DEVELOPMENT AND USE OF SOFTWARE PACKAGE FOR TEACHING AND LEARNING CIRCLE GEOMETRY IN SENIOR SECONDARY SCHOOLS IN IBADAN, NIGERIA

BY

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CERTIFICATION

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DEDICATION

This thesis is dedicated to the glory of the Almighty God, the benefactor of mankind; and to my mother, Margret Adetoun OGUNYOMI who laid my educational foundation.

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ABSTRACT

The Chief Examiners' Reports in Mathematics, 2016 to 2018 of the West African Examination Council, show that Senior Secondary School (SSS) students' performance in Circle Geometry (CG) in public examinations in Nigeria was poor. Past studies on improving students' performance in circle geometry have focused largely on students' and teachers' characteristics, with little consideration for the use of software packages for its teaching and learning. Available software packages are rarely used in secondary schools because they are expensive, foreign, with complex programming languages. This study was, therefore, designed to develop and use Circle Geometry Software Package (CiGoSPac) for teaching and learning CG in senior secondary schools in Ibadan. The user friendliness of CiGoSPac was compared with that of a proprietary software package for teaching CG. The effectiveness of the CiGoSPac and the moderating effect of perceptual ability on students' achievement in CG were also examined.

Mayer's Multimedia and Connectivism Learning theories served as framework. The descriptive survey and a 3 x 2 pretest-posttest control group quasi-experimental designs were adopted. Three Phases - Phase I: development of the CiGoSPac, using enhanced Microsoft PowerPoint package and prototyping software development process. Voice, animation, text and hyperlink were used. Phase II: use of the CiGoSPac and Phase III: determining user friendliness of the CiGoSPac in comparison with proprietary software. The simple random sampling technique was employed to select two out of eight educational zones in Oyo State. The purposive sampling technique was used to select two local government areas and the twelve schools where the CiGoSPac was used. For Phase II, there were three treatment groups (Text+Animation+Voice), (Text+Animation), and Control. Twelve schools, 763 SSSII students and 16 teachers participated. For Phase III, 151 students were randomly selected from the 12 schools and 16 teachers participated. The Rating Scale for Software Evaluation Form A (r=0.89) and Form B (r=0.70), Rating Scale for Adequacy of Software (r=0.73), Checklist for Comparability of Software (r=0.87), Circle Geometry Achievement Test (CGAT) (r=0.79) and Perceptual Reasoning Ability Test (r=0.87) were used. Data were analysed using descriptive statistics, and Analysis of covariance at 0.05 level of significance.

The CiGoSPac had three media (Text+Animation+Voice) and two media (Text+Animation). Ninety-three percent of the teachers rated the CiGoSPac as being adequate for teaching and learning of CG. Eighty percent of teachers and 65.8% of students rated CiGoSPac as being more user friendly than the proprietary software. Ninety-three percent of the teachers said they would recommend CiGoSPac for teaching CG in SSSs in Nigeria. There was significant main effect of treatment on students' achievement in CG, $F_{(2, 756)}=142.00$, partial $\eta^2=0.273$. The Text+Animation+Voice group had the highest mean score in CGAT 41.08, while Text+Animation had 26.71, and control had 19.34. Perceptual reasoning ability had no significant effect on student's achievement in CG. The interaction effect of treatment and perceptual reasoning ability was not significant on students' achievement in CG.

Circle Geometry Software Package, a locally developed Software, is effective in learning Circle Geometry. Publishers should be encouraged to make it available to teachers and students.

Keywords: Circle geometry software package, Achievement in circle geometry, User friendliness of software packages

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CHAPTER ONE
INTRODUCTION

1.1 Background to the Problem

Geometry is the branch of Mathematics that deals with measurement, properties and relationships of point, lines, circles, angles, surfaces and solids. Generally, figures and shapes are dealt with in geometry. Figures may be plane or solids. Plane figures include circles, triangles, squares, kites, rhombus and polygons, while Solid figures include pyramids, spheres, cones, cylinders and the cubes.

In Nigeria, both plane and solid figures are taught in secondary school Mathematics, and the concept of Circle Geometry occupies a central position. In fact, Geometry constitutes about 27% of total topics taught in secondary school Mathematics. Among the concepts listed in the Senior Secondary School Mathematics under circle geometry include radius, diameter, segments, angles and sectors. Several theorems and propositions are also included as topics in Circle Geometry. These topics as emphasised in Mathematics curriculum underline the importance of geometry to human beings, the fact that its fundamental principles, theorems and laws are being applied in such fields as architecture, survey, aeronautics and space travel. In addition, according to Adegoke (2003), understanding the basic principles of circle theorems, laws and propositions can help in developing one's logical reasoning ability.

Some people have studied geometry to help them develop their logical reasoning ability and this helped them tremendously to think more clearly. According to Adegoke (2003), examples of people who had their logical reasoning ability developed after they had learnt geometry, include Sir Isaac Newton (1642-1727) and Abraham Lincoln (1809-1865). There is a story that Abraham Lincoln, before he became the President of the United States of America, borrowed a geometry book so that he could learn how the theorems postulated by Euclid (300BC) in Adegoke (2003) were proved in the book. This helped him (Abraham Lincoln) to think more clearly when he was arguing in court and in the course of his presidency.

According to Perry (1974) “the study of geometry began because it was useful and it continues because of the usefulness of its result to the world”. He noted some “obvious forms of usefulness” to include: producing the higher emotions and giving mental pleasure; development of the brain; and engenders logical thinking. Geometry teaches man the importance of thinking things out for himself.

Despite the importance of Circle Geometry, especially its applications in developing reasoning ability and constructions, researchers (Ogunyomi and Adegoke, 2018) have shown that it is an aspect of Mathematics in which secondary school students in Nigeria, perform below average in Senior Secondary School Certificate Examination (SSSCE) being conducted by the West African Examinations Council (WAEC) and National Examinations Council (NECO). Topics in Geometry accounts for about 27% of the total topics in Senior Secondary School Mathematics (SSSM) in Nigeria. In fact, out of six themes in the Senior Secondary School Mathematics Curriculum in Nigeria, Geometry occupies about the second position. Therefore, it is likely that poor performance in the aspect of Geometry may transcend to poor performance in Mathematics. The profile of candidates’ performance (Table 1.1) in the WAEC SSSCE from 2005 to 2016 is a testimony to students’ low performance in Mathematics.

Table 1.1: Profile of Candidates' Results (WASSCE) in Mathematics (May/June, 2005 – 2016)

YEAR	TOTAL ENROLLED FOR EXAMINATION	TOTAL CREDIT (A1 – C6)		TOTAL PASS (D7 – E8)		FAIL (F9)	
		NUMBER	%	NUMBER	%	NUMBER	%
2005	1 054 853	402 982	38.20	267 600	25.36	363 055	34.41
2006	1 181 515	482 123	41.72	366 801	31.55	292 560	25.13
2007	1 249 028	584 024	46.76	333 844	26.73	302 774	24.24
2008	1 268 213	726 398	57.28	302 266	23.83	218 618	17.24
2009	1 348 528	634 382	47.04	344 635	25.56	315 738	23.41
2010	1 306 535	548 065	41.95	363 920	27.85	355 382	27.20
2011	1 508 965	608 866	40.35	474 664	31.46	421 412	27.93
2012	1 550 224	723 024	46.64	445 224	28.72	380 425	24.54
2013	1 399 178	618 996	44.24	371 202	26.53	406 181	29.03
2014	1 547 140	621 950	40.20	427 342	30.53	451 301	29.17
2015	1 581 420	901 845	57.02	425 628	26.91	253 947	16.06
2016	1 469 585	1 032 175	70.23	248 676	19.37	188 734	12.84

Source: The West African Examinations Council (WAEC), Yaba, Lagos (2017).

As shown in Table 1.1, in the year 2005, 1,054,853 candidates sat for Mathematics examination, out of this, 402,982 (38.20%) candidates had C6, 297,600 (25.36%) candidates had pass, while 363,055 (34.41%) of the candidates failed. This implies that only 38.20% of the candidates will be able to use the result to proceed to tertiary institutions provided they wish to do so. This is because C6 is the minimum credit pass for admission into tertiary institutions. Although, as from 2006, the percentage of candidates who made C6 grade rose, on the average, from 2006 to 2016, the percentage of those who made A1 – C6 grades was about 48%. This percentage is below average, for a nation that is aspiring for a scientific and technological self-reliant. This is because the percentage of candidates that can go for science and technological based subjects in tertiary institutions is less than of the total candidates who sat for SSCE.

The low level of performance of students in Geometry manifests in many ways. These include: students' inability to understand and explain the meaning of concepts, construct and label shapes, state and prove circle theorems. The Chief Examiners' Reports [WAEC] (2016, 2017, and 2018) show that poor ability to translate and interpret word problems, represent problems using diagrams or symbols, and relate theorems to real life contexts are some of the challenges that students face in school certificate examinations. Moreover, many students treat questions in geometry haphazardly or avoid them.

An important factor why secondary school students perform poorly in geometry may be their inability to internalise image, symbols and diagrams. This has to do with their Visual Perception Reasoning Ability (VPRA). According to Deiner (2005), VPRA refers to brain's capability to categorise and infer what is seen. Dhingra, Manhas and Kohli (2010) see it as cognitive process which identifies, organises and interprets sensory data into meaningful information. The VPRA consists of two parts: These are the Visual Discrimination (VD) and the Visual Memory (VM). The VD comprises the student's ability to join to and recognise a figure's unique features and details, such as shape, orientation, colour and size. The VM refers to the student's ability to remember a visual image.

In their study, Dhingra, Manhas and Kohli (2010) showed that students' performance in Mathematics significantly correlated with their auditory and visual perception ability. The challenges that students have in Mathematics (especially Geometry) is often times associated with deficiencies in visual spatial ability, as well as, the visual motor ability. The organisation of written mathematical symbols thus present challenges to learners who experience visual-perceptual challenges, left-right confusion or consecutive issues (Clutten, 2009).

Van Hiele (1957) in Hiele and Hiele-Geldof (1958) in the course of finding ways of improving students' geometrical thinking, identified five levels of geometric thinking. The Van Hiele Model of Geometric Thinking focuses on the degree of thinking that students undergo in understanding geometry, as well as, how teachers can assist students in moving from one level to a different one. The theory posits that the learner, when he or she is assisted by appropriate instructional experiences, he or she passes through the following: visualisation (0), analysis (1), abstraction (2), deduction (3) and rigor (4). Van Hiele believed that development of the abstract and advanced levels of thinking that are indispensable in geometry are powerfully influenced by the kind and quality of instructional experiences. Van Hiele theory shows that a lot of students do not reach level three (deduction) - which according to Van Hiele, is the point where the students is expected to prove theorems deductively by fitting relationships among networks of theorems. Inability to reach level three is a clear indication that the student has a poor understanding of school geometry (Atebe and Schafer, 2010). These inabilities need to be curbed, otherwise, the students will continue to perform poorly in Geometry generally.

No doubt, for students to learn geometry meaningfully, they need to develop their geometric thinking ability. However, research (such as Van Hiele, 1957; Mwelese and Wanjala, 2014) has shown that it may be difficult for students to develop geometric thinking ability if Mathematics teachers continue to use lecture method which is the conventional method of teaching among some Mathematics teachers. The Conventional Teaching Method (CTM) has been the principal way of explaining ideas to students for several years, subsequently, classroom instructions have been delivered using verbal communications such as lectures and printed texts (Akinbode, 2014) which are not student participatory.

An alternative to CTM in Mathematics class is the use of Mathematics Software Packages (MSP) which utilises multimedia interaction to improve teacher's efficiency, increase participation of students in teaching and learning procedure and cultivate thinking ability among which are Geometry Software Packages (GSP). The MSP helps students to learn Mathematics comprehensively through technology by exploring and interaction. It also encourages and engenders cooperation among students. The use of Mathematics Software Packages in teaching breaks the teacher-centred pathway and shifts the focus to learners.

The Software packages can help students to visualise abstract and unfamiliar concepts. Through the visualisation, students can obtain perceptual understanding of geometric figures and theorems and inspire their thinking, and consequently deepen their understanding of learning content in a jiffy (Liu and Long, 2014). It makes students' learning space to go further than the teaching tools and directs Mathematics knowledge in the trend of individualisation and independency, without stiffly adhering to time and space.

Explaining this, Mayer (2005) revealed that the essential principle in multimedia learning is that the use of words and pictures engender more positive and meaningful learning among learners. This is in line with how the brain works and processes information. The use of both words and pictures lets the brain process more information in working memory. Meaningful learning, therefore, takes place, when information from working memory successfully makes its way to long term memory. As a result of the use of multiple channels of working memory, multimedia content can increase the likelihood that information will be effectively integrated into long term memory and not lost (BrainPOP, 2008). Cognitive psychology states that mobilising various senses to apperceive is all-inclusive, insightful than one. It improves learners' retention and quickens learners' pace of learning (Liu and Long, 2014).

The importance of software package in improving students learning outcomes cannot be overemphasised. Mathematics Software Package is an educational software package purposely developed to aid the teaching and learning of Mathematics. Its use allows teachers to cover different topics at different grade levels. Various Mathematics Software Package (MSP) have been developed, commercialised and used. Examples include: NumberGym Plus (Ogunyomi, 2010), PLATO Achieve Now, Larson Pre-Algebra, Larson Algebra I, Cognitive Tutor (Campuzano, Dynarski, Agodini, and Rall, 2009), graphing calculators, Java applets, and spreadsheets, Interactive White Boards (IWB), Geosupposer, GeoExplorer and Cinderella. Other examples include Dynamic Geometry Software (DGS), Slate or graphic tablet, Geometer's sketchpad, Computer Algebra System (CAS), MATLAB which have been integrated into the teaching of Mathematics. However, these software packages are foreign and expensive. Their development entails having adequate knowledge of programming languages such as JAVA and C++ which most secondary school teachers in Nigeria have little or no knowledge of. In the recent times, however, people (such as Ahiatrogah, Madjoub and Bervell, 2013; Adegoke, 2017) who have little or no knowledge of programming have tried to develop simple software packages for teaching Mathematics but only used their knowledge of the use of Microsoft Power Point Module.

Literature on software development shows that some researchers have developed some teaching packages in the area of Mathematics, Technical and Science subjects at the secondary school level. This was in an attempt at improving performance of students in Mathematics and Science subjects. For example, Ahiatrogah, Madjoub and Bervell (2013) developed a Computer Assisted Instruction software using Microsoft Office PowerPoint for teaching Pre-technical skill in Junior High Schools. Also, Adegoke (2017) developed a computer assisted instruction software using Microsoft Office PowerPoint for teaching Circle Geometry in senior secondary schools.

In developing software packages, different types of approaches have been used since the inception of information technology, among which are; (a) waterfall, (b) incremental, (c) prototyping, (d) iterative development, (e) spiral development, (f) rapid application development, (g) extreme programming and (h) various types of agile development (Sommerville, 2011). In developing educational software, Beale and Sharples (2002) identified nine basic steps which consist of questions to be answered by the developer under these headings and order: (a) define the educational aims and objectives, (b) identify the learning needs (c) decide which needs could be addressed by computer, (d) determine the general teaching and learning approach, (e) determine the teaching strategy, (f) choose the teaching components, (g) design and test the software, (h) evaluate the entire system, and (i) deploy and maintain the system.

Fenrich (2014) further explained these nine basic steps and called them “instructional design process of activities”. They are similar in terms of headings but different in principles. The outline of Fenrich’s steps are: (a) identify the instructional goal, (b) conduct a goal analysis, (c) conduct a subordinate skills analysis, (d) identify entry behaviours and characteristics, (e) write learning outcomes, (f) develop an instructional strategy, (g) develop and select instructional materials, (h) conduct formative evaluations, and (i) produce the final product. The evaluation of any software developed must cover these three aspects:

i) *Usability*: This is the degree to which specific users can use a software to achieve quantifiable objectives with effectiveness and efficiency in a quantifiable context. It is tied to five characteristics – Efficient, Effective, Error tolerant, Engaging and Easy to learn. The question here is: can a task be effectively and efficiently performed by the users of the software?
ii) *Usefulness*: This is the degree to which the software enhances teaching and learning. The question here is: are teaching and learning improved by it?
iii) *Desirability*: This is the satisfaction derived by the users of the software that propels them to recommend it to other likely users. The question here is: do users enjoy using it?

This is done under (a) evaluate the entire system (Beale and Sharples, 2002) and (b) conduct formative evaluations (Fenrich, 2014).

No doubt, software packages are useful, however, most of them are not developed in Nigeria. Researchers such as Ogunyomi (2010) and Adegoke (2017) have shown that in Nigeria, only very few schools are able to purchase the commercially available Mathematics teaching-learning software because of its high cost. In addition, the commercially available ones do not take into consideration the environmental factors in public schools in Nigeria (Bamiro, 2007). Examples used in such software are foreign to Nigerian culture. For example, voice in most of these software packages are with foreign accent which some students in Nigeria may not be able to comprehend. It is on the basis of this that in this study, the author developed a Nigerian based Circle Geometry teaching-learning software that encompassed the peculiarity of Nigerian culture which is our language.

In earlier studies in education, developers such as Ahiatrogah, Madjoub and Bervell (2013) used Microsoft Power Point 2007; and the emphasis was on picture and text. There was no voice. This software can only be used for teaching; it cannot serve as a learning software. In the circle geometry software developed and used by Adegoke (2017), also, the Microsoft Power Point was used, emphasis was on group teaching and there was no voice. Only text and pictures were incorporated in the software packages.

1.2 Statement of the Problem

According to statistics from public examining bodies in Nigeria (WAEC and NECO) geometry is one of the major areas in which some students experience difficulties and score low marks in senior school Mathematics examination. Some factors have been put forward to explain this trend and various suggestions on how to improve its teaching-learning have been proffered. However, no considerable changes in the performance of students in the public examinations have been observed.

Perusal of literature shows that previous attempts at improving students' performance in mathematics focused more on students' and teachers' characteristics with little consideration for the development and use of software packages that can aid teaching and learning of Mathematics. Available packages such as NumberGym Plus Mathematics Software and Dynamic Geometry Software are rarely used in secondary schools in Nigeria because they are expensive, foreign with complex programming languages which make them quite incomprehensible to some secondary school students and teachers. The few ones that have been developed through the use of Microsoft power point are mainly for teaching and less emphasis was placed on students self-learning.

It was on this basis that this study developed Circle Geometry teaching-learning software that could serve as self-learning for students and teaching modules that can be used by Mathematics teachers. The effectiveness of the software in enhancing students' achievements in Circle Geometry was determined. Also, the moderating effects of perceptual ability on students' achievements in Circle Geometry was examined.

1.3 Research Questions

1. Does the CiGoSPac adequately execute the illustrated flowchart?
2. How comparable is the CiGoSPac with NumberGym Plus in terms of: (a) Navigation (b) Graphic, (c) Animation, (d) Voice, (e) Illustration and (f) Assessment?
3. How user friendly is the software - Circle Geometry Software Package (CiGoSPac) in terms of: (a) ease of use (b) animation, (b) voice (c) text (d) content and (e) colour to:
   (i) Students?
   (ii) Teachers?
4. How desirable is the software - Circle Geometry Software Package (CiGoSPac)?
5. Does the software (CiGoSPac) effectively teach senior secondary school Circle Geometry?
6. What are the challenges faced by teachers and students in using CiGoSPac for teaching and learning of Circle Geometry?

