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Pre-Service Teachers Achievement and Mastery Levels in Solid Geometry at E. P. College of Education, Bimbilla-Ghana

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Abstract

The purpose of the study was to determine Pre-Service Teachers (PSTs) achievement levels and self-evaluation of their level of mastery in Solid Geometry. The study used descriptive research design with purely quantitative approach to collect data related to Evangelical Presbyterian (E.P.) College of Education, Bimbilla-Ghana Pre-Service Teachers'. The population was one hundred and ninety-two (192) level 200 PSTs Pre-Service Teachers either majoring in mathematics, ICT or science. The sample used for the study was 140. Convenient, purposive and simple random sampling techniques were adopted. The instruments used were two comprising of achievement test and closed ended questionnaire. The overall results from the achievement test indicate that the PSTs were at good mastery level in solid geometry. Also, the self –evaluation questionnaire mastery levels for geometric properties, drawing of solid nets, finding surface areas were high and finding volume of solids were also very high. Finally, finding on composite solids area and volume was at moderate level. It was recommended that College Mathematics Tutors should encourage PSTs to always draw nets of solid shapes and also use solid nets to form solid shapes.

Keywords: Pre-service teachers; mastery level; solid geometry; high.

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1 Introduction

In Ghana, solid geometry is a compulsory component of mathematics curriculum that is studied from kindergarten to Colleges of Education level. The lengthiest-recognized main branch of mathematics is Geometry. Malkevitch [1] asserted that geometry is a branch of mathematics that entails visual phenomena. Royal Society [2] have also opined that geometry branches exploit students visual intuition to remember, understand proof, inspire conjecture, perceive reality, and give global insight of mathematics. Three-dimensional (3D) geometry consists of three dimensions: length, width and height. Geometry concepts serve as pre-requite knowledge for application in pure science, engineering, architecture and astronomy. Van de Walle [3] also reported that geometry is a footing for study in other fields such as science, engineering, architecture, geology and astronomy. "The study of geometry contributes to helping students develop the skills of visualization, critical thinking, intuition, perspective, problem-solving, conjecturing, deductive reasoning, logical argument and proof" [4]. Geometry concepts are helpful to teachers when teaching fractions, functions, calculus, decimals and percentages.

In the new 4-year Bachelor of Education (B. Ed) curriculum, Pre-service teachers (PSTs) are supposed to be trained for effective delivery in one of the following levels; Lower Primary (Kindergarten to Basic 3), Upper Primary (Basic 4 to Basic 6) and Junior High School (JHS1 to JHS3). In the new programme pre-service teachers (PSTs) are to also pick a major and a minor course as their specialized courses of study. With the new curriculum both mathematics content and methodology are taught together unlike previously where they were taught separately. Throughout the course, there is a strong emphasis on recognizing the uses of mathematics in different local and global context as well as exploring learners' misconceptions and difficulties in geometry as specific in the national teachers' standards. Specific attention is given to topic areas that have consistently been flagged up in chief's examiners reports for Senior High School core mathematics as difficult.

The geometry course is specifically designed to develop and consolidate the basic mathematical knowledge and skills of PSTs in geometry, taking into account the uses of geometry in different local contexts as well as exploring learners' misconceptions and difficulties in geometry. The goals of the geometry course are in three – folds: (1) to extend the mathematical knowledge and skills of PSTs to a level significantly beyond what they are likely to teach in basic schools mathematics curriculum. (2) to provide PSTs with a general understanding of the basic principles of teaching the basic school mathematics and (3) to support PSTs to develop appropriate practical approaches to teaching and assessment.

2 Literature Review on Solid Geometry

Patkin and Sarfaty [5] study concluded that mathematics pre-service teachers' levels of geometric thinking can be promoted, entailing control on higher thinking levels as well as a more positive attitude towards this field. Their study aims were to determine whether the intervention programme, comprising task-oriented activities of solid geometry, enhance mathematics pre-service teachers' mastery of their geometric thinking levels as well as investigate their feelings towards this discipline prior and after the intervention. Also, Koester [6] revealed that pupils and their teachers at any level experience difficulties in solid geometry. Similarly, Patkin [7] investigated elementary school mathematics teachers' personal knowledge in solid geometry and found that the elementary school mathematics teachers showed lack of understanding and found solid geometry difficult.

Meng and Idris [8] study findings revealed that the teaching intervention could enhance the students' geometric thinking and achievement in solid geometry. Similarly, Nduka and Ajoke [9] study compared the effectiveness of Design-Based Learning (DBL) and Problem-based Learning (PbL) models among senior secondary students' achievement in solid geometry. The participants were 59 Senior Secondary School I (SSSI) students in Nigeria. The instrument used was Solid Geometry Achievement Test (SGAT). Their finding was in favor of DBL model because it proved as a better strategy to Problem-based Learning (PbL) model solid geometry achievements. In a recent study by Nduka and Charles-Ogan [10] study investigated the effect of Teaching for Understanding (TfU) instructional model on the solid geometry. Their study used a quasi-experimental design where the experimental group were taught using TfU model whereas the students in the control group were taught using the Problem-based Learning (PbL) model. Their results showed a significant effect of the TfU model in solid geometry achievement among the senior secondary students. They recommended that mathematics teachers should adopt the TfU model in solid geometry.

Furthermore, Patkin and Barkai [11] study purpose was to determine whether there were differences in their mastery of triangles and quadrilaterals, circles and three-dimensional geometric figures according to van Hiele's theory. The findings were that, all the five participating groups demonstrated higher mastery in the three main geometry topics. Further analysis revealed that, the participants failed to master (solid) three-dimensional geometric figures.

Finally, Lie and Harun [12] conducted a study titled "Malaysian Students' achievement in solid Geometry" whose objectives were for students to self-evaluate their level of mastery, their satisfaction towards teachers" teaching strategies and mastery level of solid geometry among Form 4 students and the factor affecting their mastery level. Their findings indicated that, the students' achievement was moderate at 62.47% in solid geometry. Again, the students' self-evaluation of mastery level in solid geometry was high with an overall mean of 3.80. Furthermore, the students' satisfaction towards their teachers' teaching strategies was moderate with an overall mean of 3.60.

2.1 Problem statement

In Ghana, solid geometry is a significant component of the pre-service teachers' mathematics curriculum. Since it is applicable and helpful in everyday life, it is not astonishing that most international and local examinations bodies like Trends in International Mathematics and Science Study (TIMSS), Institute of Education, University of Cape Coast and West African Secondary School Certificate Examination (WASSCE) always have some aspect of solid geometry questions for students to answer.

Notwithstanding, its relevance, pre-service teachers in Colleges of Education consistently performed poorly on the compulsory solid geometry questions in the Institute of Education, University of Cape Coast examinations from 2007 till date. In 2007, 56.8% PSTs failed the geometry examination while 31.8% failed in 2009. Again in 2013, 1,965 (26.4%) PSTs obtained weak grades (grade D+ and D) while, 12.4% failed the geometry semester examination. The 2015 analysis was worst 42.3% PSTs failed and had to re-sit the examination.

