instruction is for students to be successful on academic tasks [6,7]. When learners find it difficult understanding a concept, the way a teacher responds in correcting an error, or addressing a misconception can leave the students feeling either satisfied or helpless. Since this phase of the teaching and learning process is a shared responsibility between the teacher and his or her students, it can be called guided instruction. When well done, students usually feel some sense of support and teachers also feel that their efforts are being rewarded. According to [8], teachers must ensure that students have a successful learning experience, even if that means providing a direct explanation and giving the students the answer.

While cues deal with the clarity, variety, meaningfulness and strength of the teacher’s explanations; reinforcement refers to the amount of acknowledgement or social support which the learner receives for learning. Participation includes the extent to which students are allowed to engage actively in the learning process. Cues, Prompts and Probes readily perform these functions by...
facilitating and optimising Science/Physics teaching and learning.

When a teacher begins a lesson and poses a question to his/her students, he/she is checking the students’ understanding. The teacher may do this by using cues, prompts, probes, questions or gestures or a combination of these. Cues, also referred to as clues, are secondary stimuli which function as guides to response by way of perception or action to situation. In this respect, cues are techniques which teachers may use to trigger the previous knowledge of students thus functioning as hints to what students are about to experience. Cues when used in the classroom form part of the tacit or unspoken knowledge of the learner and shift his/her attention to the required information source. Cues are more direct and specific than prompts as they point attention to invisible/not so obvious details to a novice. Prompts are efforts/actions intended to instigate/move learners into action. They are intended to elicit written or oral/verbal responses on the part of students. They could come in form of questions (what, why, how, who, which, etc.) meant to guide students’ inquiry. Here, the teacher may supply the student with forgotten words or suggest to his/her mind (act prompting). Prompts are useful and necessary in a Physics/Science classroom to the extent that they help students develop skills such as listening, concept association, comparing and contrasting as well as making of inferences. Prompting/pretesting of relevant knowledge is said to be one of the general models of direct instructions [8]. Visual prompts and demonstrations are examples that have been applied to mediate between concrete and abstract concepts [9]. Probes (diagnostic probes) are prods or investigations which enable learners to examine an issue or topic at hand searchingly. They motivate students to focus clearly on the expected learning outcomes since they help to elicit and sustain interest. Probes provide explanation regarding students’ initial/previous understanding and form part of formative assessment activities. They should be short and inform the teacher if students are acquiring the concepts being presented or not. Questions are interrogative comments/sentences which inquire from a learner. It is a direct demand for an answer from the student by the teacher. Questions are used to assess what initial learning has taken place or stuck and what has not. Question of who, what, when, where and which (often called reproductive/recognition recall questions) draw on the first three lower levels of Bloom’s Taxonomy namely: knowledge, understanding and application. [10] have submitted that 85% of novice teachers use this type of questions while experienced teachers ask these questions 68% of the time. On the other hand, questions of why, how, suppose, justify and give an example (also referred to as higher order questions) are used less often in the classroom as they draw on the top three levels of Bloom’s Taxonomy viz.: analysis, evaluation and creativity. Questions in general should be used for elicitation, elaboration, clarification, inventive/divergent and heuristic purposes [8]. Questions can also stimulate deeper thinking, arouse curiosity, provoke and stimulate interest and inquiry and motivate students to seek new information, and spark additional questions, allowing for greater intellectual focus [11,12]; for effective use of questioning enable students to be engaged in the questioning process. The resultant effect is the benefit of clarification of concepts, emergence of key points, and enhancement of problem-solving skills. In using questions, teachers assess students’ knowledge, determine needs for focused re-teaching and remediation, and encourage students to think at higher cognitive levels [12]. According to [13], all learning begins with questions and thinking is not driven by answers but by asking quality and thought-provoking questions [14]. Also, according to [15], by classifying questions according to a particular system, a teacher may determine the cognitive level at which the class is working and make adjustments as needed and such questions should be adapted to students’ level of ability. Consequently, questioning techniques that encourage the widest spectrum of student participation should be used. Gestures are non-verbal/spoken (symbolic) expressions used by the teacher for communicating, negotiating, understanding and reasoning. Specifically, a gesture is a posture or body movement, an action especially of the hands expressing/intended to show inclination or disposition. Together with cues, prompts, probes, and questions, gestures assist students in making connections or associations which facilitate correct responses [16].