1.4 Hypotheses

Three null hypotheses were tested in this study at 0.05 level of significance:

$H_0 1$: There is no significant main effect of treatment on students' achievement in Circle Geometry.

$H_0 2$: There is no significant main effect of perceptual ability on students' achievement in Circle Geometry.

$H_0 3$: There is no significant interaction effect of treatment and perceptual ability on students' achievement in Circle Geometry.

1.5 Scope of the Study

The study developed and use a software package called CiGoSPac using prototyping development process for teaching and learning Circle Geometry among Senior Secondary School Two (SSSII) Mathematics students and teachers in 2018 / 2019 academic session in Ibadan City and Ibadan-Less City in Ibadan, Nigeria with the variables of interest as achievement in Circle Geometry and Perceptual ability of the students. The study compared the CiGoSPac with NumberGym Plus, and found out how user friendly it is, desirability and the extent to which it would effectively teach Circle Geometry. The study did not take into cognisance any other treatments and learning outcome variables other than the ones mentioned.

The results and conclusions drawn from the study are therefore limited to the development of educational software and defined target population that were examined, and to Circle Geometry aspect of Mathematics as a subject in Senior Secondary school. No attempts should be made to employ them directly as a basis for either predicting or explaining any of the learning outcomes for the students not in this category or even in other subjects other than Mathematics.

1.6 Significance of the Study

The results would provide information, serve as reference point and launching pad for further research on the development and use of Mathematics Software Package (MSP) and its effectiveness in improving students' performance in Mathematics. Software and curriculum developers in Education would be expected to use the outcome of the study to enrich the method of instruction in Mathematics.

1.7 Definition of Terms

C ++: General-purpose object-oriented programming language for software developers for coding which have four features: abstraction, encapsulation, inheritance and polymorphism. It is an extension of **C** programming language.

Circle Geometry Software Package: It is a multimedia software package purposely developed to aid the teaching and learning of Circle Geometry. It is an audio-visual software package to illustrate the instructional materials and its operation based on Microsoft PowerPoint presentation software 2013 to assist in the teaching and learning Circle Geometry. Its features include drawings, animations, theorems, proofs, problems, feed-backs and sound.

Java: Computer programming language for software developers usually for visual arrangements.

Learning: A relatively permanent change in behaviour or performance which comes as a result of practice, experience or exposure.

Mathematics Software Package: It is an educational software package developed to support instructions in Mathematics. It covers different topics for students at various level of educational development in Mathematics.

Teaching: Process of attending to learner's needs, experiences and feelings, and making specific interventions to help them learn particular things.

1.8 Abbreviations

CiGoSPac: Circle Geometry Software Package

CLI: *C*ommand-line Interface or Command Language Interpreter

CTM: Conventional Teaching Method

DGS: Dynamic Geometry Software

EAI: Enhanced Anchored Instruction

FRN: Federal Republic of Nigeria

IWB: Interactive White Board

MAN: Mathematics Association of Nigeria

MATLAB: Matrix Laboratory Mathematical Software Program

MIP: Mathematics Improvement Projects

MLA: Mastery Learning Approach

NERDC: Nigerian Educational Research and Development Council

NMC: National Mathematics Centre

OCA: Out – of – Class Activity

STAN: Science Teachers Association of Nigeria.

CHAPTER TWO
LITERATURE REVIEW

2.1 Theoretical Background

Several theories underlie development and utilisation of Software Packages in the teaching and learning processes in schools. Among these theories, the Mayer's Cognitive theory of Multimedia learning and Connectivism learning theory were relevant and therefore formed the theoretical background for this study.

2.1.1 Mayer's Cognitive Theory of Multimedia Learning (MCTML)

The underlying principle behind the MCTML is that students learn better from the combination of words and pictures than from only words. The MCTML says that students learn better and learning is more meaningful when teaching and learning processes involve different kinds of media such as text, words, graphics and pictures. This is because these media appeal and stimulate both the auditory and visual channels of communication. The fundamental behind the MCTML is that the two distinct channels for information processing are auditory and visual. This is why the MCTML is sometimes called Dual-Coding theory.

This theory is pertinent to this study, the reason being that using CiGoSPac in teaching and learning processes involve making use of a variety of media such as sound, pictures and texts, while presenting materials to be learnt. These three media help information to move from short term memory through working memory to long term memory. The combination of these media is hypothesised to improve the learning of Geometry among students.

Mayer identified three types of memory and their roles in learning. These are:

a) Sensory or short-term memory which receives stimuli and stores it for a short time
b) Working memory which processes data to form mental constructs (or 'schema'), and
c) Long-term memory which is the storehouse of all things learned.

The MCTML posits that the brain does not interpret a multimedia presentation of words, pictures, and auditory information in a mutually exclusive manner, rather, these components unit were chosen and arranged dynamically to provide logical mental constructs.

2.1.2 Connectivism Learning Theory

No doubt, we are presently in a digital age. The way we learn, live, and communicate is quite different from what obtained about 100 years ago. Technology has overtaken the usual way through which human beings communicate with one another. On the basis of this, theorists in the behavioural and cognitive psychology such as (Brown, 2002; Kleiner, 2002) espoused the connectivism theory of learning by linking the effects of technology on how humans interact among themselves. Connectivism learning theory recognises the importance of technology and internet technologies (such as web browsers, search engines, wikis, online discussion forums, and social networks) in the way people learn, live and communicate in this modern world. No doubt, technologies have enabled people to learn and share information across the World Wide Web and among themselves in ways that were not possible before the digital age.

Connectivism learning theory explains that learning resides in non-human appliances, for example, software packages for teaching and learning such as the CiGoSPac. Learning does not simply happen within an individual, but within and across different networks. What sets connectivism apart from theories such as constructivism is the view that “learning (defined as actionable knowledge) can reside outside of ourselves (within an organisation or a database), and is focused on connecting specialized information sets”. The use of software packages as in computer-assisted instruction hinges on connectivism theory and that such instruction can be programmed.

2.2 Programmed Instruction and Software Development

The concept of programmed instruction is as old as formal schooling. In the formal school system, each grade level has a certain small portion of accumulated knowledge allotted to it and each learner is expected to master that segment before being allowed to proceed to the next grade. For example, in circle geometry, concepts are arranged hierarchically. Concepts such as circumference, radius and diameter are first learned before moving on to concepts for calculating the area of a circle, the circumference of a circle and so on. In the programmed instruction, any learner(s) who cannot keep up with the rest of the class is held back and repeat the year. However, learners (such as high ability) who are found not to be adequately challenged by the content in their grade are skipped ahead to a level that are more consistent with their ability.

What is programming? Programming is the arrangement of the materials to be learned in a sequence of steps designed to lead students to the final goal. The steps are usually quite close together. This is to ensure a gradual increase in difficulty. The material being presented is broken down into small units called frames, which can be presented by mechanical means (teaching machine). In this computer age, the teaching machine is usually the computer and the programming of instruction is in the computer-assisted instruction. In the computer-assisted instruction, the instructional software packages may have hundreds of frame and the frames are written in such a way as to maximise the possibility of success. In the development of instructional software packages, the first frame is always very easy and the students are led by small steps into more complicated frames until the unit is completed or until the students have achieved the desired terminal behaviour.

Programmes may be written in book form with the questions on one page and the answers put on the facing page. The students cover the answers, respond and then uncover the answers as a self-check. In some computer-assisted instruction, the developed software packages have frames that are set so as not to move from one frame to the next until each one in turn has been successfully completed. The programming are even equipped with a buzzer or bell that sounds when a correct response has been given. The buzzers and bells act as reinforcement for correct responses.

Programmed instruction has several key advantages. These include:

1) It makes students to become active participant in their learning process and not just a passive listener and observer. This is because the student must pay attention to the instructional process of the machine (computer).

2) It allows each student to proceed at his or her own pace and rate. This is because a faster student may finish learning earlier than his or her colleagues who are not so fast.
3) It engenders immediate feedback. There are no delays between the response and knowledge of results.
4) It engenders positive reinforcement.
5) Programmed instruction through machines such as in computer-assisted instruction can be set automatically to keep track of errors.

In this study, the developed CiGoSPac have been programmed is such a way that learners that use it as learning package can maximally enjoy these benefits.

2.3 History of Software Development

Norman (2016) divided the history of software development into decades starting from 1950 to 2020. This was further divided into two: the early (1950 - 1990) and modern (2000 to 2020) years.

a) The 1950's: The period when Software Engineering was done like hardware engineering. Software had the outlook of hardware engineering and names of packages reflected the names of associations such as the IEEE Computer Society and Association of Computing Machinery
b) The 1960's: The period of improved computing infrastructure, development of operating systems, high-level languages (such as FORTRAN, COBOL), and establishment of software development companies (such as IBM's OS/360, Apollo mission) for profit making. Also, during this period code-and-fix approaches were developed.
c) The 1970's: This was the advent of replacement of go-to-statement, code-and-fix approaches with prototyping, waterfall and sequential waterfall processes for software development.
d) The 1980's: This period witnessed the establishment of software engineering institutes such as Carnegie Mellon University's Software Engineering Institute in 1984. There was the development of International Standards Organization ISO-9001 for standardization processes, development of software testing tools. Moreover, Object-Oriented (OO) approaches, visual programming and powerful workstations were also developed.

e) The 1990's: This period witnessed the continued use and improvement of OO methods and development of Unified Modelling Language (UML). During this period there was paradigm shift from the applications of sequential Waterfall approach to concurrent engineering of software phases. There were developments in the area of Rational Unified Process (RUP) and Rapid Application Development (RAD). There was more emphasis on agile methods, development of software such as Linux, Apache and Python.

f) The 2000's. This period witnessed the continued use of RAD. There were more emphasis on Information and communication technology such as Google and other web-based collaboration.

g) The 2010's: This period witnessed the need for agility, global connectivity and large systems of systems. Emphasis was placed on integration of skills (e.g. software, systems, marketing, finance, domain skills),

h) The 2020's: This is the era of increased development of software capable of high computational ability. Various software that can work in devices such as smartphones are being developed. Also, there are ongoing developments in new platforms (e.g. smart materials, nanotechnology), sensor networks, and autonomic software (e.g. self-reconfigure to cope with changes), cloud services, and parallel processing.

2.3.1 Types of Software

According to Bamiro (2007), there are three core classes of software in the market:

1. ***System software*** (SS) – The SS are primarily Operating Systems (OS) that regulate the activities of the computer together with some elementary routine tasks. Examples include, MS-DOS, PC-DOS, UNIX, and Microsoft Windows NT among others.
2. ***Proprietary software*** (PS) – The PS was developed to undertake particular tasks like word processing (Microsoft Word, Word Perfect, etc.), Database Management (Dbase, Access, FoxPro, Oracle, etc.), Spreadsheet (Lotus, Excel, Quattro, etc.), Desktop Publishing (Coredraw, Pagemaker, etc.), and software design platforms (Python, Java Script, Java, SQL, Visual Basic, C^{++}, C, Cobol, Fortran, etc.) which are utilised to develop other software, especially, applications software.

3. ***Applications software*** (AS) – The AS was developed to satisfy the numerous wants of users within the various sectors of the economy. The AS are usually, either made-to-order for individual users or customised packages that may be tailor-made to satisfy the needs of various teams of users. Examples include payroll, human resources, finance, accounting packages, and enterprise resource planning among others, which can be classified on their functional basis. Remarkably is the limitless difference of requests for software in this category by various users. They are solutions employed predominantly within the business realm to fulfill particular needs of the end-user(s), making at an equivalent time a numerous business prospects for software developers.

2.3.2 Software Developments and Utilisation in Africa

In Africa, software development efforts have focused primarily on the AS with the aim of satisfying the varying needs of users within the various sectors of her economies. The level of software utilisation and development in an economy are directed mostly by the degree of information available on the economic activities plus the presence of enabling atmosphere for the generation, analysis and utilisation of information. The amount of utilisation of ICT in the Africans' economies should vary from among countries within the continent. However, the pattern of the market for AS are determined by the activities of supply and demand sides.

The supply side consists of different marketing firms promoting application software packages in Nigeria. Bamiro (2007) classified these marketing firms into three classes. These are

a) Direct Developers (DDs)
b) Value-Adding Resellers (VARs) and the
c) Direct Foreign Representatives (DFRs).

The VARs have the competence to provide support service and promote the marketing of applications software. There are many VARs supporting totally different classes of software within the Nigerian market. For example, SystemSpecs which started as a VAR firm for SunSystems promoting an accounting package developed by Systems Union of UK. After about five years into the affiliation, SystemSpecs was able to develop its' own software product – the Human Manager –

which currently dominates Nigeria and ECOWAS sub-region as human resources management software market.

The DDs are software firms with ability to develop, support and market their own software. They include: Programos Software Ltd, Progenics, Future Technology Systems, Labyet Polaris, etc. In Nigeria, it was observed that most DDs firms began as representatives of foreign software developers, acquired expertise from them, and translated the expertise to software package sales, execution and value-adding activities, then scanned the setting for a window of opportunity to form a distinct segment for themselves in a dissatisfied part of the market.

The demand side is the degree to which actors in main sectors of an economy employ ICT to develop their operational effectiveness. The major classes of application software utilised in the following sectors of the economy are:

i. **Banking and Finance:** This is made up of variety of software and software modules utilised in the banking and finance sectors.
ii. **Human Resources Management**: This is the array of software that possess different abilities to handle different human resources management needs and the payroll system.
iii. **Enterprise Resource Planning** (ERP): This category of software incorporate all divisions and tasks through a company onto a single computer system that can handle product planning, purchasing and logistics, human resources, finance, customer service, vendor management, production, inventory management and other essential business activities
iv. **Accounting**: This is the collection of software which handles accounting and several accounting practice in the diverse sectors of the economy.
v. **Insurance**: The software packages here handle different activities of the firm in the industry, like reinsurance, insurance accounting, claims administration, policy management, and client management.
vi. **Education**: This includes different software packages designed to handle registration of students for examinations, computation of examination results, computer-assisted learning and computer-assisted instruction, distance education, planning and statistics, and management.

vii. **Others**: These include a group of tailor-made, function-specific software packages that are often developed to meet the particular generally limited requests of individuals. Such software are usually categorised as customised software packages. Examples include software to assist an individual manage his or her finances as he or she deems fit.

2.4 Mathematics Software Package

The mathematics software packages fall within the education software. There are two forms of technology integrated into Mathematics teaching and learning as Preiner (2008) pointed out. These are:

a) Virtual manipulative tool (VMT) and
b) General software tool (GST).

The VMT: This is as an interactive and web-based visual representation of a dynamic object that presents opportunities to users to construct mathematical knowledge. Examples of these are provided by the Internet in the form of 'applets', 'mathlets', or 'dynamic worksheets'. The Virtual manipulative tool supports students' active learning, promotes their conceptual understanding and problem solving skills. Also, it provides interactive environments where students could pose and solve problems; form connections between mathematical concepts and operations. Also, the VMT helps the users to get immediate feedback about their actions that might lead them to reflect on their conceptualization. They are mostly available online or on the Internet. It is therefore accessible to students both in school and at home.

The GST is an open and flexible software. It is not made for specific topics or limited to teach specific tasks, and therefore provides the users the opportunity to plan and decide what to do. The GST can be used for a wide variety of problems and can provide varied learning situations for users to explore and experiment with mathematical connections.

Generally, the MSP is an educational software package that allows more flexibility and enables both teachers and students to visualize and explore mathematical concepts in their own creative ways.

Although the MSP is versatile as an educational software package purposely developed to aid the teaching and learning of topics at different grade levels, Preiner (2008), identified questions teachers need to answer before selecting and using any of its varieties.

a) The sense and the need for a software (Does it make sense?)
b) The effectiveness of the use of software over the 'traditional' tools like paper, pencil, straightedge and compass (Is it more effective than the use of traditional method of learning Mathematics?)
c) Appropriateness of the software (Is the software appropriate for the given mathematical content?)
d) Familiarity of the features of the software to the user (Are the students familiar with the features of the software?)
e) Effective use of the software (Can the user effectively use the software to solve a given task?)
f) Guidance and instruction needed by the user (What kind of guidance and instructions do students need to successfully use the software to solve a given task?

Examples of MSP include dynamic geometry software, computer algebra systems, spreadsheets, dynamic Mathematics software, graphing calculator, presentation software MATLAB, PLATO Achieve Now, Larson Pre-Algebra, Larson Algebra I, Cognitive Tutor (Campuzano et al, 2009). According to Ogunyomi and Adegoke (2018) and Saha, Ayub and Tarmizi (2010), the MSP such as Geometer's Sketchpad, Derive, Cabri, Autograph, SAGE, FreeMat, GeoNet, JLab, Maxima, Axiom, YACAS, JsMath can be downloaded from the internet and utilised in teaching and learning of Mathematics. These Mathematics software packages have been utilised in schools, colleges and universities across the world, especially in Europe, United States of America and Asia. Schools in developing countries such as Nigeria need to procure some of the afore-mentioned software so as to utilise them within the learning room though certain of them are expensive. Notwithstanding, there abound software packages which can be used free of charge on the part of educators while teaching. There are some Open Source Software (OSS) packages which users can download depending on their suitability for use.

2.5 User Friendly Software

User friendliness of a software package refers to the degree of easiness of understanding its operation and use for the purpose it was created and developed. A software that is difficult to decode and poorly supported is not user friendly. A user friendly software has interface that guides the users through different stages towards the accomplishment of a given task. It reduces the difference between users and the systems. That is, such users can interact more with the tasks and less with the system (Alan, 2004). The criteria for user friendliness is applied to every operating system, end-user application and all proprietary in-house applications.

Wallen (2010) identified what makes an application user-friendly giving the following conditions:

1. ***Simple to install***: The installation should be simple and well documented.
2. ***Easy to update***: The update process should be easy. If updates are complex, users will likely avoid the procedure. Updates need to be simple enough to ensure that users continue to profit from the software, if not, the software becomes less and less reliable and secure.
3. ***Intuitive***: A user friendly interface should be built upon the human visual and cognitive capabilities, and thereby lower the learning difficulty. This can be achieved by using metaphors that allow users to learn from known to unknown so as to assist in the understanding of the concepts. Software is as good as its Graphical User Interfaces (GUIs). If the GUI is not well thought out and well executed, users will have problems with its usage. It should work as expected.
4. ***Efficient***: It should work perfectly with simple subsystems and structures. From the user's opinion, the software should be an effective way of finishing the task. The efficiency of a software is tied up with its intuitiveness.
5. ***Pleasant, easy-to-navigate GUI***: It must be pleasing in appearance. Once a developer chooses to go with trends as an alternative to what works, it creates an unfriendly experience for end-users. Rather than going with trends, include your own idea on what is established. If that can be accomplished with the design, go for it. However, if your design is counterintuitive and ineffective, it fails the user-friendliness test.
6. ***Easy to remove***: A software should be easy to uninstall. Lacking in this respect makes the software become clumsy and cannot be user-friendly. Just

as developers do not need their users to get rid of their software, the removal procedure may well be the last impression your software creates. Do not make that impression an undesirable one.

