EFFECT OF CONCEPT MAPPING AND GENDER ON STUDENTS' ACADEMIC ACHIEVEMENT IN PHYSICS IN CALABAR EDUCATION ZONE OF CROSS RIVER STATE, NIGERIA

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Abstract
The study investigated the effect of concept mapping strategy on academic achievement of 349 SSI Physics students. Two research questions and two hypotheses were formulated to guide the study. The study adopted a pretest, posttest, non-equivalent, control group quasi-experimental research design. Data collected using Physics Achievement Test (PAT) were analysed using ANCOVA statistics, with hypotheses tested at 0.05 probability level. Results of the study indicated a positive effect of concept mapping on students' achievement, as mean achievement score of students in the experimental group taught through concept mapping was higher than the mean score of students in the control group taught using lecture method. It also showed a significant difference in the mean scores of male and female students taught Physics using concept mapping strategy. Based on these findings, it was recommended that concept mapping should be adopted by physics teachers in secondary schools.

Keywords: Concept mapping, gender, students' academic achievement

Introduction

The role of science and, by extension, science education to national development cannot be overemphasised, hence the central position it occupies in school curricula at all levels of education. From the point of view of industrialisation, agricultural development and food security, commerce, transportation, communication and even warfare, a solid foundation of science is very paramount (Uche & Longinus, 2018). The goal of science education is to ensure that the teaching and learning of science concepts is at its best form. Taber (2009) asserted that the global aim of science education is to ensure that learners acquire the required knowledge, skills and attitudes that would be relevant to their future livelihoods. Science education is designed to guide the world towards a scientifically literate society and it is important for an understanding of science as it offers personal fulfillments and excitement (Olasehinde & Olatoye, 2014).

Physics is one of the natural sciences; and it is concerned with the study of matter, energy and the interaction among them over time and through space. The benefits derived from studying the subject and applying its principles to human life and the society are enormous, in terms of maintaining health, providing energy, communication, transportation, entertainment, manufacturing, building and construction, the stimulating economy, providing jobs, human comfort, among others. Johnson (2018) summarised this when he asserted that physics touches every aspect of human life and development. As enormous as the benefits of physics are to the advancement of the society and human comfort, students' academic achievement in the subject has over the years been reportedly low

with its attendant negative consequence such as frustration, anxiety, academic vices (Umoke & Nwafor, 2014; WAEC Chief Examiner's Report, 2016). The ugly trend in students' poor academic achievement in physics is reflected in external examination results like the West African Senior School Certificate Examination (WASSCE), National Examinations Council (NECO), Unified Tertiary Matriculation Examination (UTME), among others. For instance, in Senior School Certificate Examinations (SSCE) May/June 2014, physics recorded only 14.2% passes for distinction and credit grades, while 56.3% failed the subject (WAEC, 2014). This is an indication that students' academic achievement in physics is poor and not commensurate with the huge amount of resources invested in it.

A number of factors have been held accountable for the continued persistence of this hideous trend. These include: teaching methods, lack of teaching skills, inadequate instructional facilities, learning environment, students' attitude, gender, school location, among others. Several research findings have identified the teaching method adopted by the teacher as the major factor responsible for the under achievement (Oladejo, Olosunde, Ojebisi & Isola, 2011). Igbanugo (2014) maintained that students' interest in learning science could be enhanced by the teacher through careful choice of the most appropriate teaching methods. The researcher further asserted that the lecture method commonly used in teaching physics in Nigerian schools is boring and uninteresting. Ugwu and Nzewi (2015) maintained that the lecture method used in imparting knowledge which was found to be successful in the past appears to be outdated and has failed to produce the desired outcomes in contemporary students. This is because the method limits learners to passive involvement and rote learning which render them incapacitated when engaging in complex problem-solving activities. Okoye (2014) shares the same sentiment when he reported that the teaching and learning of physics have gone beyond the teacher standing in front of learners to disseminate information without the active participation of the learners. Rawatee (2014) stated that there is a disconnection between the ways of learning and the methods of teaching physics, and concluded that teachers used the same ineffective traditional teaching methods which result in producing half-baked physics students. Judging from the above, there is need for a radical shift to innovative teaching strategy to make up for the knowledge deficit noticed in learners.