Also, the West African Examination Council chief examiners reports have also consistently stated that Senior High Schools performed poorly in solid geometry. It was revealed in [13] study that Senior High candidates were unable to solve core Mathematics questions requiring 3-dimensions measuring their spatial visualization and geometric reasoning. Furthermore, grade 8 Ghanaian basic school pupils' performance was among the lowest in countries that participated in the 2003, 2007 and 2011 TIMSS studies [14,15]. The rankings in TIMSS revealed lack of solid geometric comprehension among Ghanaian Basic School pupils. Notwithstanding the growing need for learning solid geometry as a topic in particular, the truth is that several research studies have revealed an unsatisfactorily low performance level in plane geometry, with the solid geometry being the worse in the United States [16] and in Malaysia [8].

Finally, there are limited studies in Ghana's Colleges of Education that explores pre service teachers' achievement and mastery levels in solid geometry. Hence, the motivation of doing this paper is to narrow the gaps in the Ghanaian setting.

2.1.1 Purpose of the study

The study purpose was to determine Pre-Service Teachers achievement levels in Solid Geometry and self-evaluation of their level of mastery in Solid Geometry.

2.1.2 Research questions

Based on the purpose of this study, these research questions were formulated to guide the study.

- What are the achievement levels of the Pre-Service Teachers in Solid Geometry?
- What is the Pre-Service Teachers self-evaluation of their level of mastery in Geometric properties of Solid Geometry?
- What is the Pre-Service Teachers self-evaluation of their level of mastery in drawing nets of Solid Geometry?
- What is the Pre-Service Teachers self-evaluation of their level of mastery in finding surface area of Solid Geometry?
- What is the Pre-Service Teachers self-evaluation of their level of mastery in finding volume of Solid Geometry?
- What is the Pre-Service Teachers self-evaluation of their level of mastery in finding composite solids area and volume?

3 Methodology

3.1 Research design

By way of design the descriptive research design was employed with purely quantitative approach to collect data related to E.P. College of Education, Bimbilla-Ghana Pre-Service Teachers achievement levels in Solid Geometry and self-evaluation of their level of mastery in Solid Geometry.

3.2 Population

The study population consisted one hundred and ninety-two (192) level 200 PSTs mathematics Pre-Service Teachers of E. P. College of Education, Bimbilla-Ghana. The Mathematics PSTs composed of mathematics and science major/minors and Mathematics and ICT major/minors. The population was made up of 61 mathematics major science minor, 60 science major mathematics minor, 54 mathematics major ICT minor and 17 ICT major mathematics minor. From the population 170 (88.5%) were male PSTs while 22 (11.5%) were female PSTs.

3.3 Sample size and sampling procedure

The sample used for the study was 140 mathematics and science major/minors and mathematics and ICT major/minors PSTs. The sampled was one hundred and forty (140) represents 72.9% of the study population. Out of the sample one hundred and forty (140), 118 (84.3%) were male PSTs while two hundred and eighteen 22 (15.7%) were female PSTs. Convenient, purposive and simple random sampling techniques were as adopted in selecting the College and the Mathematics and Science major/minors and mathematics and ICT major/minors. Convenient was used because the researcher is a Tutor hence organizing the PSTs for the study was easy. Purposive was also used because the concepts being investigated best suited PSTs offering mathematics as mathematics major or minors. The simple random sampling technique was also used to give all the mathematics PSTs opportunity to participate in the study. The random number method developed from Microsoft Excel was used to generate the index numbers of the sample for the study.

3.4 Research instruments and pilot test

Two instruments were used comprising of closed ended questionnaire adopted from Lie & Harun, [12] and achievement test. The self-evaluated mastery level questionnaire had 24 items composed of the following concepts cube and cuboids, prism, pyramid, cylinder, cone and sphere measuring their properties, drawing nets, finding surface area and volume, finding composite solids surface area and volume. This questionnaire used a 3 Likert scale of which Fair = 1, Good = 2 and Excellent = 3. The 3 Likert scale was used for easy data analysis and interpretation of results. Also, the achievement test was divided into three sections namely sections A, B and C. Section A achievement test of (solid) three-dimensional geometric figures composed of 30 multiple choice items of which the first fifteen questions were developed by Patkin, [17]; Patkin & Levenberg; [17, 18] represented the first three levels of van Hiele theory. The remaining fifteen were also developed by the researcher after going through several solid questions in Colleges of Education Mathematics Education curriculum. Five options answers were provided for each question and the respondents had to choose the correct one. Section B had 7 items requiring the PSTs to fill in the: (number of flat surfaces, number of curved surfaces, number of sides, number of vertex and number of edges of cube, cuboid, pentagonal prism, rectangular pyramid, cylinder, cone and sphere). The section C items were 7 measuring PSTs skills in drawing solid nets of the following: cube, cuboid, pentagonal prism, rectangular pyramid, cylinder, cone and sphere. The instruments were pre-tested with 35 level 300 PSTs of E.P. College of education who were on field practicum in Bimbilla, the capital of Nanumba North Municipality. The pilot test afforded the researcher the opportunity to refine the instruments for the main study especially the achievement test. It also enables the researcher to determine the reliability to confirm the relevance of the instruments.

3.5 Validity and reliability

Instruments validation was improved through expert judgment [19]. The two instruments were given to two experts in Mathematics Education and another colleague of the researcher in E.P. College of Education, Bimbilla for scrutiny and vetting. Their recommendations were the basis for its validation and administering. The reliability coefficient of the PSTs Solid Geometry Achievement Test (SGAT) was calculated using Kuder-Richardson formula 21 (KR-21). This is because the questions were scored as follows: zero (0) mark for any wrong answer and one (1) mark for correct responses. This formula determines the reliability of the instrument in a single administration. The reliability test yielded 0.85 for achievement test. The questionnaires also used Cronbach alpha method to determine the coefficients of the self-evaluated mastery level in solid geometry which gave a value of 0.88.

3.6 Data collection procedure

The researcher having met the ethical requirements made the instruments available to the pre-service teachers in the College. The questionnaire on self-evaluated mastery level of pre-service teachers' in solid geometry was given to the pre-service teachers' to fill on 25th November, 2019 within 30 minutes. A week later the achievements test were administered to the pre-service teachers' to answer with duration of 1 hour 30 minutes covering section A and B. Two weeks later again, the section C items were also administered to the PSTs.

3.7 Data analysis

Data obtained from the mathematics and science major/minors and mathematics and ICT major / minors PSTs completed copies of the questions were sorted, coded and entered in statistical package for social science (SPSS) software version 16.0 and Microsoft excel 2013 version. To address research question 1, which was on the achievement levels of the Pre-Service Teachers in Solid Geometry were analyzed using frequency count and Percentages to classify their mastery levels of Excellent: (80-100%), Good: (70-79%), Fair: (60-69%), Satisfactorily: (50 -59%), and Fail: (0-49%). Section A was scored out of 30 marks, sections B and C were scored 35 marks each making a total of 100 marks for the test item. To address research question 2, data from the 3 Likert scales of Fair =1, Good =2 and Excellent =3 were analyzed using frequency count, percentages, and means. To determine the PSTs geometric mastery levels in solid geometry the following range of scales were used: 2.6-3.0 = very high, 2.1-2.5 = high, 1.6-2.0 = moderate, 1.1-1.5 = weak and 0.0-1.0 as very weak.