7. ***No need for third-party software***: When a software entails third-party software to have it running, this generates levels of difficulty that most ordinary end users cannot handle. This makes the software not to be user-friendly. This third-party software can be anti-spyware, antivirus and other protection-based implements short of which your computer is defenseless to whatever damaging powers that will be thrown at you.
8. ***Easy to troubleshoot***: No software is perfect. If there is any problem with the software, it is imperative that the end user can request for support and that support can resolve the issue. Without any support in these area (troubleshooting), it will be difficult for the administrator or user to keep running the software.
9. ***Adheres to standards***: Problems arise when developers do not adhere to standards. This creates issues with applications interacting with such software. When users are affected by a lack of compliance with standards, they will face an unfriendly experience trying to get their tools to communicate with tools that follow standards.
10. ***Effective error handling***: When a software encounters an error, it should make the error known to the developers. Reporting of bugs is not the responsibility of the end users, but it can assist in improving the software. When a software runs into an error without warning, users are left troubled. Always create an avenue to help users to know there was a problem and how to resolve it.

Davidson (2017) compressed the idea of Wallen (2010) user friendliness of software to six. These are

a) Simple to Install
b) Easy to Navigate
c) Easy to Update
d) Aesthetics (Pleasant)
e) Intuitive and
f) Easy to Uninstall.

Also, the Tech Terms Computer Dictionary (2014) sees user-friendly software as:

1. ***Simple***: A user-friendly interface is not very complex, but instead is straightforward, providing quick access to common features or commands.
2. ***Clean***: A good user interface is well-organized, making it easy to locate different tools and options.
3. ***Intuitive***: In order to be user-friendly, an interface must make sense to the average user and should require minimal explanation on how to use it.
4. ***Reliable***: An unreliable software is not user-friendly since it will cause undue frustration for the user. A user-friendly software is reliable and does not malfunction or crash.
5. ***Good User Experience (UX):*** This may depend on different end users for whom the software was designed. The presence of many advanced features in a software does not make it user-friendly. The objective of a user-friendly software is to provide a good user experience (UX).

User-friendly software are typically more successful than those with multifaceted, complicated interfaces that are difficult to use. In order to ensure a good user experience, developers often thoroughly test their software before releasing them to the market. Coombs (2000) concluded that user-friendly learning software can be associated to a form of "conversational fluency in the form of reflective learning combined with reflexive user control of an IT software system in an appropriate socially situated learning environment." A user-friendly software system implies faster learning and immediacy of usage for novices.

2.5.1 Interface Design

The Interface design (ID) is one of the factors that influence the User-friendliness of a system. There are three main types of User Interface (UI). These are:

a) C*ommand-line Interface* or *Command Language Interpreter* (CLI): The CLI is the means by which the user interacts with a computer software through *commands* to the program in the form of successive lines of text. Examples are the MS-DOS operating system and the command shell in the Windows operating system.

b) *Menu-Driven Interface*: This refers to a series of screens which are navigated by choosing options from lists, i.e. menus. A menu driven interface is commonly used on cash machines (also known as automated teller machines

(ATMs), ticket machines, information kiosks (for example in a museum) and remote controls.

c) *Graphical User Interface* (GUI): The GUI allows users to interact with electronic devices through graphical icons and visual indicators rather than secondary notations (such as text-based user interfaces, typed command labels or text navigation).

2.6 Development of Instructional (Educational) Software

Fenrich (2014) identified the instructional design process of activities that can solve an instructional problem as follows:

1. ***Identify the instructional goal***: This involves assessing the need to determine the actual problem and clearly defining and verifying the instructional goal.
2. ***Conduct a goal analysis***: This involves providing a visual statement of what the learner will be able to do and classifying the goal into a learning domain.
3. ***Conduct a subordinate skills analysis***: A subordinate skills analysis is based on the goals learning domain classification. The designer of the instructional design process must perform a cluster analysis for verbal information, a hierarchical analysis for intellectual skills, a procedural analysis for psychomotor skills and the appropriate instructional analysis for attitudinal skills.
4. ***Identify entry behaviours and characteristics***: This is based on the instructional skills analysis and learner analysis which determine which skills will be taught. The task of learner analysis helps in identifying the target audience population and discovering factors as abilities, language capabilities, motivation, interest, human factors, and learning styles that may influence the instructional design. The learner analysis should also show the way to defining a student population that is neither too narrow nor too broad. This information can be obtained from personal experience interviews with students and instructors, questionnaires, tests, and literature.
5. ***Write learning outcomes***: These are specific measureable skills that students need to learn. Steps to writing learning outcomes include;
    i. Identifying specific behaviours by using action verbs.
    ii. Specifying the content area after the verb.
    iii. Specifying applicable conditions.

iv. Reviewing each learning outcome to be sure it is complete, clear and concise.
v. Develop criterion- referenced test questions.

6. ***Develop an instructional strategy***: An Instructional strategy clearly describes the instructional materials, components, the media selection and the procedures used with the materials to have the students achieve the learning outcomes. It is based on the Instructional analysis, the learning outcomes, and other previous steps. This is based on the foundations of learning theory, constructivist principles and support meta-cognition. The instructional strategy will be used as a framework for developing the instructional materials or evaluating whether existing materials are suitable or need revision.
7. ***Develop and select instructional materials***: Where existing materials are available, evaluate the material to determine if the material is suitable or can be adapted or supplemented. When the needed material must be developed after finalizing the media selection, develop and / or gather the media and complete the programming.
8. ***Conduct formative evaluations***: It involves collecting data and information that is analyzed and used to improve the material's efficiency while it is being created. This should be done through one-to-one, small group and field trial evaluations. It must be conducted throughout the instructional development process to minimize the loss of time and money due to errors.
9. ***Final Product***: The instructional software can now be used in a real educational setting for the teaching purpose on the appropriate population.

   The prototyping software development approach was used in designing instructional or educational software as shown in figure 2.1.

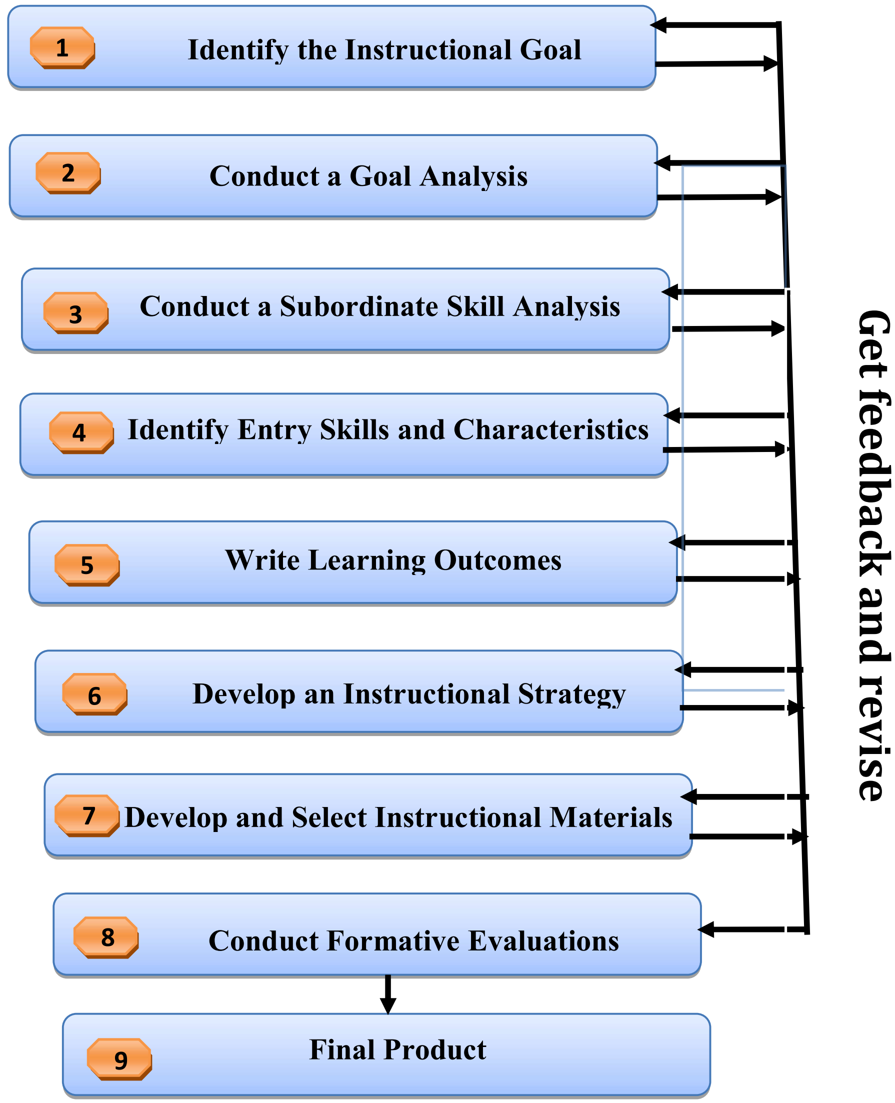

Figure 2.1: Instructional Design Process Chart (Fenrich [2014])

2.7 Mathematics Software Packages and Students' Achievement

Kushwaha et al (2014) examined the effects of dynamic Mathematics software GeoGebra on secondary students' achievement in Geometry. There were two groups: Experimental and Control group. In the control group, traditional method was used while in the experimental group teaching-learning was through GeoGebra software package. Results showed meaningful differences in scores and experimental group performed better than their colleagues in the control group.

Gambari et al (2014) compared the effects of two modes of CAI packages on the performance of Senior Secondary School students in solid geometry in Minna, Niger State, Nigeria. In their study, there were three groups: Group I was Animation with text (AT), Group II was Animation with narration (AN) and Group III was lecture method. They hypothesised that "there would be no significant differences in the post-test mean scores of students taught solid Geometry using Animation with text (AT), Animation with narration (AN) and lecture method, and gender difference. The study adopted the pretest - posttest experimental design with 3×2 factorial design. One hundred and twenty Senior Secondary School students served as participants. The result shows that there was significant difference in the post-test mean scores among the three groups. The Scheffe's Post-hoc test revealed a significant difference between the AN and the lecture method groups, favouring the AN group. The CAI packages involving animation with narration (AN) engendered better learning outcomes than animation with on-screen text.

Wintz (2009) examined the impact of computer aided instruction (CAI) on students' performance in Mathematics. There were two groups: CAI and conventional method groups and the research design was pre-test – post-test equivalent group experiment. The sample comprised of eight student-teachers from eight Secondary Schools and 190 Secondary School students. Two hypotheses were tested and research questions were answered. In addition to instructional modes examined, the type of school and gender as moderating variable were examined. The CAI group performed better than their colleagues in the post achievement cognitive tests that were administered

Olusi (2008) examined the effect of computer aided instruction and traditional teaching method on the Junior Secondary School students' achievement in

Mathematics in Edo – State, Nigeria. Four research questions were answered and four hypotheses were tested in the study. The design of the study was a pre-test post-test control group experimental design. The sample for the study consisted of 270 randomly selected students from three Junior Secondary Schools in Edo state. Two instruments were used for the study. There were two groups: Computer Assisted Instruction (CAI) Group and Traditional teaching method group.

The findings of the study were that CAI significantly influenced students' achievements in Mathematics than the traditional instructional method. He reported that the significant difference could be associated with the enthusiasm and interest developed by the students with the use of computer technology in solving Mathematics.

2.8 Mathematical Software Package and Students' Achievement in Geometry

In their study, Safo, Ezenwa and Wushisi (2013) examined how effective computer instructional packages are on the achievement and retention in Geometry among Junior Secondary Schools (JSS) in Niger State, Nigeria. Two research questions were answered and two null hypotheses were tested. The pre-test and post-test, control group design was adopted. The simple random sample technique was used to select 80 JSS2 students drawn from four Junior Secondary Schools in Minna Metropolis.

In this study, the researchers developed computer assisted instructional package on Geometry (covering plane and solid shapes). This package was used as treatment instrument for experimental group while control group was exposed to conventional talk and chalk teaching method. A 40-item multiple-choice objective Geometry Achievement Test (GAT) was used to collect data. The data collected were subjected to t-test statistics. Results showed that experimental group performed better than the control group; that is, a statistically significant difference between the achievement of students taught with CAI and those taught with traditional method.

Ogunyomi (2010) examined the effect of Information and Communication Technology (ICT) on teaching and learning Mathematics in selected Lagos State Secondary Schools with emphasis on Education District II in Lagos State. The research instruments used were two likert scale questionnaires (for students and teachers), students test questions on circle Geometry and NumberGym Plus mathematical software package with Interactive White Board. The Samples were 100 randomly selected Mathematics teachers and 90 randomly selected SS2 students from the area under study. The students' test questions were administered to 3 different groups comprising of 30 students each randomly selected into the group. Five hypotheses were formulated and tested. Results indicated that four out of five null hypotheses were rejected and only that of gender was not significant. The researcher concluded that the use of ICT in teaching and learning Mathematics has positive effect on the performance of students in Mathematics and that students taught with the use of ICT performed better than the students taught with other methods in Mathematics. He concluded that computer assisted instruction in Geometry enhances the achievement and retention of the students.

In contrast, there are studies that could not establish any statistically significant relationship between computer-assisted instruction and students' achievement in Mathematics. For example, the study of Bayraktar (2008) found no significant difference between students exposed to CAI and those exposed to traditional method.

2.9 Visual Perception Abilities and Students' Achievement in Mathematics

According to Adegoke (2003), there seems to be a common opinion among Mathematics educators, psychologists and Mathematics teachers that some students lack the ability to see and realize what is given in pictorial form and so are unable to solve problems in Geometry or reproduce a theorem unless they learn it by heart. As observed by Idris (2006), some students fail Mathematics because they do not have a grasp of concepts in Geometry. Some of the factors identified as causing difficulties in Geometry learning include Geometry language, visualisation abilities and ineffective instruction. Furthermore, she highlighted that spatial visualisation has been linked with geometric achievement because Geometry is visual in nature. Geometry requires visualising abilities but many students cannot visualise three-dimensional object in a two-dimensional perspective.

The more a student finds it difficult to see and realize what is given in pictorial form, the more he or she is likely to find it difficult to cope with Geometry. Therefore, a student whose perceptual ability is not strong enough is not likely to understand the fundamentals of Geometry.

What is Perception or perceptual ability? From the point of psychologists such as Rourke (2005), Dhingra, Manhas, and Kohli (2010) and Haskell (2000), perception in general is a psychological process that helps humans to identify, analyse, organize, interpret and translate sensory data into meaningful information. The most common is the visual perception (VP) and it is related to skills needed for everyday cognitive and non-cognitive activities such as reading, writing, cutting, drawing and solving problems.

Clutten (2009) sees perception ability as involving active process, involving identifying, analysing and interpreting visual information. This is because learning comprises the process of acquiring information through experience and the storing of information. The VP is very important in the life of learners because without it, students may not be able to fully appreciate the natural world. Various research works on the relationship between perceptual abilities and achievement in Mathematics are summarised below.

Dhingra, Manhas and Kohli (2010) studied the relationship between perceptual ability and academic performance of children in Jammu & Kashmir State in India. Their sample comprised 200 academic underachievers' children. These underachievers had no apparent cause for under-achievement and they were randomly selected from a population of 597 students across the Jammu & Kashmir State. The effects of four perceptual channels such as the visual, the auditory, the kinesthetic and the tactile abilities on the academic performance of children were examined. The instruments used were Raven's coloured progressive matrices, child behaviour checklist, Objectives Assembly McCarthy scales of children's Abilities (Draw a design, verbal memory, Right and left orientation, and leg coordination), WISC III-R (Pictures Completion and digit span), test on discrimination of temperatures and differentiation of the textures and test in reading, spelling and Mathematics.

The data was subjected to statistical analysis with the use of descriptive statistics (mean and standard deviation), coefficient of correlation and percentile scores. Results showed that academic performance significantly correlated with three perceptual abilities-visual, auditory and kinesthetic. Moreover, the results revealed that mathematical abilities were found to depend significantly on auditory and visual perception. Dhingra et al (2010) concluded that perceptual abilities play a crucial role in reading and spelling performance; and that for Mathematics performance visual and auditory perceptual abilities are very important.

The findings of Dhingra et al (2010) were in line with the earlier studies of Haskell (2000) Kulp, Cline, Whoeler and Loraine (2002) and supported by the later studies of Saha, Ayub, Tarmiz (2010). In the earlier study of Haskell (2000), it was found out that disorders in the perceptual ability of children may be one of the factors why some children had difficulties in coping with arithmetic. In the study of Kulp et al (2004), the authors concluded that poor visual memory ability had direct relationship with children's (across grades 2 to 6) below average scores in reading, decoding and mathematics. In another study while using test of visual memory and supplemental development test of visual memory perception, Kulp et al (2002) showed that poor visual perceptual skill is positively correlated with poor achievement in Mathematics

Research in Computer-Assisted Instruction has however shown that the use of software packages can be used to significantly improve visual spatial ability of students and consequently improve their achievement in Geometry. This was demonstrated in the study of Saha et al (2010) and Idris (2006). In their study, a software package known as GeoGbra was used in teaching the concept of coordinate Geometry among secondary school students. A sample size of 60 students aged between 16 and 17 years were involved in the study. The study was conducted in Kuala Lumpur. There were two groups: The group that learnt Geometry through the use of GeoGbra and the group that learnt Geometry through the conventional method of teaching. Spatial Visualisation Ability was introduced as a moderator variable, and the students were classified as either high visual ability or low visual ability. An interesting result was that students with low visual ability in the GeoGbra group performed better than students with low visual ability in the conventional group.

However, not all studies have found significant relationship between students' perceptual ability and achievement. In the study of Adegoke (2003), wherein teacher influence on students' achievement in Geometry was examined as the main independent variable, and perceptual reasoning ability was a moderator variable, results showed that perceptual reasoning ability had no significant main effect on the students' achievement in Geometry. Although in the study, only teacher characteristics was the major focus, students' perceptual ability was just a moderator variable and there were three classes of perceptual ability viz: high, moderate and low. It was interesting to note that perceptual ability had no significant effect on students' achievement in Geometry. However, students with high perceptual ability which was measured with Raven's Progressive Matrices had consistently highest scores in Geometry, but, the differences were not statistically significant among the three classes of perceptual reasoning ability.

2.10 Appraisal of Reviewed Literature

Literature and everyday use to which geometrical objects are put shows that Geometry is very important and every effort should be geared towards its effective teaching and learning in schools, especially at the secondary school level. In order to facilitate its teaching and learning, literature has suggested the use of software packages. Literature says that students' perceptual ability could be enhanced. Besides, literature says students' achievement in Geometry in particular and Mathematics in general could be enhanced.