Concept mapping is an innovative teaching strategy adopted by the teacher with a view to enhancing meaningful learning. Samba and Eriba (2012) defined it as the process of constructing a graphical representation of the concepts in question, showing clearly how the individual views the concept in his/her mind. Concept mapping strategy is enquiry-based, activity-based, student-centred and a minds-on approach that caters for individual needs and differences, learning styles, interest and abilities (Awofala, 2011). The strategy was first developed in the 1970s at Cornell University by Joseph D. Novak, based on Ausubel's theory of cognitive learning. Concept mapping strategy creates a rich social environment that encourages active participation, as learners work individually and collaboratively in small groups to discuss the meaning of concepts. The strategy advocates brainstorming, which enhances creativity in learners. Teachers play the role of providing the guide to enable students discover knowledge by themselves. The strategy is, therefore, very essential for teaching and learning at the different levels of education from primary to tertiary. Jack (2013) found a significant effect of concept mapping and reported that the strategy enhances students' academic achievement and retention in chemistry. Regarding the effectiveness of the strategy, Aziz and Rahman (2014), in their study, stated that the use of concept mapping strategy is more effective in enhancing students' achievement in science than the traditional lecture and discussion method. Awofala (2011) holds that the strategy will help encourage students and bridge the gap in science, mathematics and technology from primary to secondary schools. Concept mapping was considered based on the fact that

the strategy helps the teacher to identify the learning needs and the knowledge deficits of individuals. This study, therefore, sought to investigate the effect of concept mapping instructional strategy on SSI students' academic achievement in Physics in Calabar Education Zone of Cross River State, Nigeria.

Gender is a social or cultural construct and characteristics attributed to males and females. Available research evidence has reported gender disparity in relation to students' achievement gained in school subjects. Some researchers have found a significant difference in the achievement of male and female students in sciences (Aniodoh & Egbo, 2014; Giginna & Nweze, 2014). Okoye, Okongwu and Nweke (2015) conducted a research on students' interest as a correlate of achievement in chemistry and found that male students achieved higher in chemistry than females. Abdu-Raheem (2012) reported that males out-performed females in Mathematics, Science and social sciences. Both sexes performed equally in English, while females did better in Arts, except Yoruba. Also, Abukpa and Anyagh (2015) reported that male students outperformed their female counterparts in Mathematics word problem achievement, whereas female students obtained higher mean scores in reading ability test. Nnoli and Okafor (2017) reported that gender has no effect on students' learning achievement in science. Ihejiamaizu, Ekon and Neji (2017) and Ugwuanyi, Eze and Magbo (2017) shared the same view when they asserted that male and female students could perform equally well if subjected to similar learning conditions and environment. According to Neji (2013), gender stereotype affects choice of career, therefore, there is urgent need to adopt alternative teaching strategies to bridge this gap.

Statement of the problem

The issue of poor students' academic achievement in physics and other science subjects in Nigerian schools has been a recurring decimal, thus attracting the concerns of all and sundry. The problem is so pronounced that it has led to the widely acclaimed fallen standard of education in Cross River State and Nigeria at large. Students recorded percentage failure of 85.80%, 40.99% and 42.05% in SSCE physics in 2014, 2015 and 2016 respectively (SSEB, 2016). Empirical studies have identified a number of factors as being responsible for the continued persistence of this ugly trend. One of the major problems militating against students' academic achievement in physics is poor teaching strategies adopted by teachers (Oladejo, Olosunde, Ojebisi & Isola, 2011). In the light of the observed decay in academic achievement and the poor quality of students, which presumably is a multifaceted issue in Cross River State public secondary schools, one ponders if students' underachievement, poor quality and high failure rate is not a reflection of the instructional quality in the educational system. It is on this premise that this research was conducted, with the aim of investigating the effect of concept mapping strategy on academic achievement of students in Physics in Calabar Education Zone, Cross River State, using gender as a moderating variable.

Research questions

The following research questions were posed:

i. What is the difference between the achievement mean scores of students taught using concept mapping and those taught through lecture method?
ii. What is the difference between the achievement mean scores of male and female students taught using concept mapping strategy?

Research hypotheses

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

i. There is no significant difference between the achievement mean scores of students taught physics concepts using concept mapping and those taught through lecture method.
ii. There is no significant difference between the achievement mean scores of male and female students

taught using concept mapping strategy.