4 Results

The purpose of the study was to determine Pre-Service Teachers achievement levels in solid geometry and self-evaluation of their level of mastery in Solid Geometry. The results of the study are organized by means of descriptive statistics. The results are presented according to the research questions.

Research Question 1: What are the achievement levels of the Pre-Service Teachers in Solid Geometry?

In order to answer the research question one, the results was analyzed sequentially from section A to B and to C before the overall analysis.

Section A: Multiple choice items

Table 1. Cumulative frequency of the raw marks of the PSTs in solid geometry achievement test

Mark	Frequency	Valid Percent	Cumulative Percent
20	46	32.9	32.9
21	5	3.6	36.4
22	13	9.3	45.7
23	23	16.4	62.1
24	9	6.4	68.6
25	14	10.0	78.6
26	18	12.9	91.4
27	9	6.4	97.9
28	3	2.1	100.0
Total	140		

From Table 1, the PSTs performed better in the solid geometry objectives test with minimum and maximum marks of 20 representing 32.9% and 28 representing 2.1% respectively. Also, the modal mark was 20 representing 32.9%. A mean mark of 22.86 was also found. The standard deviation of 2.5 was realized hence most of the PSTs marks were between 20.36 and 25.36 as lower and upper bounds respectively.

Section B: Fill in the blank

The Table 2 analyses is done horizontally taking questions 31 to 37 on overall achievement of flat surfaces, curved surfaces, sides, vertex and edges for rectangular pyramid, cuboid ,cylinder , pentagonal prism, cube, sphere and cone.

Table 2. Correct and wrong answer of Pre-service Teacher's section B achievements in determining the individually solid shapes number of: flat surfaces, curved surfaces, sides, vertex and edges of rectangular pyramid, cuboid, cylinder pentagonal prism, cube, sphere and cone

	Shape	percentage of Correct answers	percentage of Wrong answers
31	Rectangular Pyramid	427 (61.00%)	273 (39.00%)
32	Cuboid	420 (60.00 %)	280(40.00 %)
33	Cylinder	285 (40.71 %)	415 (59.29 %)
34	Pentagonal Prism	301 (43.00 %)	399 (57.00 %)
35	Cube	406 (58.00 %)	294 (42.00 %)
36	Sphere	265 (37.86%)	435 (62.14 %)
37	Cone	349 (49.86 %)	351 (50.14 %)
	Total	2453 (50.06%)	2447 (49.94%)

From the Table 2, the students were able to identify or determine the rectangular pyramid and cuboid questions requiring number of: flat surfaces, curved surfaces, sides, vertex, and edges very well with rectangular pyramid correct answer responses of 427 (61%), while identifying or determining number of: flat surfaces, curved surfaces, sides, vertex, and edges of the cuboid yielded 420 responses with 60% correct answer rate. Also, the PSTs performed well on number of: flat surfaces, curved surfaces, sides, vertex and edge of the cube with correct answer rate of 58% with 406 correct responses. However, the PSTs had difficulty in identifying number of: flat surfaces, curved surface, sides, vertex and edges of cylinder, pentagonal prism and sphere where their correct answer rates fell below 44%. The overall performance was just average correct answer rate of 50.06%. The best performance was rectangular pyramid while the worst was sphere. Further analysis has indicated that the minimum, maximum, mode and average marks recorded were 2, 33, 17 and 17.29 respectively for the section answers.

The Table 3 analyses is done vertically taking questions 31 to 37 on overall achievement of rectangular pyramid, cuboid ,cylinder, pentagonal prism, cube, sphere and cone for flat surfaces, curved surfaces, sides, vertex and edges.

Table 3. Pre-service Teacher's section B corrects and wrong answers in percentage in determining the overall solid number of: flat surfaces, curved surfaces, sides, vertex and edges

% of Correct answers flat surface	% of Wrong answers flat surfaces	% of Correct answers curved surface	% of Wrong curved surface answers	% of Correct answers of sides	% of Wrong answers of sides	% of Correct answers of vertex	% of Wrong answers of vertex	% Of Correct answers of Edges	% of Wrong answers of edges
62.55%	37.45%	44.80%	52.20%	54.39%	45.61%	52.14%	47.86%	37.04%	62.98%

From Table 3, the PSTs performed well in identifying flat surfaces of rectangular pyramid, cuboid, cylinder, pentagonal prism, cube, sphere and cone with 62.55% correct answers. Also, the PSTs identification of curved surfaces of rectangular pyramid, cuboid, cylinder, pentagonal prism, cube, sphere and cone was 44.80% while identification of sides of rectangular pyramid, cuboid, cylinder, pentagonal prism, cube, sphere and cone was 54.39%. Furthermore, identification of vertex and edges of rectangular pyramid, cuboid, cylinder, pentagonal prism, cube, sphere and cone were 52.14% and 37.04% respectively.

Table 4. Pre-service teacher's section c achievements in drawing of solid nets

Question Number	Shape	Percentage of Correct Net drawn	Percentage of Wrong Net drawn
38	Rectangular Pyramid	132 (94.29%)	8 (5.71%)
39	Cuboid	96 (68.57%)	44 (31.43%)
40	Cylinder	132 (94.29%)	8 (5.71%)
41	Pentagonal Prism	50 (35.71%)	90 (64.29%)
42	Cube	99 (70.71%)	41 (29.29%)
43	Sphere	24 (17.14%)	116 (82.86%)
44	Cone	91 (65.00%)	49 (35.00%)
	Total	624 (63.67%)	356 (36.33%)

From the Table 4, the PSTs performance in drawing nets was far better than their performance in determining number of: flat surfaces, curved surfaces, sides, vertex and edges. They performed well in drawing nets of rectangular pyramid 94.29%, cuboid 68.57%, cylinder 94.29%, cube 70.71% and cone 65.00% with percentages of correct answer rate all above 64%. However, some of the PSTs had difficulty in drawing nets of pentagonal prism and sphere with correct drawings rates at 35% and 17.14% respectively. Again, from the analysis the minimum score for drawing nets was 0, maximum of 35, mode 25 and mean score of 22.3. Their overall performance in the drawing of nets of rectangular pyramid, cuboid, cylinder, pentagonal prism, cube, sphere and cone gave total correct drawing of 63.67% representing 624 correct net drawing of the solid shapes.

Table 5 presents the overall analysis from section A, B and C that is questions 1- 44, the marks are grouped in to mastery levels. The table also contains number of PSTs and percentages achievements.