Mathematics Software Packages (MSP) of various types ranging from CAI, CBI and CBL have been integrated in the educational process. Studies in the area of MSP and Students' Achievement in Mathematics have established that they have significantly influenced students' achievement in Mathematics. Despite the importance of Geometry in the World and Mathematics Software Package, current research evidence shows that not much has been done in the area of its integration into educational processes such as Circle Geometry Software Package. Even where such studies have been conducted, especially those with empirical background, it appears that they were mostly in foreign settings as evidenced in the reviewed literature.

In this study therefore, the author used prototyping software development process. In earlier studies in education, developers used Microsoft PowerPoint 2007 and the emphasis was on picture and text. There was no voice. This software can only be used for teaching. It cannot serve as a learning software. In this study, the researcher developed Circle Geometry Software Package (CiGoSPac) and incorporated diagrams, text and voice. It also includes modules that are in units that enhance self-learning, units on assessment and feedback that can engender repeat of a module being explained as well as teaching modules which teachers can use to teach topics to individual and groups of students. However, teachers can use it to teach by deactivating the voice component.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

Prototyping software development process was adopted for the design and development of the software package called "Circle Geometry Software Package" (CiGoSPac). Survey design was used to determine its quality and user friendliness while a 3 X 2 quasi-experimental design was adopted to evaluate its effectiveness in teaching Circle Geometry.

Treatment/Experimental Groups: There were three groups. Group I learnt Circle Geometry by exposing them to the CiGoSPac with the three media (animation and text plus voice) Group II learnt Circle Geometry by exposing them to the CiGoSPac with two media (animation and text) while Group III learnt Circle Geometry through the conventional chalk and talk method. The 3 x 2 factorial design is shown in Table 3.1.

Table 3. 1: 3 x 2 Factorial Design

Perceptual Ability	Treatment Groups		
	Group 1 (Animation + text + voice)	Group II (Animation + text)	Group III Conventional
High (H)			
Low (L)			

Illustration of the Research Design

Group I – O_1 X_1 O_2 (Animation + text + voice)

Group II – O_1 X_2 O_2 (Animation + text)

Group III – O_1 $\subset$ O_2 (Conventional group)

O_1 = represents pre-test achievement in Circle Geometry and perceptual ability towards Circle Geometry.

O_2 = represents post-test achievement in Circle Geometry and Rating Scale for Software Evaluation.

X_1 = represents group taught using Circle Geometry Software Package (CiGoSPac) teaching method (Animation + Text + Voice).

X_2 = represents group taught using Circle Geometry Software Package (CiGoSPac) teaching method (Animation + Text).

$\subset$ = represents group taught using conventional method of teaching.

3.2 Variables of the Study

Independent Variable

Treatment {At three levels: Level 1 (Use of CiGoSPac [Animation + Text + Voice]), Level 2 (Use of CiGoSPac [Animation + Text]) and Level 3 (Conventional method)

Moderating Variable

Perceptual Ability (At two levels: Level 1 - Low and Level 2 – High)

Dependent Variable

Achievement in Circle Geometry

3.3 Population

Public Senior Secondary School II Students (SSS2) in Ibadan, Nigeria formed the target population. These set of students were free from the pressure of external examinations usually noticed among SS3 students. Ibadan consists of Ibadan city (with five local government areas) and Ibadan less city (with six local government areas). In all, there are 196 public secondary schools. For administrative convenience, schools in Ibadan city are under Educational zone I, while schools in Ibadan less city are under Educational zone II. The distribution is as shown in Table 3.2.

Table 3.2 Distribution of Public Senior Secondary Schools in Ibadan.

Educational Zones	Number of local Government	Number of Public Schools
Ibadan city	5	96
Ibadan less city	6	100

Source: Oyo State Ministry of Education Secretariat, Ibadan, 2018

3.4 Sampling Technique and Samples

Selection of samples involved three stages. Stage one was the selection of two local government areas, purposively, from each educational zone. Stage two was purposive selection of six schools where the software was used for trial testing and validation purposes. The criteria used were that the schools must have functional desktops, laptops and audio amplifier. The schools were not part of the final school sample. In each of the selected schools used for trial-testing, an arm of a science, social sciences and arts based classes were selected. The student sample size was 291.

Stage three was sampling of schools where the effectiveness of the software was ascertained. In each of the selected schools, an intact arm of a science, social science and arts based classes were selected. Twelve schools and 16 SS2 Mathematics teachers were sampled. The student sample size was 763.

For content validation of the CiGoSPac, the opinion of five independent validators (consisting of three secondary school Mathematics teachers drawn from Lagos State, Nigeria and two versatile computers scientists and software developers) were sampled. To examine the relevant of the content of the CiGoSPac.

For the survey on the determination of the adequacy and desirability of the software, 37 experts in software engineering comprising of educational technologists, computer scientists and software developers were randomly sampled from among companies which are into software development in Lagos, Nigeria

3.4.1 Trial-testing of the software

For the trial testing of the software, the researcher purposively selected Ibadan city educational zone, Oyo State. For this stage, three schools were randomly selected from each zone totaling six in all. The purpose of the trial testing was to collect data from the end users (Teachers and Students) on how to improve the software. In each school, one intact SS2 class was randomly chosen making six SS2 classes. In each school, the SS2 Mathematics teachers were sampled.

Three different samples were used for the quasi-experiment. Two samples learnt circle geometry through the use of the developed CiGoSPac, while the other sample learnt circle geometry through conventional method. Table 3.3 shows the schematic diagram of groupings.

Table 3.3 Distribution of Public Senior Secondary Schools for Trial Testing

Group	No. of Schools
Treatment (CiGoSPac)	
I (Voice, Text and Animation)	2
II (Text, Animation and Disabled Voice)	2
Control	
III (Conventional Method)	2
Total	**6**

3.4.1.1 Report of the Trial Testing of the Software

Prior to the full scale implementation of experiment, the initial version of the developed CiGoSPac was trial tested among students who were not part of the sample of the final experiment conducted. The essence was to determine the efficacy of the initial version of the CiGoSPac in terms of finding out if there would be significant difference in the mean scores of students who learnt Circle Geometry through the use of software package and those who learnt geometry through the conventional classroom teaching method.

There were three groups as in the final experiment. Group I (Animation + text + voice), Group II (Animation + text) and Group III (Conventional). The incorporated voice in Group I was through the voice component of the Microsoft power point module. The CGAT (serving as a pretest) was first administered to the students in each of the three groups. The mean scores of each of the groups were Group I ($\bar{x}$ = 2.14, SD = 1.12), Group II ($\bar{x}$ = 2.22, SD = 1.04) and Group III ($\bar{x}$ = 2.19, SD = 1.26). Results of the One-way ANOVA showed that scores of the students in all the three groups were not significantly different $F_{(2, 288)} = 0.56$, $p = 0.572$. After four weeks of trial testing among students, the PoCGAT was administered. The results showed that students in Group 1 had the highest post test score in the PoCGAT. Group II followed while Group III had the lowest scores and the observed differences were statistically significant, $F_{(2, 288)} = 91.35$, $p< 0.001$.

3.4.2 Testing the effectiveness of CiGoSPac (Use of CiGoSPac)

For this stage, three different samples were used. This was because experimental design was used. For the experiment, two samples learnt Circle Geometry through the Use of CiGoSPac, while the other sample learnt Circle Geometry through conventional method. For this stage, six schools each were selected from each educational zone, making 12 schools in all. From each zone, two schools received the treatment, while two schools did not receive treatment.

Table 3.4 presents the distribution of schools to treatment and conventional groups.

Table 3. 4: Distribution of Schools to Treatment and Conventional Groups

Group	Educational Zone (Schools) I	II	Total
Treatment (CiGoSPac)			
I (Voice, Text and Animation)	2	2	**4**
II (Text, Animation and Disabled Voice)	2	2	**4**
Control			
III (Conventional Method)	2	2	**4**
Total	**6**	**6**	**12**

Note: Because this study involved development of software which has the three media (Voice, Text and Animation) incorporated, one of the CiGoSPac groups received the treatment through the use of Voice, Text and Animation as designed. While the CiGoSPac group 2 received treatment through Text and Animation only.

3.5 Instrumentation

Twelve instruments were used:

a) Circle Geometry Software Package (CiGoSPac)
b) Rating Scale for Software Evaluation Students (RSSES) Form A - Appendix I
c) Rating Scale for Software Evaluation Teachers (RSSET) Form B -Appendix II
d) Rating Scale for Adequacy of Software (RSAS) - Appendix III
e) Checklist for Comparability of Software (CCS) - Appendix IV
f) Pre-Test Circle Geometry Achievement Test (PeCGAT) - Appendix V
g) Post-Test Circle Geometry Achievement Test (PoCGAT) - Appendix VI
h) Manual for the Use of the Circle Geometry Software Package (CiGoSPac) - Appendix VII
i) Lesson Guide for Conventional Method (LGCM) – Appendix VIII
j) Marking Guide For Circle Geometry Achievement Test – Appendix XI
k) Marking Guide For Post-Test Circle Geometry Achievement Test – Appendix XII
l) Perceptual Reasoning Ability Test (PRAT) - Appendix XIII

3.5.1 Rating Scale for Software Evaluation Students (RSSES) Form A

The main objective of the rating scale (RSSES) was to evaluate the extent of users' friendliness of Circle Geometry Software Package (CiGoSPac) by the students after using the software. This was a rating scale consisting of two parts (A and B): Part A had items on the bio-data of the Mathematics students and part B had four point scale items designed to elicit information on CiGoSPac. The following indicators were considered in the design of RSSES form A:

1. The **Ease of Use** indicator examines how learners can use the software effectively to study Circle Geometry.
2. The **Animation** indicator covers the liveliness of the software in teaching Circle Geometry.
3. The **Text** indicator examines the extent to which the text is appropriate for learners.
4. The **Voice** indicator examines the audibility of the sounds in the software.
5. The **Content** indicator examines the effectiveness of the lesson and coverage of the topics in studying Circle Geometry.
6. The **Colour** indicator examines the brightness and appropriateness of the colours used in the software.

Students were required to indicate the level of extent of friendliness after using the software to learn Circle Geometry on a 4-point scale ranging from "Not at all (1) to A very large extent (4)". The reliability of the RSSES was 0.89 (Cronbach alpha). The responses were analysed based on the indicators with reference to criterion mean of 2.50. The decision on each indicator was based on mean of means and decision rule in Table 3.5.

Table 3. 5: Extent of Users' Friendliness Based on Mean of Means

Range of Mean of Means	Extent of Users' Friendliness
Below 2.40	Poor
2.45 – 2.60	Moderate
2.65 – 3.00	Large
Above 3.05	Very Large

3.5.2 Rating Scale for Software Evaluation Teachers (RSSET) Form B

The main objective of the rating scale (RSSET) was to evaluate the extent of users' friendliness of Circle Geometry Software Package (CiGoSPac) by the teachers after using the software. This was a rating scale consisting of three parts (A, B and C): Part A had items on the bio-data of the Mathematics teachers; part B had four-point scale items designed to elicit information on CiGoSPac; and part C focused on general recommendation on the software. The following indicators were considered in the design of RSSE form B:

1. The **Ease of Use** indicator examines how learners can use the software effectively to study Circle Geometry.
2. The **Animation** indicator covers the liveliness of the software in teaching Circle Geometry.
3. The **Text** indicator examines the extent to which the text is appropriate for learners.
4. The **Voice** indicator examines the audibility of the sounds in the software.
5. The **Content** indicator examines the effectiveness of the lesson and coverage of the topics in studying Circle Geometry.
6. The **Colour** indicator examines the brightness and appropriateness of the colours used in the software.

Mathematics teachers were required to indicate the extent of friendliness of the software after using it to learn Circle Geometry on a 4-point scale ranging from "Not at all (1) to A very large extent (4)". The reliability of the items was established using Cronbach alpha which yielded a reliability coefficient of .70. The responses were analysed based on the indicators with reference to criterion mean of 2.50 in section B. The decision on each indicator was based on mean of means and decision rule in table 3.4. While section B was analysed based on the criterion mean of 2.50, the mean of means and decision rule in Table 3.5.

3.5.3 Rating Scale for Adequacy of Software (RSAS)

The aim of this scale was to confirm whether the Circle Geometry software package (CiGoSPac) conform to the illustrated design flowchart. It was specially designed for experts (Educational Technologists, Computer Scientists and programmers, and Software developers) involved in software design and development. The RSAS consists of four parts (A, B, C and D): Part A has items on the bio-data of the experts; part B has six point scale items designed to elicit information; The experts indicated the extent of compliance of CiGoSPac with the illustrated flowchart in its development on a 6-point scale ranging from "Not at all (0) to To a very great extent (5)"; part C focused on general comments that can assist in improving the software and part D focused on general comments for desirability of the software, that have four options and analysed using Table 3.6. The reliability of the RSAS was 0.73 (Cronbach alpha).

Table 3. 6: Desirability of the Software Based on Mean of Means

Range of Mean of Means	Degree of Desirability
Below 2.40	Low
2.45 – 2.60	Average
2.65 – 3.00	High
Above 3.05	Very High

3.5.4 **Checklist for Comparability of Software** (CCS)

The aim of this checklist was to compare Circle Geometry software package (CiGoSPac) with NumberGym Plus. It was specially designed for experts (Educational Technologists, Computer Scientists and Software developers). This was a checklist consisting of two parts (A and B): Part A had item on the bio-data of the respondent; part B was the checklist field for scoring by respondent after examining CiGoSPac and NumberGym Plus. The score ranged from "Not present at all (0) to Present to a very great extent (5)". The following indicators were considered in the design of CCS: Navigation, Graphic, Animations, Voice, Illustrations and Assessment. The Scott's Pi inter rater reliability procedure was used to establish the reliability of CCS which was estimated to be .87.

3.5.5 **Circle Geometry Achievement Test** (CGAT)

The researcher developed the Circle Geometry Achievement Test (CGAT). The CGAT has two sections - objective type having four options as section A and five essays as section B on the topic - Circle geometry. Fifty objective (multiple-choice test items) with four options (A, B, C, and D) were first developed from Circle Geometry using SS 2 Mathematics syllabus. The content validity of the CGAT was ensured by using Test Blueprint covering three (Knowledge, Comprehension and Application) of the six levels of Bloom's taxonomy of educational objectives.

The initial 50 test items were vetted by experienced secondary school Mathematics teachers. Their suggestions and corrections were noted and effected, and thereafter, the items were pilot tested on 50 SS2 students from a co – educational school having similar characteristics with the targeted samples. This was to establish both the difficulty and discriminating indices of each item. Thirty items with difficulty indices between 0.40 and 0.75 and discriminating indices of greater than 0.35 were finally selected. The reliability of the CGAT was 0.79 (KR-20). Table 3.7 presents the Table of specification for the Circle Geometry Achievement Test.

Every correct option was awarded one (1) mark, while every wrongly options item was scored zero (0). This makes the total obtainable mark 30 and the least as zero. A Marking Scheme was developed to assess the essay (section B) with marks obtainable from 0 to 50. The total marks obtained by the students were converted to percentage.

Table 3.7 Table of Specification for Geometry Achievement Test

S/N	Contents	Knowledge 40%	Comprehension 40%	Application 20%	Total
1	Angles in a circle 17%	**2** (1, 6)	**2** (12, 24)	**1** (23)	**5**
2	Angles in the same segment 40%	**5** (2,3,5,7,11)	**5** (4,8,9,13,28)	**2** (26, 27)	**12**
3	Angles in semicircle 20%	**1** (30)	**3** (18, 20, 29)	**2** (17, 30)	**6**
4	Tangent to a circle 23%	**4** (14,15,16,25)	**2** (19,21)	**1** (22)	**7**
	Total	**12**	**12**	**6**	**30**

The CGAT served as both pretest and posttest.

3.5.4 **Perceptual Reasoning Ability Test** (PRAT)

The adopted PRAT assessed student's capability to recognise correspondence and similarity in sets of spatial figures using the Raven Progressive Matrices (RPM). The PRAT consists of 60 problems and is divided into five sets of 12 questions each. Generally, it is used for assessing general intellectual functioning and is a non-verbal test of reasoning ability. The testee is required to choose which of the six or eight pattern pieces fit best into an overall display or background. The RPM has test-retest reliability ranging from 0.83 to 0.93 and correlation between scores with other intelligence test range from 0.40 to 0.80.

The intellectual capacity of student is determined from his or her score in the test. The score obtainable ranges from 0 to 60. Students were grouped into high and low ability groups using the criteria of:

High - Top 50%

Low - Below 50%

3.5.5 **Circle Geometry Software Package** (CiGoSPac)

This is a multimedia Mathematics software package on Microsoft PowerPoint presentation. The CiGoSPac was developed with embedded sound to assist in the teaching and learning of circle geometry in an easy – to – use fashion with or without teacher's assistance. It provided audio-visuals through drawings, animations, theorems, proofs, problems, feed-backs and embedded sound to explain the content of material for the students to study at their own pace and in line with their individual differences with little or no teacher assistance. This greatly assisted the perceptual understanding of the diagrams and reduced anxiety level of learner towards the topic.

3.5.5.1 **Development of Circle Geometry Software Package** (CiGoSPac)

The development process used was the prototyping process which allowed the researcher to demonstrate the concepts of circle geometry and validate at every stage of its development. It assisted in providing good users interface in the design process and allowed the designer to return to the requirement at every stage to change variables as necessary. The end-users were constantly involved in every stage of its development to give functionality to the package.

In designing CiGoSPac, the Beale and Sharples (2002) and Fenrich (2014) instructional design processes were reviewed to give appropriate steps in CiGoSPac design process. These steps were as follows:

1. ***Identify topic in Circle Geometry in the Mathematics Curriculum*****:** The researcher critically examined the Senior Secondary School Mathematics Curriculum section of the Circle Geometry. This was done for content analysis of the Circle Geometry aspect of the Curriculum to identify the area of the curriculum, topics and theorems to be covered and out of which some of the topics were used.
2. ***Identify the Instructional Objectives***: Here the researcher was able to identify the purpose and level of the learning expected from the students. These are specific measureable skills that students need to learn. They involve behavioural statement of what the learner will be able to do at the end of the lesson in Circle Geometry and classify the objectives into learning domain. The teaching objectives of CiGoSPac were influenced by the following instructional objectives: Students should be able to prove and solve problems on the:
    i) angle subtended by an arc at the Centre of a circle is twice the angle subtended at the circumference (Twice angle).
    ii) angle in a semi-circle is a right angle (Semi-circle).
    iii) angles in the same segment are equal (Segment angle).
    iv) angle between a tangent and a chord is equal to any angle in alternate segment (Alternate segment).
3. ***Determine the Previous Knowledge***: This is based on the instructional skills analysis and learner analysis necessary to assist them in understanding the lesson to be taught. For Circle Geometry, the knowledge of Circle components is very essential. These subsumes: Diameter, Centre of circle, Circumference, Radius, Arc, Sector, Chord, Segment (Minor and Major) and Tangent.
4. ***Identify the Basic Facts***: The researcher was able to identify relevant Circle basic facts that will help the learners in assimilating the theorems on Circle Geometry. These are Circle with: Isosceles triangle, Radius and Tangent, Chords, Exterior Angle, Cyclic Quadrilateral and Two Tangents.