Methodology

As suggested by Kerlinger (1973), the pretest, posttest, non-equivalent, control group quasi experimental research design was adopted for the study. The design had one treatment variable (teaching strategy) as the independent variable and one moderator variable (gender). The dependent variable is academic achievement in physics. The design is as illustrated symbolically below:

Z_1	0_1	X_1	0_2	E
Z_1	0_1	X_2	0_2	C

E = Experimental group
C = Control group
0_1 = Pretest measurement before treatment
0_2 = Posttest measurement after treatment
X_1 = Treatment using concept mapping strategy
X_2 = Treatment using lecture method
Z_1 = Moderator variable of gender

Sample and sampling technique

Purposive sampling technique was used to select the four (4) schools that participated in the study. The sample comprised of three hundred forty-nine (349) SSI Physics students (157 males and 192 females). Also, the 349 sampled subjects had 188 students in the experimental group and 161 students in the control group.

Instrumentation

One instrument named Physics Achievement Test (PAT) was used for the collection of data. The 40-item PAT had sections A and B. Section A consisted of information on demographic variable of student's gender, while Section B comprised of 40-item multiple-choice objective test with 4 options lettered A-D. The PAT was constructed by the researcher, who later subjected the instrument to face and content validation by experts in Measurement and Evaluation. The reliability of PAT was ascertained by administering the test to 35 SSI physics students who were not part of the sampled subjects, and a reliability coefficient of 0.80 was obtained using Kuder-Richardson (K-R) formula 20 Estimate.

The instrument was administered to students in both the experimental and control groups as pre-test, before treatment to determine their knowledge level. Physics teachers from the selected schools, trained for one week, were used as research assistants. The experimental group subjects were taught selected physics concepts using concept mapping strategy, while lecture method was used to teach the sampled subjects in the control group the same topics. The treatment lasted for a period of six weeks, and at the end of the treatment, items in the pre-test were rearranged and administered as post-test to the same students in both groups, in order to determine the effectiveness of the treatment on students' academic achievement in physics.

Results

Question One: What is the difference between the achievement mean scores of students taught physics concepts using concept mapping and those taught through lecture method?

Table 1: Descriptive statistics showing mean scores of students taught selected physics concepts using concept mapping strategy and lecture method.

Variable	Group	N	Mean	S.D	Mean Difference
Concept mapping	Experimental	188	32.63	4.33	6.61
Lecture method	Control	161	26.02	5.14	

Table 1 above indicates a difference between the mean scores of students taught selected physics concepts using concept mapping and those taught through lecture method. The computed achievement mean scores for the experimental and control groups are 32.63 and 26.02 respectively, with a mean difference of 6.61. The implication of the above is that students in the experimental group had higher mean scores compared to their counterparts in the control group.

Question Two: What is the difference between the achievement mean scores of male and female students taught using concept mapping strategy.

Table 2: Descriptive statistics showing mean and standard deviation of male and female students taught selected physics concepts using concept mapping strategy.

Variable	N	Mean	S.D	Mean Difference
Males	83	31.62	4.99	3.67
Females	105	27.95	5.81	

Table 2 above indicates a difference between the mean scores of male and female students taught selected physics concepts using concept mapping strategy. The computed achievement mean scores of males and females in the experimental group are 31.62 and 27.95 respectively, with a mean difference of 3.67. This implies that male students outperformed their female counterparts because they had higher mean scores.

Hypothesis One: There is no significant difference between the achievement mean scores of students taught physics concepts using concept mapping and those taught through lecture method.

Table 3: Analysis of Covariance (ANCOVA) test statistic for students' post-test achievement mean scores in physics with pre-test as the covariate.

Source of variation	Sum of square	Df	MS	F-ratio	p-level
Corrected model	4283.725[a]	2	2141.862	102.513*	.000
Intercept	2474.716	1	2474.716	118.444*	.000
Pre-test	502.639	1	502.639	24.057*	.000
Group	3795.146	1	3795.146	181.641*	.000
Error	7229.198	346	20.894		
Total	316914.000	349			
Corrected Total	11512.923	348			

*Significant at P<0.05

When the mean achievement scores in Table 1 were compared using Analysis of Covariance, the obtained F-ratio of 181.641 with a p-value of .000 at 1 and 346 degrees of freedom at .05 level of significance indicated that the main effect of the treatment (concept mapping strategy) on students' academic achievement in physics was statistically significant. Thus, the null hypothesis, which states that there is no significant difference in the mean achievement score of SSI Physics students taught through concept mapping strategy and those taught using lecture method, was rejected and the alternative hypothesis upheld. The study concludes that the high significant difference between the groups' performance was as a result of the concept mapping strategy.