2. The Problem

It is a challenge to most students taking high school and further physics but it is well worth the effort because most modern technology involves Physics, that is any technology involving for example electricity, magnetism, force, pressure, heat, light, sound, optics comes from physics. Even though the basic knowledge required for products like fertilizers, drugs, plastics, and chemicals comes from chemistry and biology, these items have to eventually be manufactured, and manufacturing is dominated by physics-based technology [17,18,19]. Also, an understanding of physics leads to a better understanding of almost any other science. Like technology, virtually all branches of Science contain at least some physics. Physics has been called the most basic science and in many cases is required in order to understand concepts in other Sciences. Physics therefore is the basis for all types of analytical and measuring systems [17,18,19]. The current study investigated the effect of the application of cues, prompts, probes, questions and gestures in the instruction of Level 200 Geography Education Students of Modibbo Adama University of Technology, Yola, Nigeria. The research sample consisting of 40 students who had little or no second school Physics background and were required to take Level 200 General Science course with Physics as a core course based on the following curriculum: Mechanics, optics and heat (thermal physics). The purpose of the study was to determine the effect of integrating CPPQG into instruction by adopting [20] Transaction Model of Direct Instruction (TMI) and the Instructional Decision Making Tree (IDMT) by [21]. For more details see Figs 1 and 2 respectively. This was done based on the assumption that these tools are capable of making Physics learning interesting to these learners who ordinarily are not capable of making the kind of connections expected in maximizing Physics teaching and learning due to their poor background in secondary school physics. It is
anticipated that this will ultimately lead to improved performance of the students in the course.

Figure 1. The Transactional Model of Direct Instruction (Source: see [20])

Figure 2. Instructional Decision-Making Tree (IDMT) [Source: see [21]]

3. Methods and Instrument

The study adopted the action research methodology of McNiff (2002) which states that we:
• review current practice,
• identify an aspect that is to be improved,
• imagine a way forward,
• try it out,
• take stock of what happens and modify plan in the light of what is to be found, and continue with the ‘action’,
• monitor what was done,
• evaluate the modified action,
• [continue] until one is satisfied with that aspect of work done. (p. 7) [22].

The primary reason for engaging in action research is to assist learners in improving and/or refining their conceptions of physics concepts. The study participants were 40 Level 200 Geography Education Students (intact group) of the Department of Science Education, Modibbo Adama University of Technology, Yola, Nigeria participated. CPPQG were integrated into the face-to-face instructional format which is still very prevalent in the Nigerian University System. They were applied to remediate learning difficulties of this student set as opposed to other Level 200 students in the Department specializing in Mathematics, Statistics, Physics, Chemistry and Biology Education who have strong Physics background based on their secondary school certificate examination results. The General Science Course (SE 203) contains concepts in the following topics of Physics: mechanics, optics and thermal physics.

For example, after one of the teaching sessions on the equations of linear motion, that is, the one dimensional equations of motion for constant acceleration viz:

1st equation  
2nd equation  
3rd equation

using Figure 1 and Figure 2 as a guide, students were given the following question to test their understanding in using the equations of linear motion.

Question: If a car starts from rest and accelerates in a straight line at 1.6 m/s² for 10s, calculate:

i. its final speed
ii. how far has it travelled in this time.
If the brakes of the car are then applied and it travels a further 20 m before stopping, (iii) calculate its deceleration.

Student A was called to the board to answer the first part of the question. After a bit of hesitation, she was prompted to first write down the knowns and unknowns in the question and wrote acceleration, \(a = 1.6 \text{ m/s}^2\); time, \(t = 10\text{ s}\); \(v = ?\). She then went ahead to write the first equation of linear motion, \(v = v_0 + at\), and said there are two unknowns, \(v\) and \(v_0\). She was then cued to read the question again. She then realized that the car starts from rest so \(v_0 = 0\). Hence was able to solve the problem as:

\[ v = v_0 + at = 0 + 1.6(10) = 16.0\text{ m/s}. \]

Similarly, for (ii) and (iii), using prompts, cues, gestures and direct instruction, students were able to solve the rest of the problem using equations 2 and 3 as:

(ii) \(x = x_0 + \frac{1}{2}at^2\)
(iii) Initial speed, \(u = 16\ \text{ m/s}\), final speed, \(v = 0\), distance, \(x = 20\ \text{ m}\). So \(v^2 = v_0^2 + 2a(x - x_0)\)
\[ 0 = 16^2 + 2(-6.4)(20), \]  
and \(a = -256/40 = -6.4\ \text{ m/s}^2. \) Hence, deceleration = \(6.4 \text{ m/s}^2\).