5. ***Select the Teaching Strategy***: The strategy adopted as part of the computer program was to present an ordered sequence of teaching and assessment into the lesson. The ordered sequence of teaching are outlined as follows:

   Unit 1: Component of a Circle covering Diameter, Centre of Circle, Circumference, Radius, Arc, Sector, Chord, Segment (Minor and Major) and Tangent.

   Unit 2: Basic Notation covering Angle, Triangle, Line, Radius, Perpendicular and Parallel.

   Unit 3: Circle Basic Facts covering Isosceles triangle, Radius and Tangent, Chords, Exterior Angle, Cyclic Quadrilateral and Two Tangents.

   Unit 4: Circle Theorems covering Twice angle, Semi-circle, Segment angles and Alternate segment.

   Under each of units 1 and 3, the assessment techniques involved multiple choice questions (MCQs). The MCQs had four options in which only one alternative was the correct answer under RECAPs, correct answers attracted a reward of "***very good***" and provided the learner the opportunity to the next question or next page, while the wrong answer attracted a reward of "***you are wrong***" and directed the learner to re-learn the concept. In Unit 4, the assessment techniques involved learners typing their responses in a blue box provided and compared their response with the correct answer.
6. ***Choose Design Components***: Here, the researcher / designer selected design components as computer with the media selection which was PowerPoint presentation software for use. Enhanced Microsoft PowerPoint presentation software supported the development of visual mental rotation, spatial visualization, the ability to deal with two and three dimensions' space, the ability to keep track of too much different information at the same time, and the ability to read, interpret pictures and diagrams, all of which are skills essential in Circle Geometry.
7. ***Develop / Design the Software***: After selecting the design components, the researcher then developed the Circle Geometry Software Package (CiGoSPac) using the Microsoft PowerPoint 2013 which enabled the developer to develop a good user virtual interface to assist the learner to understand the Circle Geometry concepts. The end-users were involved in all the stages of its design

that led to iterative activities to change the requirements in any necessary stage.

The first stage here is to draw *flowcharts* showing the procedure of this Software. A flowchart is a diagram that represents an algorithm or process showing the steps as boxes of different kinds and their order by connecting them with arrows to illustrate a solution model to a given problem. In developing CiGoSPac, two flowcharts were drawn – the simple and exponential sub-system flow charts (see Appendix IX and X) which guided the process of its development. The simple flowchart gives a general information about the procedure of the software (see Figure 3.1) while the exponential sub-system flowchart gives a specific and more intrigue information about the procedure of development.

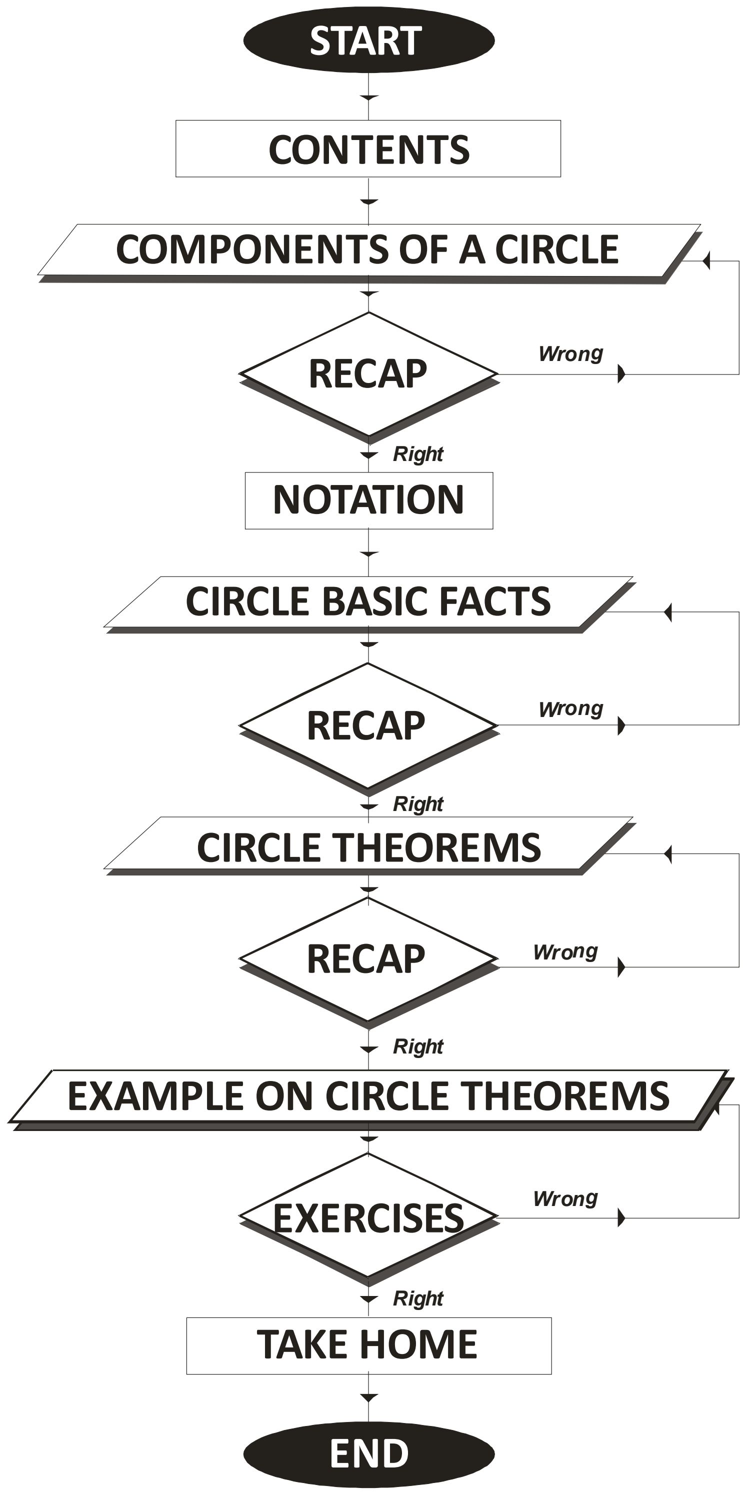

Figure 3.1: Simple flowchart for Circle Geometry Software Package

The second stage was the development of CiGoSPac. The exponential sub-system flow chart was used as guide in developing the software. Microsoft PowerPoint package 2013 was used for the design. Each slide design followed this process to give its uniqueness - Texts, Diagrams, Animations and Sounds. Figure 3.2 reveals the process of designing each slide in Microsoft PowerPoint 2013 package.

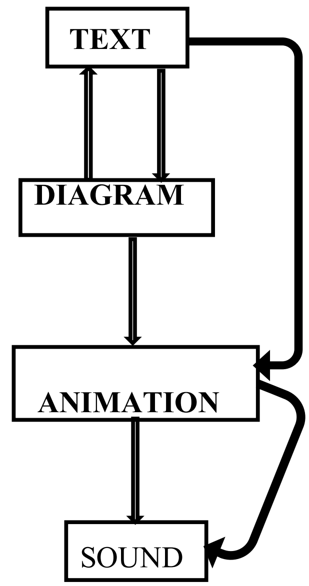

Figure 3.2: Process of slide design

The Text or Diagram can be written or drawn first to be followed by Animation and finally the Sound. The CiGoSPac will be developed with embedded sound to assist the students.

8. ***Trial Testing of the Software***: The developer / researcher will now trial test the software by trying-out the Circle Geometry software package (CiGoSPac) on other systems and allow other end-users (teachers and learners) to use the software. Appropriate data will be collected to improve the software. The requirement software and hardware for CiGoSPac are:
    i. Minimum requirement software is Window 7 with at least Microsoft Office PowerPoint 2013.
    ii. Minimum requirement hardware is any system with 2 GB RAM and 32 bit system with or without Audio Amplifier speakers.
9. ***Final Product***: Here, after carrying out all the necessary corrections needed as requested by the experts and end-users of the CiGoSPac, the software will then be used in a real educational setting for the teaching of Circle Geometry on the appropriate population as defined by the researcher.

These steps were further classified into four areas of Circle Geometry Software Package (CiGoSPac) prototype development process as: CiGoSPac Objectives comprises of the first four steps (Identify topic in Circle Geometry in the Mathematics Curriculum, Identify the Instructional Objectives, Determine the Previous Knowledge and Identify the Basic Facts),

CiGoSPac Functionality comprises of the fifth and sixth steps (Select the Teaching Strategy and Choose Design Components), CiGoSPac Development comprises of the seventh step (Develop / Design the Software), while CiGoSPac Evaluation comprises of the eighth and ninth steps (Trial Testing of the Software and Final Product). Figure 3.3 reveals the prototyping process of software development used in designing Circle Geometry Software Package (CiGoSPac).

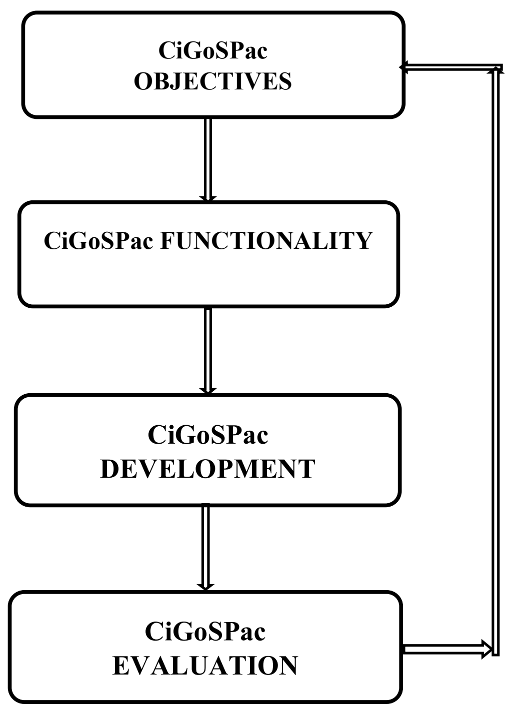

Figure 3.3: CiGoSPac Prototyping Development Process

3.5.5.2 Teacher's Activities

1. Teacher ensures that the computer is functioning properly.
2. Teacher manages the classroom and ensures it is not rowdy.
3. Teacher guides the class in easy transition and adherence to instructional steps with CiGoSPac.
4. Teacher assists students with technical problems

3.5.5.3 Student's Activities

1. Listen to CiGoSPac.
2. Click the buttons or arrows according to instructions.
3. Respond to CiGoSPac where necessary.
4. Observe the visual presentation.
5. Answer questions where necessary.
6. Attempt exercises.
7. Practise more problems.

3.5.5.4 Group I CiGoSPac (Voice, Text and Animation)

1. The research assistant puts on the computer and slots in the CD containing the software.
2. Students will click on the software.
3. Students were to follow the instructions on the software.
4. Students were left to navigate the software.
5. The research assistant were allow to assist students with difficult at one point or the other during the use of the software.
6. Student were engaged by the software.

3.5.5.5 Group II CiGoSPac (Text, Animation and Disabled voice)

1. The research assistant puts on the computer and slots in the CD containing the software.
2. Students will click on the software.
3. Students were to follow the instructions on the software.
4. The teacher explains the content as the CD plays.
5. The teacher directs students.
6. The teacher engaged students through the software.

3.5.5.6 Group III (Conventional Method)

1. Teacher introduces the concept.

2. Teacher explains the content
3. Teacher asks questions
4. Teacher evaluates the delivery of contents
5. Teacher gives assignment.

3.5.6 Manual for the Use of Circle Geometry Software Package (CiGoSPac)

This was a document that assisted the users of CiGoSPac in effective usage of the software. It consists of sets of instructions or information on how to use the software according to sub-sections.

3.5.7 Lesson Guide for Conventional Method (LGCM)

The purpose of LGCM was to assist the Research Assistants (Mathematics Teacher) to teach Circle Geometry uniformly and for the effective coverage of the required Circle theorems so as not to give room for bias in the study. Six Daily lesson plans were developed by the researcher to cover the scope of the lesson (Components of a circle, Notation and circle basic facts, twice Angle, semi-circle, segment angle and Alternate segment). The Classwork and assignment were based on New General Mathematics Textbook for SSS2 as recommended Mathematics textbook by the Oyo state Ministry of Education, West Africa Examination council (WAEC) and National Examination Council (NECO) to reinforce the learning of circle Geometry. The LGCM was given to the Research assistants as a guide in teaching the control group (see Appendix VIII).

3.6 Administration of the Package

Schools with functioning Desktop Computer /Laptop Computer, Audio Amplifier (speaker) for use in the teaching of students participated in the study. The researcher sought for permission from the school authority to use their schools for the study. The researcher with the aid of research assistants installed Circle Geometry Software Package (CiGoSPac) on their computers some days before the commencement of the study. After this, the Mathematics teachers of the schools concerned were trained on how to use the software to teach Circle Geometry. They served as research assistants for schools concerned. Students were taught Circle Geometry using the software. This was done in their Computer lab / classrooms. Figure 3.4 is the flow chart for experimentation (CiGoSPac).

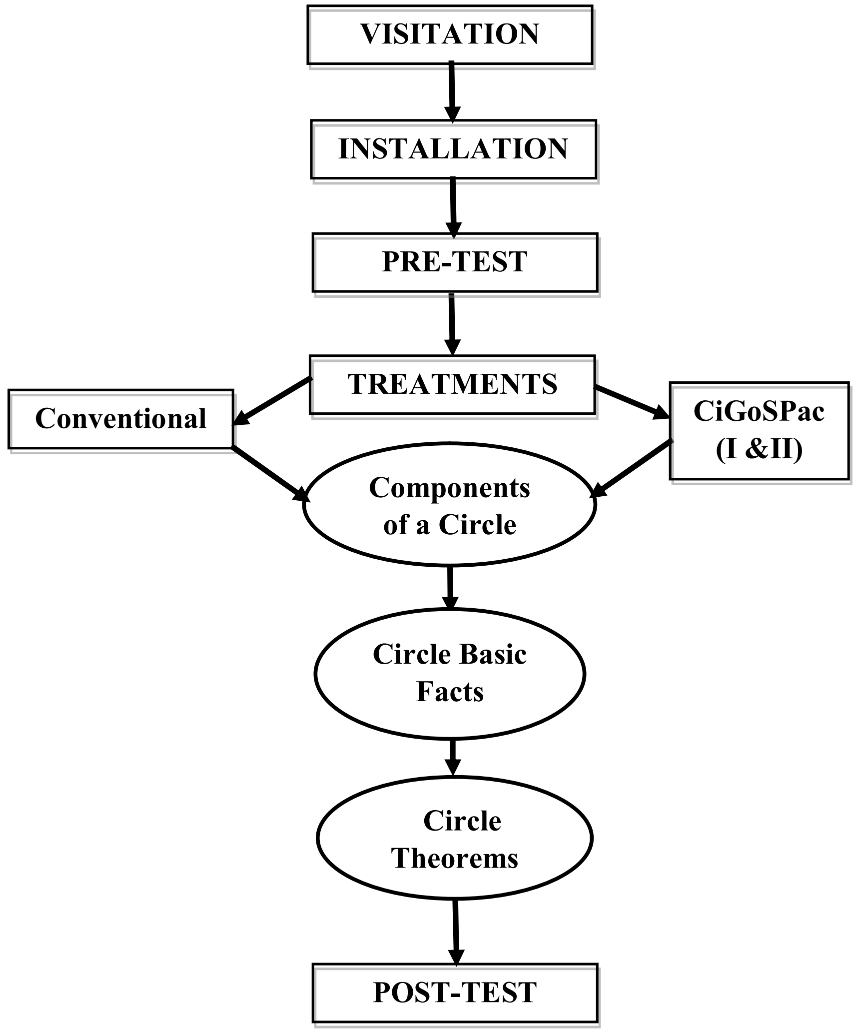

Figure 3.4: Flow Chart for Experiment (CiGoSPac)

3.6.1 Summary of Activities for Quasi-experimental phase

1st week: Visitation to Schools, selection of research assistants (Mathematics Teachers).

2nd week: Installation of the Software on the Computer and Training of research assistants (Teachers) and conduct of pre-test (PeCGAT) and PRAT

3rd - 4th week: Teaching Circle Geometry using CiGoSPac in groups I and II, and Conventional group.

5th week: Administration of RSSES Form A and RSSET Form B.

6th week: Conduct of post-test (PoCGAT).

3.7 Validity of the Instruments

The CiGoSPac: The initial version of Circle Geometry software package (CiGoSPac) was validated by Mathematics teachers, computer scientists/software developers. They evaluated the loudness, easiness and suitability of its content for teaching and learning Geometry at secondary school level. They verified the extent to which the items of each unit were considered, checked the possible errors and suggested answers. Comments, corrections and advice enhanced the quality of the final version of the CiGoSPac.

The CGAT: The Circle Geometry Achievement Test which was used as pre-test (PeCGAT) and post-test (PoCGAT) was validated using test blue print for content validity, while the Rating Scale for Software Evaluation (RSSE) Forms A and B, Rating Scale for Adequacy of Software and Checklist for Comparability of Software were given to experts and project supervisor for review in order to ensure content and construct validity. The Lesson Guide for conventional Method (LGCM) was validated by a team of three experienced Mathematics teachers and Project supervisor. This ensured the content validity of the LGCM in teaching Circle Geometry.

3.8 Data Collection

After the development of the Circle Geometry software package (CiGoSPac) to confirm whether it conformed to the illustrated design flowchart (Appendix IX), Rating Scale for Adequacy of Software (RSAS) was administered on some randomly sampled experts in the field of software development. Checklist for Comparability of Software (CCS) to compare CiGoSPac and NumberGym Plus was also administered.

Prior to treatments (about a week) the Pre-test Circle Geometry Achievement Test (PeCGAT) and Perceptual Reasoning Ability Test (PRAT) were administered to participants. Both the instruments and the participants' responses were collected immediately. After treatment, which lasted two weeks, Post-test Circle Geometry Achievement Test (PoCGAT) and Rating Scale Questionnaire for Software Evaluation (RSSE) Form A were administered to the participants the same way, the instruments were collected alongside with the participants' responses. The responses of the participants to the instruments were then scored.

3.9 Method of Data Analysis

Both descriptive (mean, percentages and frequency) and inferential statistics (correlated t-test and ANOVA) were adopted. The testing of the hypotheses through ANOVA was at the 0.05 level of significance.

Table 3.8 presents how the data were analysed

Table 3.8 Table of Data Analysis Instruments

Type	Statistical Tool	Instrument(s)
RQ1	Descriptive Statistics	Appendix III
RQ2	Descriptive Statistics & Correlated Samples t-test	Appendix IV
RQ3	Descriptive Statistics	Appendix I and II
RQ4	Descriptive Statistics	Appendix II and III
RQ5	Descriptive Statistics	Appendix V and IV
RQ6	Content Analysis	Appendix II and III
RH1	ANCOVA	Appendix V and VI
RH2	ANCOVA	Appendix V, VI and XIII
RH3	ANCOVA	Appendix V, VI and XIII

3.10 Methodological Challenges

One of the major challenges encountered was difficulty in accessing the computer rooms of the selected schools. The authorities of the schools felt reluctant to the point of rejecting the offer. The principals were afraid of theft, damages and maintenance. The researcher, apart from tendering letter of Introduction from the Institute of Education had to appeal and make promises before overcoming this challenge. Also, there was the fear that the school's programmes could be interrupted and that the academic activities of the students involved could be disturbed. This challenge was overcome by making sure that the normal time for Mathematics on their school time table was strictly adhered to for the study. This was made easy since the topics were already in their second term scheme of work for that period. The researcher appealed to the selected schools to start the topic at the same time. The problem of inadequate computer system in schools was overcome by dividing the students into two groups and also making laptops available for their use.