Table 5. Pre-service Teacher's overall achievements and mastery levels

Marks	Mastery Level	Number of Pre-Service Teachers	Percentage (%)
80-100	Excellent	8	5.71 %
70-79	Good	51	36.43%
60-69	Fair	44	31.43%
50-59	Satisfactorily	26	18.57%
0-49	Fail	11	7.86%

From Table 5, the mastery level was good indicating 51 PSTs attaining at least 70 marks out of the 100 marks. This actually represents a modal percentage of 36.43%. Also, 11 (7.86%) were at a fail level because they scored marks between 30-44 marks while 8 (5.71%) were at excellent level because those PSTs scored at least 80 out of the 100 marks. Further analysis has indicated that the minimum, maximum and average marks recorded were 30, 88 and 62.46 respectively.

Research Question 2: What is the Pre-Service Teachers self-evaluation of their level of mastery in Geometric properties of Solid Geometry?

Table 6. Pre-service Teacher's self-evaluation of their level of mastery in geometric properties of solid geometry

No	Statement	Fair	Good	Excellent	Mean Score	Mastery Level
a.	cube and cuboids	9 (6.4%)	62 (44.3%)	69 (49.3%)	2.4	High
b.	Prism	7 (5.0%)	68(48.6%)	65 (46.4%)	2.4	High
c.	pyramid	10 (7.1%)	48 (34.3%)	82 (58.6%)	2.5	High
d.	cylinder	5 (3.6%)	42 (30.0%)	93 (66.4%)	2.6	Very High
e.	Cone	5 (3.6%)	55 (39.3%)	80 (57.1%)	2.5	High
f.	Sphere	16 (11.4%)	60 (42.9%)	64 (45.7%)	2.3	High
	Total	52 (6.19 %)	335 (39.88%)	453 (53.93%)	Average = 2.5	Overall mastery Level = High

Table 6 presents the PSTs level of understanding of geometric properties of cube and cuboids, prism, pyramid, cylinder, cone and sphere. The analysis has revealed that, the PSTs level of understanding on properties of cylinder was excellent, better than any of the solid geometric figures with a mean score of 2.6 representing 93 (66.4%) very high mastery level. The next level of better understanding which the PSTs indicated were the properties of pyramid and cone with 82 (58.6%) and 80 (57.1%) respectively signifying excellent with high mastery levels. The cone and pyramid had the same mean score of 2.5. The self-evaluation level of sphere geometric properties was between good (42.9%) and excellent (45.7%) with a high mastery level with mean of 2.3. The overall self-evaluation level responses of the solid geometric properties of shapes were 453 (53.93%) as excellent, 335 (39.88 %) as good and 52 (6.19%) as fair with overall mean of 2.5 mean indicating high mastery level. In conclusion, the PSTs level of mastery of geometric properties of cube and cuboids, prism, pyramid, cone and sphere was high while that of cylinder was very high level.

Research Question 3: What is the Pre-Service Teachers self-evaluation of their level of mastery in drawing nets of Solid Geometry?

Table 7. Pre-Service Teachers self-evaluation of their level of mastery in drawing nets of Solid Geometry

No	Statement	Fair	Good	Excellent	Mean Score	Mastery Level
a.	cube and cuboids	13 (9.3%)	47 (33.6%)	80 (57.1%)	2.5	High
b.	Prism	13 (9.3%)	63 (45.0%)	64 (45.7%)	2.4	High
c.	pyramid	9 (6.4%)	56 (40.0%)	75 (53.6%)	2.5	High
d.	cylinder	7 (5.0%)	44 (31.4%)	89 (63.6%)	2.6	Very High
e.	Cone	15 (10.7%)	47 (33.6%)	78 (55.7%)	2.5	High
f.	Sphere	35 (25.0%)	53 (37.9%)	52 (37.1%)	2.1	High
	Total	92 (10.95%)	310 (36.90%)	438 (52.14%)	Average= 2.4	Overall mastery Level = High

As shown in Table 7, the PSTs has indicated a better mastery level in understanding the drawing of cylinder net with a mean score of 2.6 which is very high mastery level representing 89 (63.6%) out of the 140 PSTs responses signifying excellent level with 36.4% indicating between a fair and good understanding. The next self-evaluation understanding nets were cube and cuboids, and cone. The PSTs responses for cube and cuboids and cone were 80 (57.1%) and 78 (55.7%) respectively for excellent understanding with mean of 2.5 each which is high mastery level. The drawing net of the sphere was difficult for the PSTs because 35 (25%) for fair understanding and 37% indicated both good and excellent understanding of drawing the sphere net which resulted in a mean score of 2.1. The overall responses for the drawing of solid nets revealed a mean score of 2.4 which is high. The overall level understanding responses of the solid geometric net drawing of shapes were 438 (52.14%) as excellent, 310 (36.90%) as good and 92 (10.95%) as fair. In conclusion, the PSTs level of overall mastery of drawing nets of cube and cuboids, prism, cylinder, pyramid, cone and sphere was high.

Research Question 4: What is the Pre-Service Teachers self-evaluation of their level of mastery in finding surface area of Solid Geometry?

Table 8. Pre-service teachers self-evaluation of their level of mastery in finding surface area of solid geometry

No	Statement	Fair	Good	Excellent	Mean Score	Mastery Level
a.	cube and cuboids	10 (7.1%)	45 (32.1%)	85 (60.7%)	2.5	High
b.	prism	11 (7.9%)	61 (43.6%)	68 (48.6%)	2.4	High
c.	pyramid	12 (8.6%)	57 (40.7%)	71 (50.7%)	2.4	High
d.	cylinder	6 (4.3%)	40 (28.6%)	94 (67.1%)	2.6	Very High
e.	cone	8 (5.7%)	45 (32.1%)	87 (62.1%)	2.6	Very High
f.	sphere	21 (15.0%)	52 (37.1%)	67 (47.9%)	2.3	High
	Total	68 (8.10%)	300 (35.71%)	472 (56.19%)	2.5	High

The results of Table 8 revealed that the PSTs understood how to find surface area of cylinder easily than any of the solid shapes in the Table 8 with a mean score of 2.6 indicating a very high mastery level with 94 (67.1%) indicating excellent level of understanding. The self-evaluation level of understanding of finding surface area of cylinder also indicated 4.3% and 28.6% for fair and good understanding respectively by the PSTs. The next mastery level concept was finding surface area of cone with a mean of 2.6 with 87 out of the 140 PSTs saying that they have excellent understanding of surface area better representing 62.1%. Also, 5.7% and 32.1% of the PSTs indicated fair and good understanding of finding surface area of cone. The understanding levels responses on finding areas of the cube and cuboids were 60.7% for excellent, 32.1% for good and 7.1% for fair. Finding surface area of sphere concept indicated 47.9% for excellent understanding, 37.1% for good understanding and 15% for fair understanding with a mean score of 2.3 signifying high mastery level. The overall mean for finding the surface areas: cube, cuboid, prism, pyramid, cylinder, cone and sphere were 2.5 which is high mastery level. The overall understanding level responses of finding the surface areas: cube, cuboid, prism, pyramid, cylinder, cone and sphere were 472 (56.19%) as excellent, 300 (35.71%) as good and 68 (8.10%) as fair. In conclusion, apart from cylinder and cone which was at very high mastery level the rest of the concepts on finding surface area of Solid Geometry was at a high level with mean 2.5.