Hypothesis Two: There is no significant difference between the achievement mean scores of male and female students taught selected physics concepts using concept mapping strategy.

Table 4: Analysis of Covariance (ANCOVA) test statistics for male and female students taught selected physics concepts using concept mapping strategy.

Source of variation	Sum of square	df	MS	F-ratio	p-level
Corrected model	1394.085[a]	2	697.044	23.834*	.000
Intercept	3144.196	1	3144.196	107.512*	.000
Pre-test	236.287	1	236.287	8.080	.005
Gender	905.506	1	905.506	30.963*	.000
Error	10118.837	346	29.245		
Total	316914.000	349			
Corrected Total	11512.923	348			

*Significant at P< 0.05 level

The results of the analysis in Table 2 shows that the post-test mean score of 31.62 with a standard deviation of 4.99 obtained by the 83 male subjects was higher than the post-test mean

score of 27.95 with a standard deviation of 5.81 obtained by the 105 female students. When these mean scores were compared using Analysis of Covariance, the obtained F-ratio of 30.963 with a p-value of .000 at 1 and 346 degrees of freedom at .05 level of significance shows that gender has a significant effect on students' academic achievement in physics. Thus, the null hypothesis, which states that there is no significant difference between the achievement mean scores of male and female students taught selected physics concepts using concept mapping strategy, was rejected and the alternative hypothesis retained.

Discussion of findings

The result of the data analysis as presented in Table 3 indicates that there is a significant main effect of concept mapping strategy on students' academic achievement in physics since the experimental group students had a higher mean score than the control group students. The difference in the achievement recorded by both the experimental and control groups can be attributed to the potency of the teaching strategy adopted in each group. Thus, a significant positive effect exists in favour of the experimental group because of the treatment (concept mapping strategy). The effectiveness of concept mapping instructional strategy in enhancing students' learning and academic achievement in study corroborates the results and findings of previous studies. This result was found to be consistent with the findings of Neji and Nja (2013) who reported that concept mapping strategy enhances students' academic achievement and retention in chemistry. The result of their work indicates that students taught selected chemistry concepts using concept mapping strategy perform significantly better than those taught with the expository method. The results also agree with the findings of Jack (2013) who found concept mapping as effective teaching method for teaching difficult chemistry concepts since it improved students' performance and retention. The finding of Ihejiamaizu, Ekon and Neji (2017) is not different, as they reported that the use of concept mapping strategy enables the teacher teach effectively, while the students get deeper understanding of biology. Also, Aziz and Rahman (2014), in their study, stated that the use of concept mapping strategy is more effective in enhancing students' achievement in science than the traditional lecture and discussion method.

The analysis in Table 4 indicates that there is a significant difference between the mean achievement scores of males and females taught selected physics concepts using concept mapping strategy. This implies that sex has effect on students' mean scores and, by extension, their academic achievement when taught through concept mapping instructional strategy. This finding is in agreement with the study of Okoye, Okongwu and Nweke (2015) who researched on students' interest as a correlate of achievement in chemistry and found that male students achieved higher in chemistry than females. Abukpa and Anyagh (2015), in their study on the relationship between junior secondary school students' mathematics reading ability and achievement in mathematics word problems, reported that female students obtain higher mean score in reading test than male students, whereas male students outperformed their female counterparts in mathematics word problem achievement.

Conclusion and Recommendation

Based on the findings of the study, it was concluded that the two methods used in teaching indicated a significant positive effect on students' academic achievement in physics. However, students in the experimental group taught selected physics concepts using concept mapping strategy had a higher mean achievement scores, implying that they performed better than students in the control group taught through the conventional lecture method. The result further shows that male students achieve higher learning than female students when exposed to concept mapping strategy, because the mean achievement score of males was higher than that of their female counterparts. This shows that concept mapping strategy is more in favour of male students than

female students. It is, therefore, recommended that:

(i) Physics teachers should endeavour to incorporate concept mapping strategy into the mainstream of teaching pedagogy in order to enhance meaningful learning of the subject, and also employ the innovative teaching strategy in such a way as to eliminate gender disparity.

(ii) Government, as well as professional bodies like STAN, MAN, NERDC, should organise seminars, workshops and conferences for the training of physics teachers at secondary school level on the best way to implement the strategy.

(iii) Science educators, heads of department and school heads should also emphasise and encourage the use of concept mapping instructional strategy by physics teachers in preparing notes of lesson in order to enhance effective classroom lesson delivery.