Another big problem was erratic power supply encountered during experimentation. The researcher got over this by making provision for fuel and a stand by generating set during the course of delivery for the CiGoSPac groups.

3.11 Limitations to the Study

The developed software package centered only on Circle Geometry and covered only topics for SS 2 students. The trial testing and final testing for the efficiency of the packages were carried out in six and 12 schools respectively. The researcher had planned to trial test and tested the efficiency of the packages in teaching and learning of geometry in many schools but could not due to financial constraints.

CHAPTER FOUR
RESULTS AND DISCUSSIONS

The results of the study were presented in this section. Results were presented in the order in which the research questions and hypotheses were stated. The hypotheses were tested at $p < 0.05$ level of significance.

4.1 Socio-Demographic Characteristics of the Samples

1) Students

Trial Testing of the Software: For this phase, 291 SS 2 students were used.

Gender: This consisted of 162 Boys (55.7%) and 129 Girls (44.3%).

Age Distribution: Their ages ranged between 14 years and 19 years (Mean Age =14.7 Years, SD = 1.8).

Final Experimental Study: For this phase, 763 SS 2 students were sampled.

Gender: This consisted of 408 Boys (53.5%) and 355 Girls (46.5%).

Age Distribution: Their ages ranged between 14 years and 20 years. (Mean Age = 14.9 Years; SD = 1.6).

2) Teachers

Sixteen SS 2 Mathematics Teachers were sampled:

Gender: This consisted of 10 Males (62.5%) and six Females (38.5%).

Age Distribution: Their ages ranged between 31 and 53 Years (Mean Age = 38 Years, SD = 3.9).

Work Experience:

a) 5 – 10 Years Teaching Experience = 7 Teachers.

b) 11 – 16 Years Teaching Experience = 4 Teachers.

c) 17 – 22 Years Teaching Experience = 5 Teachers.

3) Experts in Computer Software Technology

Thirty-Seven experts in Computer Software Technology were sampled. They were all males. This consisted of 12 Educational Technologists, 10 Computer Scientists and 15 Software developers.

Age Distribution: Their ages ranged between 28 and 43 Years. (Mean Age = 29 Years, SD = 0.9).

4.2 Research Questions

4.2.1 Research Question One

Does the CiGoSPac adequately execute the illustrated flowchart?

The Rating Scale for Adequacy of Software (RSAS) in appendix III was used to obtain the responses of the experts (Educational Technologists, Computer Scientists and Software developers) as presented in Table 4.1. For decision on each item, the criterion value of 3.5 was adopted.

Table 4.1: Summary of Responses for Adequacy of Software

S/N	STATEMENTS	0	1	2	3	4	5	$\bar{x}$	SD
1.	To what extent is the flow chart branching well executed in the software?	-	-	1 (2.7)	-	19 (51.2)	17 (45.9)	4.4	0.6
2.	To what extent is the looping in the flow chart implemented in the software?	-	-	-	3 (8.1)	19 (51.4)	15 (40.5)	4.3	0.6
3.	To what extent does the decision boxes represent the RECAP in the flow chart executed in the software?	-	-	1 (2.7)	1 (2.7)	19 (51.4)	16 (43.2)	4.4	0.7
4.	To what extent are the Data boxes implemented in the software?	-	-	-	2 (5.4)	13 (35.1)	22 (59.5)	4.5	0.6
5.	To what extent are sub-systems properly executed in the software?	-	-	-	2 (5.4)	18 (48.6)	17 (45.9)	4.4	0.6
6.	To what extent is the logicality of the flow chart implemented in the software?	-	-	-	2 (5.4)	19 (51.4)	16 (43.2)	4.4	0.6
7.	Does the software reflect the illustrated flow chart?	-	-	-	1 (2.7)	12 (32.4)	24 (64.9)	4.6	0.6

N.B ( ) indicate percentages.

Table 4.1 revealed the extent to which CiGoSPac adequately executed the design flowchart in its development. For each of the seven items, the mean value is higher than the established criterion of 3.50; this indicates that the extent of compliance with the design flowchart in developing the software (CiGoSPac) is very high, thus, the software adequately executed the illustrated flowchart.

4.2.2 Research Question Two

How comparable is the CiGoSPac (Ci) with NumberGym Plus (NP) in terms of: (a) Navigation [Nav], (b) Graphic [Grap], (c) Animation [Ani], (d) Voice [Voc], (e) Illustration [Ill] and (f) Assessment [Ass]?

The Checklist for Comparability of Software (CCS) in appendix IV was used in gathering information to answer this research question. Table 4.2 presents the summary of responses of the 37 experts in computer software technology that were sampled.

Table 4.2: Summary of Responses of Paired Sampled t-Test

S/N	Variable	N	$\bar{x}$	SD	95% Confidence Interval of the Difference		t	df	Sig.
					Lower	Upper			
1.	Nav. NP	37	19.73	3.48	-8.92	-6.86	-15.54	36	.000
	Nav. Ci	37	27.62	1.06					
2.	Grap.NP	37	23.92	4.66	-9.93	-6.88	-11.17	36	.000
	Grap. Ci	37	32.32	1.47					
3	Ani. NP	37	17.68	2.95	-6.32	-4.39	-11.23	36	.000
	Ani. Ci	37	23.03	1.09					
4	Voc.NP	37	4.65	6.08	-30.15	-25.58	-24.78	36	.000
	Voc.Ci	37	32.51	1.50					
5	Ill.NP	37	21.19	3.94	-7.68	-4.76	-8.64	36	.000
	Ill.Ci	37	27.41	1.34					
6	Ass.NP	37	18.08	4.60	-7.82	-4.77	-8.38	36	.000
	Ass.Ci	37	24.38	1.23					

Item 1 Navigation: Navigation (Nav) shows that NumberGym plus (NP) and CiGoSPac (Ci) rating scores were positively and averagely correlated ($r = 0.50$, $p < 0.05$). There was a significant average difference between NP and Ci scores ratings ($t_{36} = -15.54$, $p < 0.05$). On average rating scores, Ci ratings were 7.89 points higher than NP rating scores (95% CI [8.92, 6.86]). There was a significant difference in the rating scores for NP ($\bar{x} = 19.73$, SD = 3.48) and Ci ($\bar{x} = 27.62$, SD = 1.06) with $t_{36} = -15.54$, p =.000. One can conclude that it is easier to navigate CiGoSPac (Ci) than NumberGym plus (NP).

Item 2 Graphic: Graphic (Grap) shows that NumberGym plus (NP) and CiGoSPac (Ci) rating scores were weakly and positively correlated ($r = 0.21$, $p < 0.05$). There was a significant average difference between NP and Ci rating scores ($t_{36} = -11.17$, $p < 0.05$). On average scores rating, Ci ratings were 8.41 points higher than NP rating scores (95% CI [9.93, 6.88]). There was a significant difference in the rating scores for NP ($\bar{x} = 23.92$, SD = 4.66) and Ci ($\bar{x} = 32.32$, SD = 1.47) with $t_{36} = -11.17$, p =.000. We conclude that the graphic of CiGoSPac (Ci) is better than NumberGym plus (NP).

Item 3 Animation: Animation (Ani) shows that NumberGym plus (NP) and CiGoSPac (Ci) rating scores were weakly and positively correlated ($r = 0.24$, $p < 0.05$). There was a significant average difference between NP and Ci rating scores ($t_{36} = -11.23$, $p < 0.05$). On average scores rating, Ci ratings were 5.35 points higher than NP rating scores (95% CI [6.32, 4.39]). There was a significant difference in the rating scores for NP ($\bar{x} = 17.68$, SD = 2.95) and Ci ($\bar{x} = 23.02$, SD = 1.09) with $t_{36} = -11.23$, p =.000. We conclude that the animation of CiGoSPac (Ci) is better than NumberGym plus (NP).

Item 4 Voice: Voice (Voc) shows that NumberGym plus (NP) and CiGoSPac (Ci) rating scores were negatively correlated ($r = -0.41$, $p < 0.05$). There was a significant average difference between NP and Ci rating scores ($t_{36} = -24.78$, $p < 0.05$). On average scores rating, Ci ratings were 27.86 points higher than NP rating scores (95% CI [30.15, 25.58]). There was a significant difference in the rating scores for NP ($\bar{x}$ =

4.65, SD = 6.08) and Ci ($\bar{x}$ = 32.51, SD = 1.50) with t_{36} = -24.78, p =.000. We conclude that the voice in CiGoSPac (Ci) is better than NumberGym plus (NP).

Item 5 Illustration: Illustration (Ill) shows that NumberGym plus (NP) and CiGoSPac (Ci) rating scores were negatively correlated ($r = -0.17$, $p < 0.05$). There was a significant average difference between NP and Ci rating scores ($t_{36} = -8.64$, $p < 0.05$). On average scores rating, Ci ratings were 6.22 points higher than NP rating scores (95% CI [7.68, 4.76]). There was a significant difference in the rating scores for NP ($\bar{x}$ = 21.19, SD = 3.94) and Ci ($\bar{x}$ = 27.41, SD = 1.34) with t_{36} = -8.64, p =.000. We conclude that the illustration in CiGoSPac (Ci) is better than NumberGym plus (NP).

Item 6 Assessment: Assessment (Ass) shows that NumberGym plus (NP) and CiGoSPac (Ci) rating scores were positively correlated ($r = 0.16$, $p < 0.05$). There was a significant average difference between NP and Ci rating scores ($t_{36} = -8.38$, $p < 0.05$). On average scores rating, Ci ratings were 6.29 points higher than NP rating scores (95% CI [7.82, 4.77]). There was a significant difference in the rating scores for NP ($\bar{x}$ = 18.08, SD = 4.60) and Ci ($\bar{x}$ = 24.38, SD = 1.23) with t_{36} = -8.38, p =.000. We conclude that the assessment in CiGoSPac (Ci) is better than NumberGym plus (NP).

4.2.3 Research Question Three (i)

How user friendly is the software - Circle Geometry Software Package (CiGoSPac) in terms of: (a) Ease of use (b) animation, (c) voice (d) text (e) Content and (f) colour to students?

The Rating Scale for Software Evaluation Student (RSSES) in appendix I was used to gather responses from the students that use CiGoSPac. Table 4.3 (a, b, c, d, e and f) presents the responses of the students on users' friendliness of the software. For decision making, a criterion mean value of 2.5 was adopted.

Table 4.3a: Summary of Responses on Users' friendliness of Software by Students on Ease of Use.

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
1	Is it easy to start the software?	26 (17.2)	69 (45.7)	27 (17.9)	29 (19.2)	2.4	1.0
2	Is it difficult to navigate the software?	55 (36.4)	59 (39.1)	20 (13.2)	17 (11.3)	2.0	1.1
3	Is it always clear to the learner which point he/she has reached in the software?	16 (10.6)	62 (41.1)	36 (23.8)	37 (24.5)	2.6	1.0
4	Can students end the software at any time?	63 (41.7)	44 (29.1)	20 (13.2)	24 (15.9)	2.0	1.1
5	Is the software easy to learn?	16 (10.6)	42 (27.8)	35 (23.2)	58 (38.4)	2.9	1.0
14	Is it easy-to-follow on-screen instructions?	11 (7.3)	44 (29.1)	47 (31.1)	49 (32.5)	2.9	1.0

Table 4.3a revealed the extent of users' friendliness of the software (CiGoSPac) by Students in terms of **Ease of Use**.

From Table 4.3a, statements 1, 2, 3, 4, 5 and 14 cover the ease of use of the software. The table indicates that the mean values of the statements 3, 5 and 14 are higher than the criterion mean of 2.50. While statements 1, 2 and 4 are below the criterion mean of 2.50 which were divergent options of students on the statements: Statement 1, students did not see the software as being easy to start ($\bar{x}$ = 2.4, S.D = 1.0) which must have been as a result of some of them lacking familiarity with computer components. Statement 2, students see the software as difficult to navigate ($\bar{x}$ = 2.0, S.D = 1.1) which can be attributed to the fact that some easily forgot the instruction regarding the navigation of the software; and statement 4, students cannot end the software at any time ($\bar{x}$ = 2.0, S.D = 1.1) due to the fact that the software is designed in units / modules which must be completed before going ahead. This results show that the users' friendliness of the software in terms of ease of use of the software (CiGoSPac) is moderately friendly (Mean of means = 2.47) for student users.

Table 4.3b: Summary of Responses on Users' friendliness of Software by Students on Animation

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
6	Is animation well used?	20 (13.4)	37 (24.5)	49 (32.5)	45 (29.8)	2.8	1.0
7	Are diagrams appropriate?	11 (7.3)	28 (18.5)	43 (28.5)	69 (45.7)	3.1	1.0
8	Are animations clear?	14 (9.3)	47 (31.1)	40 (26.5)	50 (33.1)	2.8	1.0
9	Are animations relevant?	11 (7.3)	46 (30.5)	39 (25.8)	55 (36.4)	2.9	1.0
10	Do the diagrams aid understanding?	8 (5.3)	28 (18.5)	40 (26.5)	75 (49.7)	3.2	1.0

Table 4.3b revealed the extent of users' friendliness of the software (CiGoSPac) by Students in terms of **Animation**.

From Table 4.3b, statements 6, 7, 8, 9 and 10 cover the animation of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. This result shows that the users' friendliness of the software in terms of animation of the software (CiGoSPac) is largely friendly (Mean of means = 2.96) for student users.

Table 4.3c: Summary of Responses on Users' friendliness of Software by Students on Text

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
11	Is the grammar used in the software appropriate?	11 (7.3)	33 (21.9)	44 (29.1)	63 (41.7)	3.1	1.0
12	Is the vocabulary level accurate?	13 (8.6)	25 (16.6)	44 (29.1)	69 (45.7)	3.1	1.0
13	Is the text easy to read?	13 (8.6)	23 (15.2)	41 (27.2)	74 (49.0)	3.1	1.0
15	Is the text appropriate?	7 (4.6)	41 (27.2)	59 (39.1)	44 (29.1)	2.9	1.0

Table 4.3c revealed the extent of users' friendliness of the software (CiGoSPac) by Students in terms of **Text**.

From Table 4.3c, statements 11, 12, 13 and 15 cover the text of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. This result shows that the users' friendliness of the software (CiGoSPac) in terms of text is very largely friendly (Mean of means = 3.05) to student users.

Table 4.3d: Summary of Responses on Users' friendliness of Software by Students on Voice

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
16	Is audio well used?	31 (20.5)	40 (26.5)	37 (24.5)	43 (28.5)	2.6	1.1
17	Are sounds easy to hear?	27 (17.9)	46 (30.5)	31 (20.5)	47 (31.1)	2.7	1.1
18	Are sounds appropriate?	23 (15.2)	40 (26.5)	48 (31.8)	40 (26.5)	2.7	1.0
19	Is the level of language that the program offers clearly understandable?	8 (4.0)	46 (30.5)	46 (30.5)	53 (35.1)	3.0	1.0
20	Are the sounds relevant and aid understanding?	21 (13.9)	47 (31.1)	38 (25.2)	45 (29.8)	2.7	1.0

Table 4.3d revealed the extent of users' friendliness of the software (CiGoSPac) by students in terms of **Voice**.

From Table 4.3d, statements 16, 17, 18, 19 and 20 cover the voice of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. This result shows that the users' friendliness of the software (CiGoSPac) in terms of voice is largely friendly (Mean of means = 2.74) to student users.

Table 4.3e: Summary of Responses on User' friendliness of Software by Students on Contents

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
21	Is the content accurate and factual?	12 (7.9)	34 (22.5)	58 (38.4)	47 (31.1)	2.9	1.0
22	Is the content educationally appropriate?	11 (7.3)	27 (17.9)	51 (33.8)	62 (41.1)	3.1	1.0
23	Does the content meet learning goals and objectives?	13 (8.6)	30 (19.9)	45 (29.8)	63 (41.7)	3.1	1.0
24	Does the content lack bias (social, ethnic, gender, etc.)?	57 (37.7)	38 (25.2)	32 (21.2)	24 (15.9)	2.2	1.1
25	Does the software encourage performance-based learning?	14 (9.3)	30 (19.9)	47 (31.1)	60 (39.7)	3.0	1.0
26	Does the software adapt to various learning abilities?	11 (7.3)	37 (24.5)	49 (32.5)	54 (35.8)	3.0	1.0
27	Does the software increase students' level of understanding?	9 (6.0)	21 (13.9)	41 (27.2)	80 (53.0)	3.3	1.0
28	Is the feedback offered learners for wrong answers useful?	53 (35.1)	24 (15.9)	33 (21.9)	41 (27.2)	2.4	1.2
29	Does the Software offer something extra that cannot be done more in traditional ways (i.e. chalk and talk)?	54 (35.8)	31 (20.5)	34 (22.5)	32 (21.2)	2.3	1.2
30	Is learners' interest maintained?	11 (7.3)	31 (20.5)	46 (30.5)	63 (41.7)	3.1	1.0

Table 4.3e revealed the extent of users' friendliness of the software (CiGoSPac) by Students in terms of **Content**.

From Table 4.3e, statements 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30 cover the content of the software. The table indicates that the mean values of statements 21, 22, 23, 25, 26, 27 and 30 are higher than the criterion mean of 2.50 while statements 24, 28 and 29 are below the criterion mean of 2.50 which were divergent options of students on the statements: Statement 24, students believe that the content of the software does not lack bias ($\bar{x}$ = 2.2, S.D = 1.1); Statement 28, students see the feedback offered learners for wrong answers as not useful ($\bar{x}$ = 2.4, S.D = 1.2) as some believe that it is time wasting and Statement 29, students see the Software not offering something extra that cannot be done more in traditional ways ($\bar{x}$ = 2.3, S.D = 1.2). This result shows that the users' friendliness of the software (CiGoSPac) in terms of content is largely friendly (Mean of means = 2.84) to student users.

Table 4.3f: Summary of Responses on Users' friendliness of Software by Students on Colours

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
31	Are the colours used in the software bright?	8 (5.3)	31 (20.5)	39 (25.8)	73 (48.3)	3.2	1.0
32	Are colours used in the software appropriate for Circle Geometry lesson?	10 (6.6)	14 (9.3)	38 (25.2)	89 (58.9)	3.4	1.0

Table 4.3f revealed the extent of users' friendliness of the software (CiGoSPac) by students in terms of **Colour**.

From Table 4.3f, statements 31 and 32 cover the colour of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. This result shows that the users' friendliness of the software (CiGoSPac) in terms of colour is very largely friendly (Mean of means = 3.3) to student users.

4.2.4 Research Question Three (ii)

How user friendly is the software - Circle Geometry Software Package (CiGoSPac) in terms of: (a) Ease of use (b) animation, (b) voice (c) text (d) Content and (e) colour to teachers?