The researchers used short answer tests to periodically gather quantitative data using pre- and post-tests to assess students’ prior knowledge and final state respectively before and after instruction. Qualitative data were obtained by analyzing students’ explanations for their answers / solutions in the posttest. These are however not reported in this paper.

The Data gathered during the instructional period was adapted from [23] Simultaneous Prompting Instructional Session. This instructional plan tells teachers whether (1) the prompt is providing enough support for the learner to do the target skill correctly, and (2) if the reinforcer is effective in eliciting the desired effect. As the lessons progress, the teacher can make instructional changes as and when required.
Table 1. Sample Data Sheet for Simultaneous Prompting Instructional Session (Source: see [22])

<table>
<thead>
<tr>
<th>Trial</th>
<th>Stimulus</th>
<th>PC</th>
<th>PE</th>
<th>NR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total #</strong></td>
<td></td>
<td><strong>40</strong></td>
<td><strong>40</strong></td>
<td><strong>40</strong></td>
</tr>
<tr>
<td><strong>Total %</strong></td>
<td></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Key: PC = prompted correct; PE = prompted error; NR = no response

4. Data Analysis and Results

Data collected were analyzed using percentages, descriptive statistics, paired sample correlation and paired sample t-test.

Table 2. Average performance of Periodic Tests on the concepts of mechanics, heat and optics using the Modibbo Adama University of Technology (MAUTECH)’s grading system (A: 70-100%; B: 60-69%; C: 50-59%; D: 45-49%; E: 40-44%; F: below 40%)

<table>
<thead>
<tr>
<th>Concept</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>9</td>
<td>40</td>
</tr>
<tr>
<td>Heat</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>13</td>
<td>7</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Optics</td>
<td>0</td>
<td>3</td>
<td>18</td>
<td>11</td>
<td>5</td>
<td>3</td>
<td>40</td>
</tr>
</tbody>
</table>

The result from Table 2 indicates students’ relative performance.
(i). Optics: 80% of the students scored 45% and higher.
(ii). Heat: 70% scored 45% and higher.

Table 3 shows that the mean score of the post test (x = 47.718) is greater than the mean score of the pretest (x = 31.555). This resulted in a mean gain of 16.163, showing an improvement in students’ scores. This could be attributed to the application of CPPQG barring all other intervening factors.

However, in order to determine whether the mean gain recorded was significant or not at alpha level p<0.5, a paired sample t-test was carried out. The result of the paired sample t-test is as shown on Table 4. The result indicates a significant t-test value of -8.949 for the degree of freedom 39.

Furthermore, a paired sample correlation coefficient was computed (Table 5) to ascertain the relationship between the pretest and post test performance of the students. A significant correlation of 0.698 was recorded. This moderately high value suggests that students across the board improved from the pretest to posttest which could be attributed to the instructional tool of CPPQG applied.

Table 4. Paired sample t-test

<table>
<thead>
<tr>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% confidence interval of the difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
</table>

Table 5. Summary of paired sample correlations

<table>
<thead>
<tr>
<th>N</th>
<th>Correlation</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>.698</td>
<td>.000</td>
</tr>
</tbody>
</table>

5. Conclusion

The improved performance of the Level 200 Geography Education students as recorded in this study in optics, thermal physics and mechanics components a science education course SE 203 for non-science major students provides empirical evidence which tends to indicate the potency of CPPQG not only in improving the performance of students but also in changing the negative attitude and low interest in physics by students. The tools/techniques of cues, prompts, probes, questions and gestures demand that the teacher functions to: design the learning environment; manage problem solving; and focus on how learners can make connections so as to foster new understanding in students. The teaching methods adopted by the Physics/Science teacher in conjunction with these techniques should ultimately be geared towards students’ responses, e.g. their ability to analyze, interpret and predict information. These are critical traits to meaningful learning in Physics in particular and Science in general. We therefore share the views of (18, p. 58) that “teachers must ensure that students have a successful learning experience, even if that means providing a direct explanation and giving the students the answer”. Based on the result, it is our view that if physics teachers integrate the tools of cues, prompts, probes, questions and gestures into physics instruction, students’ performance through active engagement may be improved. It is said that quality questioning enhances both teacher and student thinking and learning [23] and as observed by [24], students’ achievement increases when teachers ask quality questions.