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APPENDIX 1

PHYSICS ACHIEVEMENT TEST (PAT)
SECTION A

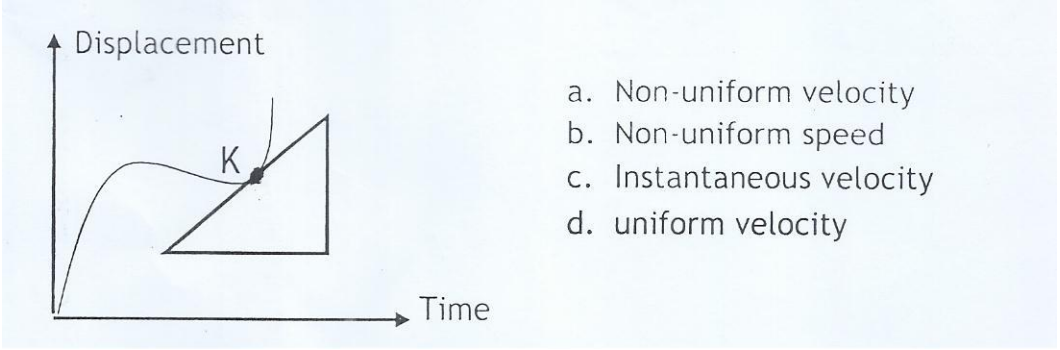
INSTRUCTION: Kindly supply the required information and also make a tick (√) on the box beside the option which bears your opinion.

1. Name of School:
2. Location of School: Urban [ ] Rural [ ]
3. Sex: Male [ ] Female [ ]

SECTION B

INSTRUCTION: Answer all questions by making a tick (√) on the correct option for each question.

1. The tyres of a car in motion have what type of motion. (a) Translational (b) Rotational (c) Oscillatory (d) Translational and rotational
2. Distance moved in a specified direction is known as (a) speed (b) displacement (c) distance (d) position.
3. The area under the curve of a velocity time graph represents (a) acceleration (b) velocity (c) total distance travelled (d) speed
4. Calculate the speed of a student who walked a distance of 3km in 20 mins. (a) 2.5m/s (b) 0.15m/s (c) 6.7m/s (d) 17m/s.
5. A car starts from rest and accelerates uniformly to a velocity of 36km/h in 5secs. What is the acceleration? (a) 7.2m/s^2 (b) 2m/s^2 (c) 5m/s^2 (d) 3m/s^2
6. The gradient of a displacement - time graph represents its (a) total distance (b) speed (c) velocity (d) acceleration.
7. A car moving at a constant speed of 10m/s for 50secs accelerates uniformly to a speed of 25m/s for 20secs. It then maintained this speed for 30secs before it was retarded to rest in another 20secs. Calculate the total distance covered in the journey (a) 1850m (b) 120m (c) 155m (d) 300m.
8. The rate of change of distance moved in a specified direction to time is (a) displacement (b) velocity (c) speed (d) acceleration
9. The gradient of the point K in the figure below represents:



10. A body moving round a circular path at a constant speed is said to have non-uniform velocity, why? (a) its motion is constant (b) the direction of velocity is constantly changing (c) acceleration is constant (d) all of the above.
11. A body at rest is given an initial acceleration of 6m/s^2 for 20secs after which the acceleration was reduced to 4m/s^2 for the next 10secs. What is the total distance travelled? (a) 2200m (b) 2000m (c) 220m (d) 200m