The Rating Scale for Software Evaluation Teacher (RSSET) in appendix II was used to gather responses from teachers that used CiGoSPac. Table 4.4 (a, b, c, d, e and f) presents the responses of the Teachers on users' friendliness of the software.

Table 4.4a: Summary of Responses on Users' Friendliness of Software by Teachers on Ease of use

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
1	Is it easy to start the software?	3 (18.8)	-	7 (43.8)	6 (37.5)	3.0	1.1
2	Is it difficult to navigate the software?	3 (18.8)	5 (31.3)	6 (37.5)	2 (12.5)	2.4	1.0
3	Is it always clear to the learner which point he/she has reached in the software?	4 (25.0)	-	7 (43.8)	5 (31.3)	2.8	1.2
4	Can students end the software at any time?	1 (6.3)	1 (6.3)	3 (18.8)	11(68 .8)	3.5	1.0
5	Is the software easy to learn?	-	-	7 (43.8)	9 (56.3)	3.6	0.5
14	Is it easy-to-follow on-screen instructions?	-	-	5 (31.3)	11 (68.8)	3.7	0.5

Table 4.4a revealed the extent of users' friendliness of the software (CiGoSPac) by Senior Secondary School Mathematics Teachers in terms of **Ease of Use**.

From Table 4.4a, statements 1, 2, 3, 4, 5 and 14 cover the ease of use of the software. The table indicates that the mean values of statements 1, 3, 4, 5 and 14 are higher than the criterion mean of 2.50 while statement 2 is below the criterion mean of 2.50 which is divergent option of teachers on the statement as they see the software as difficult to navigate ($\bar{x}$ = 2.4, S.D = 1.0). The users' friendliness of the software (CiGoSPac) in terms of ease is to a very large extent (Mean of means = 3.17) to teachers.

Table 4.4b: Summary of Responses on Users' Friendliness of Software by Teachers on Animation

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
6	Is animation well used?	-	-	6 (37.5)	10 (62.5)	3.6	0.5
7	Are diagrams appropriate?	-	-	4 (25.0)	12 (75.0)	3.8	0.5
8	Are animations clear?	-	-	5 (31.3)	11 (68.8)	3.7	0.5
9	Are animations relevant?	-	-	6 (37.5)	10 (62.5)	3.6	0.5
10	Do the diagrams aid understanding?	-	-	4 (25.0)	12 (75.0)	3.8	0.5

Table 4.4b revealed the extent of users' friendliness of the software (CiGoSPac) by Senior Secondary School Mathematics Teachers in terms of **Animation**.

From Table 4.4b, statements 6, 7, 8, 9 and 10 cover the animation of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. The users' friendliness of the software (CiGoSPac) in terms of animation is to a very large extent (Mean of means = 3.7) to teachers.

Table 4.4c: Summary of Responses on Users' Friendliness of Software by Teachers on Text

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
11	Is the grammar used in the software appropriate?	-	-	8 (50.0)	8 (50.0)	3.5	0.5
12	Is the vocabulary level accurate?	-	1 (6.3)	11 (68.8)	4 (25.0)	3.2	0.5
13	Is the text easy to read?	-	-	5 (31.3)	11 (68.8)	3.7	0.5
15	Is the text appropriate?	-	-	7 (43.8)	9 (56.3)	3.6	0.5

Table 4.4c revealed the extent of users' friendliness of the software (CiGoSPac) by Senior Secondary School Mathematics Teachers in terms of **Text**.

From Table 4.4c, statements 11, 12, 13 and 15 cover the text of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. The users' friendliness of the software (CiGoSPac) in terms of text is to a very large extent (Mean of means = 3.50) to teachers.

Table 4.4d: Summary of Responses on Users' Friendliness of Software by Teachers on Voice

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
16	Is audio well used?	-	-	12 (75.0)	4 (25.0)	3.3	0.5
17	Are sounds easy to hear?	-	1 (6.3)	8 (50.0)	7 (43.8)	3.4	0.6
18	Are sounds appropriate?	-	-	9 (56.3)	7 (43.8)	3.4	0.5
19	Is the level of language that the program offers clearly understandable?	-	1 (6.3)	4 (25.0)	11 (68.8)	3.6	0.6
20	Are the sounds relevant and aid understanding?	-	1 (6.3)	10 (62.5)	5 (31.3)	3.3	0.6

Table 4.4d revealed the extent of users' friendliness of the software (CiGoSPac) by Senior Secondary School Mathematics Teachers in terms of **Voice**.

From Table 4.4d, statements 16, 17, 18, 19 and 20 cover the voice of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. The users' friendliness of the software (CiGoSPac) in terms of voice is to a very large extent (Mean of means = 3.40) to teachers.

Table 4.4e: Summary of Responses on Users' Friendliness of Software by Teacher on Content

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
21	Is the content accurate and factual?	-	-	10 (62.5)	6 (37.5)	3.4	0.5
22	Is the content educationally appropriate?	-	-	10 (62.5)	6 (37.5)	3.4	0.5
23	Does the content meet learning goals and objectives?	-	-	5 (31.3)	11 (68.8)	3.7	0.5
24	Does the content lack bias (social, ethnic, gender, etc.)?	2 (12.5)	-	4 (25.0)	10 (62.5)	3.4	1.0
25	Does the software encourage performance-based learning?	-	-	11 (68.8)	5 (31.3)	3.3	0.5
26	Does the software adapt to various learning abilities?	-	1 (6.3)	7 (43.8)	8 (50.0)	3.4	0.6
27	Does the software increase students' level of understanding?	-	-	8 (50.0)	8 (50.0)	3.5	0.5
28	Is the feedback offered learners for wrong answers useful?	1 (6.3)	-	9 (56.3)	6 (37.5)	3.3	0.8
29	Does the Software offer something extra that cannot be done more in traditional ways (i.e. chalk and talk)?	-	-	15 (93.8)	1 (6.3)	3.1	0.3
30	Is learners' interest maintained?	-	3 (18.8)	10 (62.5)	3 (18.8)	3.0	0.6

Table 4.4e revealed the extent of users' friendliness of the software () by Senior Secondary School Mathematics Teachers in terms of **Content**.

From Table 4.4e, statements 21, 22, 23, 24, 25, 26, 27, 28, 29 and 30 cover the content of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. The users' friendliness of the software (CiGoSPac) in terms of content is to a very large extent (Mean of means = 3.17) to teachers.

Table 4.4f: Summary of Responses on Users' Friendliness of Software by Teachers on Colour

S/N	STATEMENTS To what extent:	1	2	3	4	$\bar{x}$	SD
31	Are the colours used in the software bright?	-	3 (18.8)	8 (50.0)	5 (31.3)	3.1	0.7
32	Are colours used in the software appropriate for Circle Geometry lesson?	-	3 (18.8)	7 (43.8)	6 (37.5)	3.1	0.8

Table 4.4f revealed the extent of users' friendliness of the software (CiGoSPac) by Senior Secondary School Mathematics Teachers in terms of **Colour**.

From Table 4.4f, statements 31 and 32 cover the colour of the software. The table indicates that the mean values of all the statements are higher than the criterion mean of 2.50. The users' friendliness of the software (CiGoSPac) in terms of colour is to a very large extent (Mean of means = 3.17) to teachers.

Table 4.5: Total Summary of Responses for Users' Friendliness of the Software

Item	Description of Item	Level of Friendliness	
		Students	Teachers
a	Ease of Use	Moderate	Very large
b	Animation	Large	Very large
c	Text	Very large	Very large
D	Voice	Large	Very large
E	Content	Large	Very large
F	Colour	Very large	Very large

Table 4.5 shows the total summary of the responses of the Teachers and Students about the extent of users' friendliness of the software (CiGoSPac). This result revealed that ease of use, animation, voice, text, content and colour are users' friendly to both the teachers and students. This implies that the software (CiGoSPac) is easy to use, and not difficult to learn.

4.2.5 Research Question Four

How desirable is the software - Circle Geometry Software Package (CiGoSPac)?

The responses on the section C of the Rating Scale for Software Evaluation Teachers (RSSET) in appendix II and section D of the Rating Scale for Adequacy of Software (RSAS) in appendix III were used.

Table 4.6 presents the results for teachers and for taking decision, criterion mean value of 2.5 was adopted.

Table 4.6: Summary of Responses for Desirability of Software By Teachers

S/N	STATEMENTS	1	2	3	4	$\bar{x}$	SD
1.	Which of the following is the best way to use the software?	1 (6.3)	4 (25.0)	11 (68.8)	-	2.6	0.6
2.	How likely is it that you would recommend this software to a friend or learner?	1 (6.3)	11 (68.8)	4 (25.0)	-	3.2	0.5
3.	How satisfied are you with the look and feel of this software?	1 (6.3)	11 (68.8)	4 (25.0)	-	3.2	0.5

Table 4.6 shows the responses of the teachers about the desirability of the Software. The result in question 1 indicates that majority 11 (68.8%) responded that the best way to use the Software is by both techniques (Whole-class teaching and in a computer laboratory) followed by 4 (25.0%) for in a computer laboratory, while 1 (6.3%) for Whole-class teaching. This implies that the software can be used for both Whole-class teaching (i.e. using a computer plus projector and wall screen) and in a computer laboratory (i.e. where each learner works as an individual on desktop/laptop computer). However, if computer laboratory is available it will be the best option.

The result in question 2 indicates that majority 11 (68.8%) responded that they will "*Somewhat likely*" recommend the software to a friend or learner, followed by "*very likely*" 4 (25.0%), while "*Not at all likely*" 1 (6.3%). This implies that the software will enjoy moderate recommendation for usage among teachers.

The result in question 3 indicates that majority 11 (68.8%) responded that they are "*Somewhat satisfied*" with the look and feel of this software, followed by "*very satisfied*" 4 (25.0%), while "*Not at all satisfied*" 1 (6.3%). This implies that the software moderately fulfilled the purpose of its design.

Table 4.7: Summary of Responses for Desirability of Software By Experts

S/N	STATEMENTS	1	2	3	4	$\bar{x}$	SD
1.	Which of the following is the best way to use the software?	1 (2.7)	12 (32.4)	24 (64.9)	-	2.6	0.6
2.	How likely is it that you would recommend this software to a friend or learner?	-	1 (2.7)	22 (59.5)	14 (37.8)	3.4	0.5
3.	How satisfied are you with the look and feel of this software?	-	1 (2.7)	24 (64.9)	12 (32.4)	3.3	0.5

Table 4.7 shows the responses of Experts (Educational Technologists, Computer Scientists and Software developers) about the desirability of the Software. The result in question 1 indicates that majority 24 (64.9%) responded that the best way to use the Software is by both techniques (Whole-class teaching and in a computer laboratory) followed by 12 (32.4%) for in a computer laboratory, while 1 (2.7%) for Whole-class teaching. This implies that the software can be used for both Whole-class teaching (i.e. using a computer plus projector and wall screen) and in a computer laboratory (i.e. where each learner works as an individual on desktop/laptop computer). However, if computer laboratory is available, it will be the best option.

The result in question 2 indicates that majority 22 (59.5%) responded that they will "*very likely*" recommend the software to a friend or learner, followed by "*Extremely likely*" 14 (37.8%), while "*Somewhat likely*" 1 (2.7%). This implies that the software will enjoy high recommendation for usage among learners.

The result in question 3 indicates that majority 24 (64.9%) responded that they are "*very satisfied*" with the look and feel of this software, followed by "*Extremely satisfied*" 12 (32.4%), while "*Somewhat satisfied*" 1 (2.7%). This implies that the software fulfilled the purpose of its design and they (Educational Technologists, Computer Scientists and Software developers) are pleased with its expression, structure and finishing.

4.2.6 Research Question Five

Does the software (CiGoSPac) effectively teach Senior Secondary School Circle Geometry?

The students' scores in Circle Geometry Achievement Tests (CGAT) in appendices V and VI were used. Table 4.8 presents the descriptive statistics of Gain differences in mean of Pretest and Posttest of Groups.

Table 4.8: Summary of Gain Differences in Mean of Pre-test and Post-test of Groups

Group	N	SCORE Pre-test	Post-test	Gain
I	172	11.74	41.28	29.54
		(3.52)	(15.75)	
II	216	12.18	26.95	14.77
		(4.15)	(11.88)	
III	375	10.77	19.00	8.23
		(3.57)	(13.47)	

The table shows that group I has the highest gain score of 29.54, followed by group II with 14.77 and group III with 8.23 which is the lowest. The finding revealed that the software (CiGoSPac) effectively taught Senior Secondary School Circle Geometry.

4.2.7 Research Question Six

What are the challenges faced by learners in using CiGoSPac for teaching and learning of Circle Geometry?

The Rating Scale for Software Evaluation (RSSES) Form A in appendix I and Rating Scale for Software Evaluation Teachers (RSSET) Form B in appendix II were used to obtain the comments of the students and Mathematics teachers. The teachers and SS2 students identified the challenges faced in using CiGoSPac for instruction as: irregularity in power supply (unstable electricity), inadequate computer system as it could not go round all the learners at a time, explanations were not detailed enough from the computer and their inability to ask questions during the instruction. The teachers further observed that Microsoft Office 13 is relatively slow without internet connection during Installation.

4.3 Hypotheses Testing

In answering the hypotheses, the students' scores in the following instruments were used: Circle Geometry Achievement Tests (CGAT) in appendices V and VI, and Perceptual Reasoning Ability Test (PRAT) in appendix XIII.

4.3.1 Hypothesis One: There is no significant main effect of treatment on students' achievement in Circle Geometry.

Tables 4.9 and 4.10 present the results. While Table 4.9 presents the descriptive statistics (Mean and standard deviation) of students' scores in the Circle Geometry Achievement Test by treatment and Table 4.10 presents the Analysis of covariance (ANCOVA).

Table 4.9: Descriptive Statistics of Students' Scores in CGAT by Treatment.

Group	Treatments	N	$\bar{x}$	SD	SE
I	CiGoSPac (Text, Animation and Voice)	172	41.08	15.75	1.07
II	CiGoSPac (Text, Animation and Disabled Voice)	216	26.71	11.88	.93
III	Conventional Teaching Method	375	19.34	13.47	.72

Table 4.10: Analysis of Covariance of Students' Score in CGAT and PRAT

Source	Type III Sum of Squares	df	Mean Square	f	Sig.	Partial Eta Squared
Corrected Model	60502.900[a]	6	10083.817	54.894	.000	.303
Intercept	44297.104	1	44297.104	241.143	.000	.242
PeCGAT	1162.745	1	1162.745	6.330	.012	.008
TYEXPT	52170.106	2	26085.053	142.001	.000	.273
PRATLEVEL	3.790	1	3.790	.021	.886	.000
TYEXPT* PRATLEVEL	546.104	2	273.052	1.486	.227	.004
Error	138874.397	756	183.696			

Table 4.9 shows that Group I had the highest mean score 41.08 (SD = 15.75), followed by Group II, 26.71 (11.88) and Group III had the lowest score 19.34 (13.47). The mean differences among the three groups was statistically significant, $F_{(2,\ 756)} = 142.001$, $p < 0.05$, partial $\eta^2 = 0.273$. The effect size of treatment is 27.3%. This implies that 27.3% of the variation observed in the groups' score is accounted for by treatment.

4.3.2 Hypothesis Two: There is no significant main effect of perceptual ability on students' achievement in Circle Geometry.

Table 4.11 presents the results

Table 4.11: Descriptive Statistics of Students' Scores in Perceptual Reasoning Ability Test.

Group	Treatments	N	$\bar{x}$	SD	SE
I	Low	392	29.12	17.41	0.78
II	High	371	28.97	14.55	0.72

Table 4.11 shows that low perceptual reasoning ability students had higher mean score of 29.12 (SD = 17.41) than high perceptual reasoning ability students 28.97 (SD = 14.55). The mean difference is very small and from Table 4.10, it is not statistically significant, $F_{(1, 756)} = .021$, $p > 0.05$, partial $\eta^2 = .000$, and the effect size is zero.

4.3.3 Hypothesis Three: There is no significant interaction effect of treatment and perceptual ability on students' achievement in Circle Geometry.

The results are presented in Table 4.12

Table 4.12: Descriptive Statistics of Students' Score CGAT Treatment and Perceptual Reasoning Ability Test.

Type of Experiment	PRA	N	$\bar{x}$	SD
CiGoSPac (Text, Animation and Voice)	LOW	63	40.76	16.32
	HIGH	109	41.40	15.47
CiGoSPac (Text, Animation and Disabled Voice)	LOW	106	27.97	12.15
	HIGH	110	25.44	11.56
Conventional Teaching Method	LOW	227	18.62	16.49
	HIGH	152	20.06	6.94

From Table 4.12, the mean difference of students with low and high perceptual reasoning ability in each of the three groups is very low: for group I the difference is 0.64; group II is 2.53 and group III, the difference is 1.43. The interaction effect of treatment and perceptual reasoning ability as shown in Table 4.10 is not statistically significant $F_{(2, 756)} = 1.486$, $p > 0.05$, partial $\eta^2 = .004$. The effect size is negligible.

4.4 Discussion of Findings

Research Question One

Does the CiGoSPac adequately execute the illustrated flowchart?

Findings from software adequacy to execute the illustrated flowchart shows that the extent of compliance with the designed flowchart in developing the software (CiGoSPac) is very high. That is, the software adequately executed the illustrated flowchart. This was in accordance with Sommerville (2011: 206)'s demand that the developed software should comply with standards and algorithms. The algorithm was what the flowchart provided in the case of CiGoSPac, since the flowchart was designed to solve the problem of teaching and learning Circle Geometry according to Mathematics curriculum for Senior Secondary School II. CiGoSPac has an implementation function to act as a teacher to the learner. It is a replica of the flowchart in a functional way which necessitated it's being very high in compliance, hence, the learner as at every point has the opportunity of going back to re-learn an already learnt concept for better learning.

Research Question Two

How comparable is the CiGoSPac (Ci) with NumberGym Plus (NP) in terms of: (a) Navigation [Nav], (b) Graphic [Grap], (c) Animation [Ani], (d) Voice [Voc], (e) Illustration [Ill] and (f) Assessment [Ass]?

These findings from the comparability of CiGoSPac (Ci) with NumberGym Plus (NP) show that there is a significant difference between the former and the latter, and that Ci is better than NP in terms of: Navigation, Graphic, Animation, Voice, Illustration and Assessment. This supports the assertion of Beale and Sharples (2002) in their basic steps in designing educational software under the step - evaluate the entire system - that there should be a type of comparison of the software. However, the probable reasons for CiGoSPac being better than NumberGym Plus was the presence of Menu-Driven Interface that allows for easy navigation of the software and the audible voice that gives learners the privilege to understand each concept taught by the software. The audible voice in CiGoSPac has learners' accent not foreign accent which gives it an added advantage over NumberGym Plus. CiGoSPac stimulates the classroom environment for students during its usage with assessment techniques.

Research Questions Three (i) and (ii)

How user friendly is the software - Circle Geometry Software Package (CiGoSPac) in terms of: (a) Ease of use (b) animation, (b) voice (c) text (d) Content and (e) colour?