Research Question 5: What is the Pre-Service Teachers self-evaluation of their level of mastery in finding volume of Solid Geometry?

Table 9. Pre-Service Teachers self-evaluation of their level of mastery in finding volume of Solid Geometry

No	Statement	Fair	Good	Excellent	Mean Score	Mastery Level
a.	cube and cuboids	11 (7.9%)	47 (33.6%)	82 (58.6%)	2.5	High
b.	prism	8 (5.7%)	60 (42.9%)	72 (51.4%)	2.5	High
c.	pyramid	10 (7.1%)	50 (35.7%)	80 (57.1%)	2.5	High
d.	cylinder	5 (3.6%)	38 (27.1%)	97 (69.3%)	2.7	Very High
e.	cone	6 (4.3%)	47 (33.6%)	87 (62.1%)	2.6	Very High
f.	sphere	16 (11.4%)	50 (35.7%)	74 (52.9%)	2.4	High
	Total	56 (6.67%)	292 (34.76%)	492 (58.57%)	2.5	High

From Table 9, the findings showed that, the most understood concept was finding volume of cylinder self-evaluation of finding volume of solid geometry with a mean of 2.7 representing a very high mastery level. Out of the 140 PSTs 97 (69.3%) indicated they have excellent idea of finding volume of cylinder, while 27.1% indicated good understanding and 3.6% also indicated fair understanding. The next most understood mastery concept was finding volume of cone, because 87 responses representing 62.1% indicated they have excellent idea in finding volume of cone with a mean of 2.6 which is very high mastery level. Whereas 33.6% of the PSTs indicated good understanding and 4.3% also indicated fair understanding on finding volume of cone. Also, on finding volume of the sphere 52.9% of the PSTs indicated they have excellent understanding of finding volume of sphere, finding volume of sphere. Furthermore, 11.4% and 35.7% also indicated that they have fair and good understanding of finding volume of sphere respectively. However, finding volume of sphere had the lowest mean score of 2.4 which is high mastery level. The overall mean score for volume of the solid geometry was 2.5. Also, the overall mastery level responses of finding the volume of the solid geometry were 492 (58.57%) as excellent, 292 (34.76%) as good and 56 (6.67%) as fair. In conclusion, the following cube and cuboids, prism, cylinder and sphere concepts were at high mastery with the exception of pyramid and cone which were very high on finding volume of geometric shapes.

Research Question 6: What is the Pre-Service Teachers self-evaluation of their level of mastery in finding composite solids area and volume?

Table 10. Pre-service teachers self-evaluation of their level of mastery in finding composite solids area and volume

No	Statement	Fair	Good	Excellent	Mean Score	Mastery Level
a.	Surface area of composite solids	53 (37.9%)	53 (37.9%)	34 (24.3%)	1.86	moderate
b.	Volume of composite solids	49 (35.0%)	53 (37.9%)	38 (27.1%)	1.92	moderate
	Total	102 (36.43%)	106 (37.86%)	72 (25.71%)	1.89	moderate
	Grand total	370 (10.16%)	1343 (36.90%)	1927 (52.94%)	2.43	High

Table 10 shows the result of the analysis of finding surface area of composite solids and volume of composite solids. Fifty-three each representing 37.9% indicated that they have fair and good understanding of how to find surface area of composite solids with a mean score of 1.86 which is moderate level. However, 24.3% said they have excellent idea of finding surface area of composite solids and volume of composite solids. Also, 53 (37.9%) PSTs indicated that they have a good idea of finding volume of composite solids which yielded a mean score of 1.92 which is also moderate mastery level. The overall understanding of finding surface area of composite solids and volume of composite solids are 102 (36.43%) for fair understanding, 106 (37.86%) for good understanding and 72 (25.71%) for excellent understanding.

Finally, the overall mean for mastering the geometric shapes properties, drawing nets, surface area, volume and composite geometry solids shapes was 2.43 which is high with 1927 responses representing 52.94% signifies excellent grasps of solid geometry concepts. Also, 1343 (36.90%) and 370 (10.16%) responses have indicated good and fair mastery levels for the overall geometry concepts respectively.

5 Discussion of Results

The study examined pre-service teachers' achievement levels and their self-evaluation of their level of mastery in solid geometry.

5.1 Achievement test

The section A performance of the PSTs was encouraging because 44 (31.4 %) scored at least 25 out of the 30 marks in the multiple choice achievement test. The PSTs achievements in the solid geometry test was good in the multiple choice because a minimum and maximum marks of 20 (32.9%) and 28 (2.1%) respectively were found. Also, the modal mark of 20 (32.9%) was realized. A mean and standard deviation marks of 22.86 and 2.5 were also found indicating good performance with majority PSTs marks ranging between 20.36 and 25.36. Some of the students had challenges in identifying: regular polyhedrons and its properties, coplanar edges from rectangular right prism. Also, some of the PSTs found it difficult in solving questions on rectangular prism when volume is given in a quadratic form, width as a linear equations and length as a constant value.

From the section B achievement test analysis, the PSTs exhibited understanding of geometric properties of pyramid, cuboids and cube better than prism, cylinder, cone and sphere. The analysis has revealed that PSTs understood properties of pyramid, cuboids and cube with correct answer rate of 61%, 60%, and 58% respectively. This performance could be as a result of PSTs using Maggie cubes, Matches and modeling roofs of houses in their daily lives hence are familiar with their properties. The PSTs also had difficult in identify number flat surfaces, curved surfaces, sides, vertex and edges of prism, cylinder, cone and sphere with correct answer rate between 37.86% and 49.86% as in Table 2. The analysis has revealed that the properties and drawing net of the sphere has been tough for the PSTs hence tutors should hammer on it a lot by drawing the net of the sphere and taking time to explain the properties very well. From the scripts analysis few of the PSTs were not clear about the difference between vertex and edge, because they exchanged their answers during the solid achievement test in columns 6 and 7 of questions 31- 37. The overall achievement in solid geometric properties was 2453 (50.06%) correct answer rate.

In relation to the section C achievement test again, the PSTs exhibited enough knowledge in drawing nets of solid shapes far better them their performance in determine number of: flat surface, curved surfaces, sides, vertex and edges. Their best performance came through in the drawing of nets of rectangular pyramid, cuboid, cylinder, cube and cone with percentages of correct answer rate all above 64%. Also, some of the PSTs faced challenges in drawing nets of pentagonal prism and sphere with correct drawings rates being at 35% and 17.14% respectively. This finding tallies with Patkin [17] which reported that some students found solid geometry concepts difficult. PSTs should be allowed to perform activities on making geometrical solid from their nets and vice versa during solid geometry lessons, which will improve their geometric thinking and reasoning. This is similar to the comment by Strutchens, Harris and Martin, [21] who indicated teaching of solid geometry include hands-on explorations, which will invariable lead to geometric thinking, reasoning and making conjectures. The PSTs overall achievements in the drawing of nets of rectangular pyramid, cuboid, cylinder, pentagonal prism, cube, sphere and cone yielded a total correct drawing of 63.67% in solid geometry in this study.