References

In questions 2, 4, 6, 9 & 10, show how you arrived at the correct option.

1. Which one of the following is an SI base unit?
   A. gram
   B. newton
   C. kilogram

2. The mathematical relationship between three physical quantities is given by \( a = \frac{b^2}{c} \). If the dimension of \( b = [L] \) and the dimension of \( c = [T] \), which one of the following choices is the dimension of \( a \)?
   A. \([L]\)
   B. \(\frac{[L]^2}{[T]}\)
   C. \(\frac{[L]^2}{[T]}\)
   D. \([T]\)

3. Which one of the following quantities is a vector quantity?
   A. The age of the earth
   B. The number of people attending a soccer game
   C. The temperature of hot cup of coffee
   D. The earth's pull on your body

4. Starting from rest, a particle confined to move along a straight line is accelerated at a rate of 5.0 m/s\(^2\). Which one of the following statements accurately describes the motion of this particle?
   A. The speed of the particle increases by 5.0 m/s during each second.
   B. The particle travels 5.0 m during each second.
   C. The particle travels 5.0 m only during the first second.
   D. The acceleration of the particle increases by 5.0 m/s\(^2\) during each second.

5. Which one of the following statements concerning the buoyant force on an object submerged in a liquid is true?
   A. The buoyant force depends on the mass of the object.
   B. The buoyant force depends on the weight of the object.
   C. The buoyant force is independent of the density of the liquid.
   D. The buoyant force depends on the volume of the liquid displaced.

6. An object weighs 15 N in air and 13 N when submerged in water. Determine the density of the object.
   A. 330 kg/m\(^3\)
   B. 1.2 \times 10^3 \, \text{kg/m}^3
   C. 7.5 \times 10^3 \, \text{kg/m}^3
   D. 500 \, \text{kg/m}^3

7. Which one of the following temperatures is approximately equal to "room temperature?"
   A. 0 K
   B. 293 K
   C. 100 °C
   D. 100 K

8. Two cubes, one silver and one iron, have the same mass and temperature. A quantity \( Q \) of heat is removed from each cube. Which one of the following properties causes the final temperatures of the cubes to be different?
   A. specific heat capacity
   B. density
   C. volume
   D. latent heat of vaporization
9. A ray of light is reflected from two plane mirror surfaces as shown in the figure below. Determine the correct values of $\alpha$ and $\beta$?

<table>
<thead>
<tr>
<th>Value of $\alpha$</th>
<th>Value of $\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 26°</td>
<td>26°</td>
</tr>
<tr>
<td>B 26°</td>
<td>64°</td>
</tr>
<tr>
<td>C 38°</td>
<td>52°</td>
</tr>
<tr>
<td>D 64°</td>
<td>26°</td>
</tr>
</tbody>
</table>

10. An object is placed in front of a concave spherical mirror as shown opposite. The three rays 1, 2, and 3, leave the top of the object and, after reflection, converge at a point on the top of the image. Ray 1 is parallel to the principal axis, ray 2 passes through F, and ray 3 passes through point C. Which ray(s) will pass through F after reflection?

A. 1 only
B. 2 only
C. 3 only
D. both 1 and 2

Modibbo Adama University of Technology, Yola

School of Science and Technology Education

Department of Science Education

Post test Duration 1 hour

Instructions: Answer all questions

1. A car starts from rest and accelerates in a straight line at 1.6 ms$^{-2}$ for 10 s.
   i. Calculate its final speed?
   ii. How far has it travelled in this time?
   iii. If the brakes are then applied and it travels a further 20 m before stopping, calculate its deceleration?

2. (i) State the law of conservation of energy.
   (ii) Show that an object of mass, m, as it falls through a height $h$, its potential energy is converted to kinetic energy, but the mechanical energy has a constant value, namely, mgh.

3. (a) Sketch and explain the heating curve of water at -20°C to 120°C.
   (b) An object is placed 30 cm in front of a concave mirror of focal length 15 cm. By means of a ray diagram, determine the position of the image formed by the mirror.