12. Starting from rest, a car accelerates uniformly for 5sec. to a velocity of 30m/s. It then travels with this speed for l5secs before decelerating uniformly to rest in 10secs. What is the retardation in the last phase of the journey?
    (a) 6m/s^2 (b) 2m/s^2 (c) 3m/s^2 (d) 4m/s$^{2.}$
13. The product of force and displacement in the direction of the force is
    (a) Power (b) Energy (c) Work (d) Moment.
14. A man did work of 120J by pulling a log of wood with a constant force of 50N over X distance. What is the value of X? (a) 2.4m (b)24m (c) 70m (d) 170m
15. A boy of mass 5kg runs up a set of steps of total height 4m. What work is done against gravity? (a) 12.5J (b) 200J (c) 54J (d) 2000J
16. Under which of the following conditions is work done?
    (a) carrying 100kg rice while standing in a platform
    (b) pushing against a stationary petrol tanker (c) holding a bucket of water (d) climbing a set of steps in the staircase of a building.
17. A man drags a log along a smooth horizontal floor with a constant force of 2N applied at 60° to the floor. The work done after a distance of 3m is (a) 6J (b) 5J (c) 4J (d) 3J
18. What is the work needed to stop a 20g bullet moving with a speed of 150m/s? (a) 225KJ (b) 225J (c) 200J (d) 3000J
19. The S I unit of work is (a) Joule (b) Watt (c) Newton (d) Volt
20. Calculate the work done by gravity on a solid of mass of 100kg which falls from a height of 4m (a) 400J (b) 25J (c) 40J (d) 4000J
21. The capacity to do work is termed (a) power (b) work (c) energy (d) force
22. A body of mass 4kg is projected vertically upward with a velocity of 5m/s. Calculate the potential energy at maximum height. (a) 20J (b) 50J (c) 9J (d) 1 .25J
23. What is the energy conversion that occurs when a stone is shot from catapult? (a) Kinetic energy of catapult is converted to potential energy of the stone.
    (b) Elastic P. E of catapult is converted into the K. E of the stone
    (c) Elastic P. E of catapult is converted into gravitational P.E of the stone
    (d) Gravitational P.E of catapult is converted into K.E of the stone
24. While in motion, a metal ball released from a height possesses (a) P.E only (b) K. E and P.E (c) K.E only (d) None of the above
25. A 2kg stone is thrown vertically upward until it attains a height of 2m. What is the velocity with which the stone hits the ground? Take g=10m/s^2
    (a) 6.3m/s (b) 4m/s (c) 2m/s (d) 10m/s
26. An 8kg stone falls from a tower l00m high. Neglecting air resistance, calculate the energy after falling a distance of 40m. (a) 8000J (b) 800J (c) 3200J (d) 42.00J
27. As the bob of a pendulum swings back and forth, the magnitudes of the energies at the points are…? (a) P.E is zero while K.E is maximum at the ends (b) K. E is maximum while P. E is zero at the centre (c) Both K. E and P. E is zero at the ends (d) K.E is zero while P.E is maximum at the centre.
28. If a body is suspended in a fixed height, what energy does it possess? (a) kinetic energy (b) potential energy and kinetic energy (c) potential energy only (d) all of the above.
29. At what height above the ground must a 2kg ball be situated in order to acquire potential energy equal in value to the kinetic energy of another 3kg ball moving with a velocity of 6m/s? (a) 5m (b) 2.7m (c) 6m (d) 4m.
30. Which of the statements is/are correct about the conservation of mechanical energy for a falling orange? i. The orange has P.E only at maximum height ii. It possesses both P.E and K.E while falling. iii It strikes the ground with maximum P.E
    iv. The P.E is zero on reaching the ground

(a) i and ii only (b) ii and iii only (c) i and iv only(d) i, ii and iv only

31. The energy possessed by a body in motion is (a) motion energy (b) kinetic energy (c) potential energy (d) none of the above.
32. A 5kg stone is projected such that it covers a distance of 10m in 5secs. What is the kinetic energy? (a) 10J (b) 2J (c) 5J (d) 20J
33. The rate of doing work is (a) energy (b) work(c) power (d) motion
34. The S.I unit of power is (a) joule (b) newton (c) kilogram (d) watt
35. A car moving with a velocity of 20m/s produces a force of 50N. Calculate the power. (a) 2.5W (b) 100W (c) 1000W (d) 50W
36. Calculate the power of a pump engine that is capable of lifting 1000kg of water through a height 3m in 10secs. (a) 300W (b) 3000W (c) 1000W (d) 33.3W
37. _____ is sometimes used to express power.
38. Power, force and velocity are related by the expression.
39. The equivalent of 3kw in horse power unit is _____
40. The power in h.p. of a water pump that lifts 1000kg of water through a height of 6m in 10secs is 8h.p. True or False.

APPENDIX 2

Physics Achievement Test (PAT) Marking Scheme

1 D
2 B
3 C
4 A
5 B
6 C
7 A
8 B
9 C
10B
11A
12 C
13 C
14 A
15 B
16 D
17 D
18 B
19 A
20 D
21 C
22 B
23 B
24 B
25 A
26 C
27 B
28 C
29 B
30 D
31 B
32 A
33 C
34 D
35 C
36 B
37 Horse power
38 P = fv
39 4 h. p
40 True