5.2 Questionnaire

From the questionnaire analysis on properties of solid geometry, the PSTs indicated a good grasp of solid geometry on the number of: flat surfaces, curved surfaces, sides, vertex, and edges. The PSTs indicated that they have a thorough understanding of geometric properties of pyramid, cylinder and cone questions with at least 57% excellent understanding level in identifying number of: flat surfaces, curved surface, sides, vertex and edges. This present finding is consistent with an earlier study by Lie and Harun [12] which revealed that students' best understood geometric properties of pyramid, cylinder and cone. However, some of the PSTs had some challenges in identifying number of: flat surfaces, curved surface, sides, vertex and edges of cylinder, pentagonal prism and sphere with correct answers rate below 44%. The geometric property that was best understood by the PSTs was cylinder while the least grasp was sphere. This could be due to the way sphere is taught in Ghanaian schools by teachers, because most teachers draw sphere on the chalk board without taking their time to presents it as a teaching learning material and teaching its properties to students. Most teachers also just give the formula of sphere and proceed to work with examples. This study has indicated a similar result as that of Lie and Harun [12] which also recorded a lower understanding on sphere.

Again, from the questionnaire analysis the PSTs have shown that they have a better mastery level with excellent understanding in the drawing of cylinder net with a mean score of 2.6 signifying very high representing 63.6%. This finding also corroborates the findings of Lie & Harun [12] who recorded a high mastery level percentage above 63.6%. The next high mastery levels net drawings from the questionnaire responses were pyramid, cube and cuboids and cone with all having a mean of 2.5 which was high mastery level. The PSTs responses for excellent mastery rates for pyramid, cube and cuboids and cone were 53.6%, 57.1% and 55.7% respectively. This is also similar to Lie & Harun [12] study which had percentages for pyramid, cube and cuboids, and cone above 50%. The PSTs indicated that drawing the net of the sphere was difficult, because a quarter representing 25% indicated they have a fair idea of drawing the sphere net. Teachers' inability to draw net of sphere for their students could be a reason why they are not able to draw the sphere net. Some of the students left drawing sphere net blank because they had serious challenges in drawing the sphere. This finding is in line with Lie & Harun [12] study which indicated that students confirmed drawing of sphere net was a challenge.

The analysis from the questionnaire has further revealed that the PST responded that, they have excellent knowledge in finding surface areas of solid shapes: cube, cuboid, prism, pyramid, cylinder, cone and sphere with an overall mean score 2.5 which is a high mastery level with 56.19% correct understanding 472 responses. The PSTs percentage responses tallies with those of Lie & Harun [12] who recorded a percentage above 50% mastery level in finding surface areas of solid shapes. The PSTs agreed that they excellent understanding the concept of finding surface area of cylinder easily than any of the solid shapes. However, the understanding or mastery level for the concept of finding surface area of sphere was just 15% with a mean score of 2.3.

Again, the findings from the questionnaire has showed that, majority of the PSTs 69.3% with mean of 2.7 reflecting very high level of mastery have understood the concept of finding volume of cylinder. Also, finding volume of cone was well understood by the PSTs, because 87 out of 140 PSTs indicated they could solve problems involving volume of cone excellently with mastery level being very high. Again, the lowest mastery level concept was finding volume of the sphere with 11.4% PSTs indicating that they do not understand volume of sphere. On the whole, 58.57% respondents agreed they understood the concept of finding volume of the solid geometry excellently with mastery level being very high. This finding is in agreement with the results of Lie & Harun, [12] study which documented above 50% with high mastery level. Furthermore, the questionnaire analysis has revealed that the PSTs understanding of finding surface area and volume of composite solids was moderate level with means of 1.86 and 1.89 respectively.

Finally from the questionnaire, the overall mastering level for the solids geometric shapes: properties, drawing nets, surface area, volume and composite geometry solids shapes was 2.43 which is high level with 89.94% PSTs saying they understood solid geometry concepts. The present finding is consistent with an earlier study by Lie & Harun, [12] which also indicates a high level mastery of all the solid geometry concepts.

5.3 Major findings

Based on the results of the present study the following findings were drawn:

5.3.1 Achievement test

- The PSTs achievement in solid geometry test was at good mastery level with 103 (73.57%) achieving at least 60 out of the total 100 marks.
- The PSTs understanding of solid geometric properties was at slightly above average of 50% with high identification of flat surfaces, sides and vertex.
- Majority of the PSTs understood correct nets drawing of solid shapes at excellent level.

5.3.2 Questionnaire

- Majority of the PSTs self-evaluation mastery level of solid geometric properties, drawing of solid nets, finding surface area and volume was high.
- Majority of the PSTs self-evaluation mastery level of finding surface area and volume of composite solids shapes was moderate.

6 Conclusion

The pre-service teachers' achievement in solid geometry was good and their self-evaluation of geometric properties, drawing of solid nets, finding surface area and volume of solid geometry mastery level was high.

7 Recommendations

The following recommendations are considered relevant to the study made:

- College Mathematics Tutors should always give PSTs enough time to solve problems on their own before discussing together in class.
- College Mathematics Tutors should always provide PSTs with real solid shapes to manipulate.
- College Mathematics Tutors should encourage PSTs to always draw nets of solid shapes and also use solid nets to form solid shapes more especially the sphere.

Consent and Ethical Approval

As per university standard guideline participant consent and ethical approval has been collected and preserved by the authors.

Competing Interests

Author has declared that no competing interests exist.

References

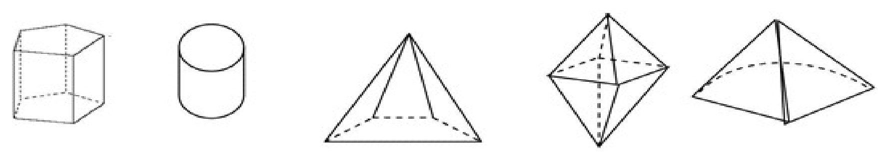
1. Malkevitch J. What is geometry. Understanding geometry for a changing world. 2009;3-16.
2. Royal Society/ Joint mathematical council. teaching and learning geometry 11-19. London: Royal Society/ Joint Mathematical Council; 2001.
3. Van de Walle JA. Geometric thinking and geometric concepts. In Elementary and Middle School Mathematics: Teaching Developmentally. (4th Ed.). Boston: Allyn and Bacon; 2001.
4. Armah RB, Cofie PO, Okpoti CA. The geometric thinking levels of pre-service teachers in Ghana. Higher Education Research. 2017;2(3):98-106.
5. DOI: 10.11648/j.her.20170203.14
6. Patkin D, Sarfaty Y. The effect of solid geometry activities of preservice elementary school mathematics teachers on concepts understanding and mastery of geometric thinking levels. Journal of the Korean Society of Mathematical Education Series D: Research in Mathematical Education. 2012;16(1):31–50.
7. Koester BA. Prisms and pyramids: constructing three-dimensional models to build understanding. Teach Child Math. 2003;9(8):436–442. ME 2003f.05035
8. Patkin D. The role of "personal knowledge" in solid geometry among primary school mathematics teachers. Journal of the Korean Society of Mathematical Education Series D: Research in Mathematical Education. 2010;14(3):263–279.
9. Meng CC, Idris N. Enhancing Students' geometric thinking and achievement in solid geometry. Journal of Mathematics Education. 2012;5(1):15-33.
10. Nduka W, Ajoke AA. Design-based learning model and senior secondary students' Learning Achievement in Solid Geometry. European Scientific Journal. 2016;12(34):1857–7881.
11. Nduka W, Charles-Ogan G. Teaching for understanding and senior secondary students' learning achievement in solid geometry. Journal of Mathematic. 2017;13(2):42-47.
12. Patkin D, Barkai R. Geometric thinking levels of pre- and in-service mathematics teachers at various stages of their education. Educational Research Journal. 2014;29(1):1-26.
13. Mullis IVS, Martin MO, Gonzalez EJ, Chrostowski SJ. TIMSS 2003 International mathematics report. Boston: TIMSS & PIRLS International Study Centre; 2004. Retrieved 2 February 2007.
14. Available: http://timss.bc.edu/timss2003/mathD.html
15. Mullis IVS, Martin MO, Foy P, Arora A. Timss 2011 international results in mathematics. Massachusetts, United States of America: TIMSS & PIRLS International Study Center and Amsterdam, The Netherlands: International Association for the Evaluation of Educational Achievement (EIA), EIA Secretariat; 2012.
16. K.M, Harun H. Malaysian students' achievement in solid geometry. Recent Researches in Education. Conference Paper. 2011:141-147.
17. Fletcher JA, Anderson S. Improving students" performance in mensuration at the senior high school level using Geometer" sketchpad. Journal of Science and Mathematics Education. 2012;6(1):63-79.
18. Gunhan BC. A case study on the investigation of reasoning skills in Geometry. South African Journal of Education. 2014;34(2):1-19.
19. Mullis IVS, Martin MO, Foy P. TIMSS 2007 International Mathematics Report. Boston: TIMSS & PIRLS International Study Center; 2008. Retrieved 7 April 2009.
20. Available: http://timss.bc.edu/TIMSS2007 /PDF/ 07/T07_M_IR_Chapter3.pdf
21. Alsina C. 3-D citizens do not deserve a flatlanders' Education: curriculum and 3-D geometry. In Future Curricular Trends in School Algebra and Geometry: Proceedings of a Conference. Charlotte: Information Age Pub. Inc. 2010;147-154.
22. Patkin D, Levenberg A. Plane geometry — Part I for junior high school and high school students (2nd ed.). Israel: Authors; 2010.
23. Patkin D, Levenberg A. Plane geometry — Part II for junior high school and high school students. Israel: Rechgold; 2004.
24. Strutchens ME, Harris KA, Martin WG. Assessing geometric and measurement understanding using manipulatives. Mathematics Teaching in the Middle School. 2001;6(7):402-405.

APPENDIX

Section A

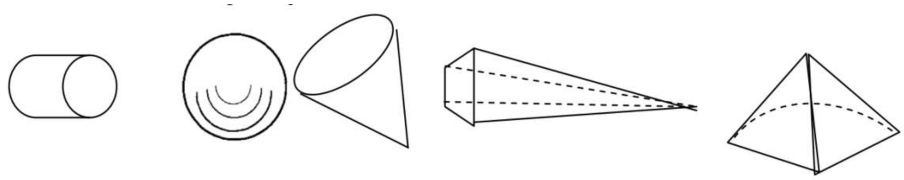
Mathematics Pre-service Teachers solid geometry test. Answer all the questions. There are 30 multiple choice questions. Circle the right option using a pen. If you want to change an answer, just cross out the first answer. You will have 1 hour to complete this test. Wait until the researcher says that you may begin.

1. **Circle the prisms among the following objects**



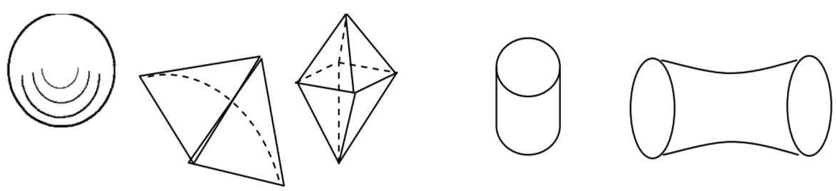
a b c d e

2. Circle the cone-shaped object



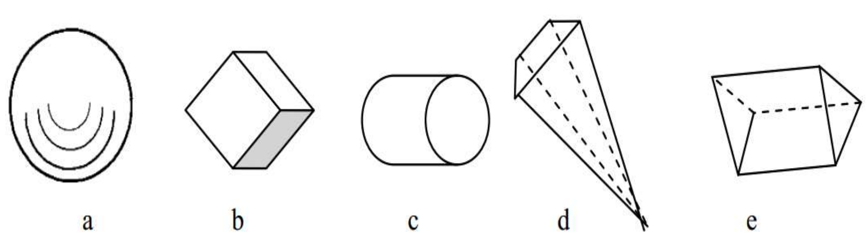
a b c d e

3. Circle the polyhedrons among the following objects



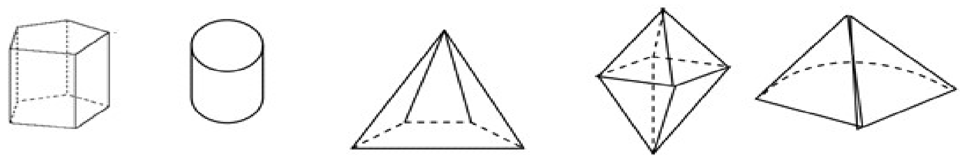
a b c d e

4. Among the following objects, circle the cylinder-shaped ones



a b c d e

5. Which of the following figures are pyramids?



a b c d e

6. Which of the following statements is always true?

(a). If an object has two bases then it must be a rectangular parallelepiped. (b). If an object has two bases then it must be a polyhedron. (c). If an object has two bases then it must be a cylinder. (d). If an object has two bases then it must be a regular polyhedron. (e). Statements a – d are false.

7. Which of the following statements is true for every cylinder?

(a). The bases of a cylinder are circular. (b). The bases of the cylinder are congruent and parallel squares. (c). The bases of the cylinder consist of regular polygons. (d). The bases of the cylinder are pentagons. (e). The bases of the cylinder are triangles.

8. Which of the following statements is true for every regular polyhedron?

a. In a polyhedron all faces are congruent. b. All polyhedrons have pairs of parallel faces. c. A polyhedron does not have curved surfaces. d. Each vertex in a polyhedron intersects a number of other faces. e. Statements a-d are true.

9. A cube has: (a). 12 faces, (b). 4 faces, (c). 6 faces, (d). 8 faces, (e). 2 faces

10. Which of the following statements is true for every prism?

(a). The lateral surface of the prism consists entirely of triangles. (b). The prism had two parallel bases. (c).The base of the prism is rectangular. (d). The lateral surface of the prism consists of regular polygons. (e). Four faces intersect every vertex of the prism.

11. All pyramids have in common:

(a). All pyramids have a triangular-shaped base. (b). The lateral surface is constructed of triangles. (c). The base is a quadrangle and the lateral surface is comprised of triangles. (d). All faces of the pyramid are triangles. (e). Statements a – d are false.

12. Which of the following statements is true?

(a) If an object is a polyhedron then it is also a prism. (b). If an object is a prism then it is also a polyhedron. (c). If an object is not a polyhedron, then it is a prism. (d). If an object is not a prism, it is not a polyhedron. (e). If an object is a prism, it is not a polyhedron

13. Which of the following statements is true?

(a). If an object has 8 vertices it must be a rectangular parallelepiped. (b). If an object has 8 vertices it must be a cube. (c). If an object has 8 vertices it must be a pyramid. (d). If an object has 8 vertices it must be a regular polyhedron. (e). Statements a – d are false.

14. Which of the following statements is true?

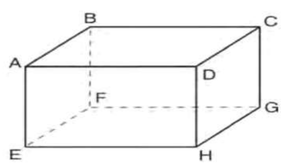
(a). If an object is a regular polyhedron, it is also a cube. (b). If an object is a cube, it is also a regular polyhedron. (c). If an object is not a regular polyhedron, it is a cube. (d). If an object is not a cube, it is not a regular polyhedron. (e). Statements a – d are true.

15. Which of the following statements is not true for a prism?

(a). The prism has two congruent and parallel bases. (b). The lateral surface of the prism is comprised of rectangles or parallelograms. (c). All the faces of the prism are rectangles or parallelograms. (d). The prism is a 3-dimensional object. (e). All the faces of the prism are polygons

16.

A rectangular right prism is shown in the diagram below.

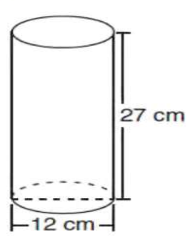


Which pair of edges are *not* coplanar?

1) $\overline{BF}$ and $\overline{CG}$
2) $\overline{BF}$ and $\overline{DH}$
3) $\overline{EF}$ and $\overline{CD}$
4) $\overline{EF}$ and $\overline{BC}$

17.

Which expression represents the volume, in cubic centimeters, of the cylinder represented in the diagram below?



1) 162π
2) 324π
3) 972π
4) $3,888\pi$

18.

A rectangular prism has a volume of $3x^2 + 18x + 24$. Its base has a length of $x + 2$ and a width of 3. Which expression represents the height of the prism?

1) $x + 4$
2) $x + 2$
3) 3
4) $x^2 + 6x + 8$

19.

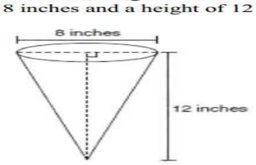
The lateral faces of a regular pyramid are composed of
1) squares
2) rectangles
3) congruent right triangles
4) congruent isosceles triangles

20.

A right circular cylinder has an altitude of 11 feet and a radius of 5 feet. What is the lateral area, in square feet, of the cylinder, to the *nearest tenth*?
1) 172.7
2) 172.8
3) 345.4
4) 345.6

21.

In the diagram below, a right circular cone has a diameter of 8 inches and a height of 12 inches.



What is the volume of the cone to the *nearest cubic inch*?
1) 201
2) 481
3) 603
4) 804

22.

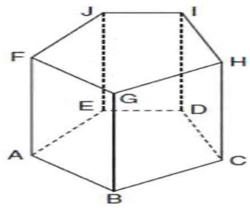
The volume of a sphere is approximately 44.6022 cubic centimeters. What is the radius of the sphere, to the *nearest tenth of a centimeter*?
1) 2.2
2) 3.3
3) 4.4
4) 4.7

23.

Two prisms have equal heights and equal volumes. The base of one is a pentagon and the base of the other is a square. If the area of the pentagonal base is 36 square inches, how many inches are in the length of each side of the square base?
1) 6
2) 9
3) 24
4) 36

24

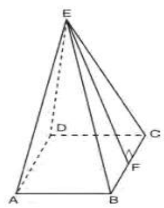
The diagram below shows a right pentagonal prism.



Which statement is always true?
1) $\overline{BC} \parallel \overline{ED}$
2) $\overline{FG} \parallel \overline{CD}$
3) $\overline{FJ} \parallel \overline{IH}$
4) $\overline{GB} \parallel \overline{HC}$

25

As shown in the diagram below, a right pyramid has a square base, $ABCD$, and $\overline{EF}$ is the slant height.



Which statement is *not* true?
1) $\overline{EA} \cong \overline{EC}$
2) $\overline{EB} \cong \overline{EF}$
3) $\triangle AEB \cong \triangle BEC$
4) $\triangle CED$ is isosceles

26

A right circular cylinder has a volume of 1,000 cubic inches and a height of 8 inches. What is the radius of the cylinder to the *nearest tenth of an inch*?
1) 6.3
2) 11.2
3) 19.8
4) 39.8

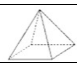
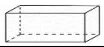
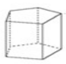
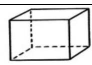
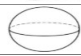
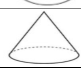
27. Find the area of a sphere whose radius is 8cm.
(a) 804.35cm^2 (b) 408.53cm2 (c) 48.35cm^2 (d) 480.35cm^2 (e) 804.53cm^2

28. The volume of a small cube is 8cm^3. How many of these cubes will be needed to completely fill a cube of edge 12cm.
(a) 216 (b) 612 (c) 162 (d) 126 (e) 215

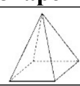
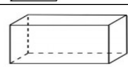
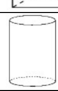
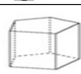
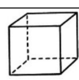
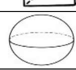
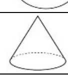
29. A tank with square base of side 25cm and height 20cm is filled with water. When 5 similar cubes are put into the tank, the volume of the water goes up by 30 %. Find the volume of each cube.
(a) 750cm^2 (b) 950cm^2 (c) 570cm^2 (d) 590cm^2 (e) 705cm^2

30. The volume of water in a cylinder container is 308cm^3. If the height of the water is 8cm, find the radius of the base of the container. Take $\pi = {}^{22}\!/_{7}$.
(a) r = 3.5cm (b) r = 7cm (c) r = 35cm (d) r = 36cm (e) r = 8cm

Section B: Complete the given table. 1mark each for correct answer 15 minutes

	Shape	Number of flat surface	Number of curved surface	Number of sides	Number of vertex	Number of edges
31						
32						
33						
34						
35						
36						
37						

Section C: Draw the nets of the following solids 15 minutes

	Shape	Net
38		
39		
40		
41		
42		
43		
44		

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