This finding revealed that: ease of use, animation, voice, text, content and colour are users' friendly to both the teachers and students. This finding supports the assertion of Alan (2004) that User friendliness software interface will guide the users through different stages towards the accomplishment of the tasks. It reduces the difference between users and the systems, such that users can interact more with the tasks and less with the system. The Menu-Driven Interface (Appendix XIV) of the Circle Geometry Software Package (CiGoSPac) that are series of screens which are navigated by choosing options from lists (i.e. menus) on the screen that lead to other screens or slides are considered more user-friendly than any other interface (Webopedia, 2019). Likewise, the use of enhanced Microsoft PowerPoint presentation that are familiar to users in the development of CiGoSPac also aided its user friendliness.

Research Question Four

How desirable is the software - Circle Geometry Software Package (CiGoSPac)?

The findings of the study on how desirable the Circle Geometry Software Package (CiGoSPac) from both experts and teachers show that the desirability of the software is very high from the former and high from the latter. This implies that students will highly enjoy its use. This step was advocated by Beale and Sharples (2002) in their basic steps in designing educational software under - evaluate the entire system - that there should be evaluation of the software desirability. The reasons for high desirability of the software is not far-fetched from its ease of use, voice and content with its effectiveness in teaching Circle Geometry in SSII.

Research Question Five

Does the software (CiGoSPac) effectively teach Senior Secondary School Circle Geometry?

The CiGoSPac effectively taught Circle Geometry in Mathematics, and this finding supported Mayer's (2001) cognitive theory of multimedia learning that people learn more deeply from words and pictures than from words alone. Also, this result is similar to that of Szabo and Hastings (2000), and Clark (2008). The use of presentation software during lectures would increase students' grades, improve class attendance and reduce some disruptive behaviours. According to Clark (2008), visual stimuli provided by presentation software assists students to gain and maintain their attention.

Hypothesis One

Main Effect of Treatment on Students' Achievement in Circle Geometry

The main effect of Treatments; CiGoSPac (text, animation and voice), CiGoSPac (text and animation) and Conventional teaching method on students' post test scores in CGAT (PoCGAT) was reported to be statistically significant after adjusting for the covariates, pre- test score in CGAT (PeCGAT). This means that there was variation in students' scores in CGAT based on the manipulation of the treatment. This result has its base in the Connectivism learning theory that resides in the fact that students were able to make connections with the CiGoSPac [text, animation and voice] which is the information tool as well as a mediating object in the teaching and learning activity rather than just being told. This finding is in consonance with the study of Kushwaha, Chaurasia and Singhal (2014) who examined the effects of dynamic Mathematics software GeoGebra on student achievement in the teaching of Geometry at secondary stage. This result agrees with that of Safo et al (2013) who found significant difference between the achievement of students taught with CAI and those taught with traditional method. It also corroborates that of Ahiatrogah et al (2013) study which compared the effects of Computer Assisted Instruction and the traditional methods of instruction and concluded that students' achievement in pre-technical skill did significantly improved due to the use of the CAI.

The results of this study also corroborates that of Ogunyomi (2010) which examined the effect of Information and Communication Technology (ICT) on teaching and learning Mathematics and concluded that the use of ICT in teaching and learning Mathematics has positive effect on the performance of students in Mathematics and that students taught with the use of ICT performed better than the students taught with other methods in Mathematics.

However, the results of this study is not in line with that of Bayraktar (2008) which could not find any significant difference between the students exposed to CAI and those exposed to traditional method in Physics lesson

Hypothesis Two

Main Effect of Perceptual Ability on Students' Achievement in Circle Geometry

In this study, the perceptual ability of students was not statistically significant, meaning that students' score in post - test CGAT after adjusting for covariate (pre-test score) was irrespective of their perceptual ability test level. This may be associated with the fact that both low and high perceptual ability students were exposed to the same instructional strategies, hence, they tend to benefit the same way. This means that the students in the classroom benefited in about the same margin irrespective of their perceptual ability levels.

This finding is not in line with that of Saha, Ayub and Tarmizi (2010) study on the effects of GeoGebra on Mathematics Achievement whose results reveal that the high visual ability students performed better than low visual ability students.

Hypothesis Three

Interaction Effect of Treatment and Perceptual Ability on Students' Achievement in Circle Geometry.

The interaction of treatment and perceptual reasoning ability had no significant effect on students' score in CGAT. The interaction effect of Treatment and Perceptual Reasoning Ability accounted for less than one percent of the variance experienced in students' achievement in Circle Geometry.

This result is not in consonance with that of Dhingra, et al (2010) that assess the relationship between academic performance and perceptual abilities of school children whose results showed significant correlation among achievement, perceptual abilities-visual, auditory and kinesthetic. The conclusion of Dhingra et el (2010) that mathematical abilities depend significantly on auditory and visual perception is not supported by the findings of this study. In support of the findings of this study, Haskell (2000), while describing the factors responsible for difficulties in Arithmetic among young children emphasised that disorders in perceptual abilities may be a factor.

CHAPTER FIVE
SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of findings

1. The developed CiGoSPac adequately executed the illustrated design flowchart.
2. The developed CiGoSPac was better than NumbersGym Plus in terms of: Navigation, Graphic, Animation, Voice, Illustration and Assessment.
3. In terms of ease of use, animation, voice, text, content and colour, the CiGoSPac was users friendly to both the teachers and students.
4. The findings on how desirable was the Circle Geometry Software Package (CiGoSPac) from both experts and teachers showed that the desirability of the software was very high from the former and high from the latter.
5. The findings showed that the software (CiGoSPac) effectively taught the Circle Geometry in Mathematics of Senior Secondary School students.
6. Students taught with the two variants of CiGoSPac (three media of text, animation and voice; two media of text and animations) performed better in CGAT than their colleagues who were taught using conventional method of teaching. There was no significant main effect of Perceptual ability on students' achievement in Circle Geometry.
7. Perceptual ability had no significant effects on students' achievement in Circle Geometry.
8. Treatment and perceptual ability had no significant effect on students' achievement in Circle Geometry.

5.2 Conclusion

The developed Circle Geometry Software Package (CiGoSPac) was tested and found to be usable, useful and desirable. It was better than the foreign one (Number Gym) in terms of its features and effectiveness in teaching Circle Geometry.

5.3 Implication of the Study

a) Students

Students should be encouraged to learn Circle Geometry through user friendly software packages such as Circle Geometry Software Package (CiGoSPac). It had been proved in this study that it can enhance students' learning.

b) Teachers

Teachers should be encouraged to teach students Circle Geometry through user friendly software packages such as Circle Geometry Software Package (CiGoSPac). It had been proved in this study that it makes teaching and learning stimulating.

c) Software Developers

Software developers should be encouraged to develop user friendly software packages for teaching and learning of Mathematics. Such software packages should be cheap and readily available for secondary schools to purchase for the use of teachers and students.

5.4 Contributions to Knowledge

The results of this study has shown that the use of software packages can enhance students' performance in Geometry. This result contributes to existing literature on the efficacy and effectiveness of computer assisted instruction in teaching and learning of mathematics in secondary schools. This results lays credence to past studies that shows the efficacy in improving students' learning outcomes.

The developed Circle Geometry Software Package (CiGoSPac) which incorporated diagrams, text and voice. Also it includes modules that can enhance self-learning. There are units on assessment and feedback that can engender repeat of a module being explained as well as teaching modules which teachers can use to teach topics to individual and groups of students. More importantly, teachers can use it to teach by deactivating the voice component.

Furthermore, the development of other ten instruments used in this study which were: Rating Scale for Software students (RSSES) Form A, Rating Scale for Software Teachers (RSSET) Form B, Rating Scale for Adequacy of Software (RSAS), Checklist for Comparability of Software (CCS), Circle Geometry Achievement Test (CGAT) for Pretest and Posttest, Manual for the Use of the Circle Geometry Software Package, Lesson Guide for Conventional Method (LGCM), and Marking Guide for Circle Geometry Achievement Tests for Pretest and Posttest were notable contributions in this study.

5.5 Suggestions for Further Studies

Packages that can incorporate topics in other aspects of Mathematics can be developed by other researchers. Similar studies can be carried out at the lower classes. This study can be extended to students in private schools in order to confirm whether the same result will be generated. Also, the study can be replicated in other parts of the country for more empirical fact about the effectiveness of the Circle Geometry Software Package (CiGoSPac) developed.

5.6 Recommendations

1. Students should be advised to make prudent use of the current advances in ICT to learn Circle Geometry so as to improve their understanding of the topic.
2. Mathematics teachers should be dynamic in teaching and embrace connectivism approach to teaching, most especially Circle Geometry Software Package (CiGoSPac) as this will not only enhance students' achievement but also affect behaviour. They need to maximise the advantages of technology to ease their lesson delivery and promote learning.
3. Teachers should be encouraged to learn the use of Computer-based multimedia instruction.
4. The Ministries of Education in Federal, State and Local Government should make provision for the use of ICT facilities in schools to encourage the use of CiGoSPac.

5. Curriculum planners and School Principals should include the use of Computer-based instruction in Senior Secondary School Mathematics Curriculum and enforce compliance among teachers.

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APPENDIX I

RATING SCALE FOR SOFTWARE EVALUATION STUDENTS (RSSES)

FORM A

INTRODUCTION

The aim of this questionnaire is to evaluate the users' friendliness of Circle Geometry software package (CiGoSPac). This questionnaire is therefore designed to gather information from Senior Secondary School Students after using the software.

Please provide honest information. Your responses shall be treated as confidential and be used for research purpose alone.

SECTION A: PERSONAL DATA

Kindly tick [√] in the box that best represents your opinion.

1. Name of School: ……………………………………………………….
2. Type of School: Public [ ] Private [ ]
3. Sex: Male [ ] Female [ ]
4. Age: 12 – 14 [ ] 15 – 17 [ ] 18 – 19 [ ] 20 and above [ ]

SECTION B: Please tick [√] in the box that best represents your opinion. Use the scale and record your response in the space provided to the left of each question.

1- Not At All, **2**- To Some Extent, **3** – To A Large Extent, **4** – To A Very Large Extent.

S/N	**STATEMENTS** **To what extent:**	**1**	**2**	**3**	**4**
1	Is it easy to start the software?				
2	Is it difficult to navigate the software?				
3	Is it always clear to the learner which point he/she has reached in the software?				
4	Can students end the software at any time?				
5	Is the software easy to learn?				
6	Is animation well used?				
7	Are diagrams appropriate?				
8	Are animations clear?				
9	Are animations relevant?				

10	Do the diagrams aid understanding?				
11	Is the grammar used in the software appropriate?				
12	Is the vocabulary level accurate?				
13	Is the text easy to read?				
14	Is it easy-to-follow on-screen instructions?				
15	Is the text appropriate?				
16	Is audio well used?				
17	Are sounds easy to hear?				
18	Are sounds appropriate?				
19	Is the level of language that the program offers clearly understandable?				
20	Are the sounds relevant and aid understanding?				
21	Is the content accurate and factual?				
22	Is the content educationally appropriate?				
23	Does the content meet learning goals and objectives?				
24	Does the content lack bias (social, ethnic, gender, etc.)?				
25	Does the software encourage performance-based learning?				
26	Does the software adapt to various learning abilities?				
27	Does the software increase students' level of understanding?				
28	Is the feedback offered learners for wrong answers useful?				
29	Does the Software offer something extra that cannot be done more in traditional ways (i.e. chalk and talk)?				
30	Is learners' interest maintained?				
31	Are the colours used in the software bright?				
32	Are colours used in the software appropriate for Circle Geometry lesson?				

Outline the challenges experienced during the use of CiGoSPac.

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………………………………………………………………………………………….

APPENDIX II
RATING SCALE FOR SOFTWARE EVALUATION TEACHERS (RSSET)
FORM B

INTRODUCTION

The aim of this questionnaire is to evaluate the users' friendliness of Circle Geometry Software Package (CiGoSPac). This questionnaire is therefore designed to gather information from Senior Secondary School Mathematics Teachers after experiencing the use of the software.

Please provide honest information. Your responses shall be treated as confidential and be used for research purpose alone.

SECTION A: PERSONAL DATA

Kindly tick [√] in the box that best represents your opinion.

1. Name of School: ……………………………………………………………….
2. Type of School: Public [ ] Private [ ]
3. Sex: Male [ ] Female [ ]
4. Age: 21 – 30 [ ] 31 – 40 [ ] 41 – 50 [ ] 51 – 60 [ ] 61 and above [ ]
5. Educational Qualification (s): …………………………………………………
6. Working Experience: 1 – 5 years [ ] 6 – 10 years [ ] 11 – 15 years [ ]
 16 – 20 years [ ] 21 – 25 years [ ] 25 – 30 years [ ]
 31 years and above [ ]

SECTION B: Please tick [√] in the box that best represents your opinion. Use the scale and record your response in the space provided to the left of each question.

1- Not At All, **2**- To Some Extent, **3** – To A Large Extent, **4** – To A Very Large Extent.

S/N	STATEMENTS To what extent:	1	2	3	4
1	Is it easy to start the software?				
2	Is it difficult to navigate the software?				
3	Is it always clear to the learner which point he/she				

	has reached in the software?				
4	Can students end the software at any time?				
5	Is the software easy to learn?				
6	Is animation well used?				
7	Are diagrams appropriate?				
8	Are animations clear?				
9	Are animations relevant?				
10	Do the diagrams aid understanding?				
11	Is the grammar used in the software appropriate?				
12	Is the vocabulary level accurate?				
13	Is the text easy to read?				
14	Is it easy-to-follow on-screen instructions?				
15	Is the text appropriate?				
16	Is audio well used?				
17	Are sounds easy to hear?				
18	Are sounds appropriate?				
19	Is the level of language that the program offers clearly understandable?				
20	Are the sounds relevant and aid understanding?				
21	Is the content accurate and factual?				
22	Is the content educationally appropriate?				
23	Does the content meet learning goals and objectives?				
24	Does the content lack bias (social, ethnic, gender, etc.)?				
25	Does the software encourage performance-based learning?				
26	Does the software adapt to various learning abilities?				
27	Does the software increase students' level of understanding?				
28	Is the feedback offered learners for wrong answers useful?				
29	Does the Software offer something extra that cannot be done more in traditional ways (i.e. chalk and talk)?				

30	Is learners' interest maintained?				
31	Are the colours used in the software bright?				
32	Are colours used in the software appropriate for Circle Geometry lesson?				

SECTION C: GENERAL

Kindly tick [√] in the box that best represents your opinion.

1. Which of the following is the best way to use the software?

   ☐ Whole-class teaching e.g. using a computer plus projector and wall screen

   ☐ In a computer laboratory i.e. where each learner works as an individual on desktop/laptop computer

   ☐ Both techniques are suitable

   ☐ None of the above is suitable

2. How likely is it that you would recommend this software to a friend or learner?

   ☐ Not at all likely

   ☐ Somewhat likely

   ☐ Very likely

   ☐ Extremely likely

3. How satisfied are you with the look and feel of this software?

   ☐ Not at all satisfied

   ☐ Somewhat satisfied

   ☐ Very satisfied

   ☐ Extremely satisfied

Outline the challenges faced by learners in using of CiGoSPac.

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APPENDIX III

RATING SCALE FOR ADEQUACY OF SOFTWARE (RSAS)

INTRODUCTION

The aim of this questionnaire is to confirm the Circle Geometry software package (CiGoSPac) adequacy in executing the illustrated flowchart. It is specially designed for experts (i.e. Educational Technologist, Computer Scientist and Software developers) involved in software design and development.

Please provide honest information as regards the extent to which CiGoSPac sufficiently execute the illustrated flowchart. Please use the following scale to answer the questions below.

SECTION A: PERSONAL DATA

1. Sex: Male [ ] Female [ ]
2. Age: 21 – 30 [ ] 31 – 40 [ ] 41 – 50 [ ] 51 – 60 [ ]
   61 and above [ ]

SECTION B: Please tick [√] in the box that best represents your opinion. Please use the following scale to answer the questions below: **0** – Not at all, **1** – To a small extent, **2** – To some extent, **3** – To a moderate extent, **4** – To a great extent, and **5** – To a very great extent.

S/N	STATEMENTS	0	1	2	3	4	5
1.	To what extent is the flow chart branching well executed in the software?						
2.	To what extent is the looping in the flow chart implemented in the software?						
3.	To what extent does the Decision boxes representing the RECAP in the flow chart executed in the software?						
4.	To what extent are the Data boxes implemented in the software?						
5.	To what extent are sub-systems properly executed in the software?						
6.	To what extent is the logicality of the flow chart implemented in the software?						
7.	Does the software reflect the illustrated flow chart?						

SECTION C: COMMENTS: Write general comments that can assist in improving CiGoSPac:

…………………………………………………………………………………………………

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SECTION D: GENERAL

Kindly tick [√] in the box that best represents your opinion.

1. Which of the following is the best way to use the software?
   - ☐ Whole-class teaching e.g. using a computer plus projector and wall screen
   - ☐ In a computer laboratory i.e. where each learner works as an individual on desktop/laptop computer
   - ☐ Both techniques are suitable
   - ☐ None of the above is suitable
2. How likely is it that you would recommend this software to a friend or learner?
   - ☐ Not at all likely
   - ☐ Somewhat likely
   - ☐ Very likely
   - ☐ Extremely likely
3. How satisfied are you with the look and feel of this software?
   - ☐ Not at all satisfied
   - ☐ Somewhat satisfied
   - ☐ Very satisfied
   - ☐ Extremely satisfied

APPENDIX IV

CHECKLIST FOR COMPARABILITY OF SOFTWARE (CCS)

INTRODUCTION

The aim of this checklist is to compare Circle Geometry software package (CiGoSPac) with NumberGym Plus. It is specially designed for experts (i.e. Educational Technologist, Computer Scientist and Software developers). Please provide honest information. Your responses shall be treated with upmost importance and be used for research purpose only.

SECTION A: PERSONAL DATA

1. Sex: Male [ ] Female [ ]
2. Age: 21 – 30 [ ] 31 – 40 [ ] 41 – 50 [ ] 51 – 60 [ ]
   61 and above [ ]

SECTION B: Please rate the degree of presence according to the criteria mentioned as sub-heading in the box that best represents your opinion when the software are compared. Please use the following scale to answer the questions below and write your response in the space provided under each software to the left of each question: **0** – Not present all, **1** – Present to a small extent, **2** – Present to some extent, **3** – Present to a moderate extent, **4** – Present to a great extent, and **5** – Present to a very great extent.

S/N	STATEMENTS	Number Gym Plus	CiGoSPac
Navigation			
1.	Navigation options are clearly obvious and understandable.		
2.	Links to other pages and back to home page are functional.		
3.	Easy to start the program.		
4.	Can be navigated without difficulty.		
5.	Clear to learner which point he/she has reached.		
6.	Can be ended any time.		
Graphic			
7.	Colour texture is nice.		
8.	Front size is well designed.		

9.	Direction buttons are user friendly.		
10.	The colours used were bright enough.		
11.	Colours used are appropriate for the lesson.		
12.	Text is easy to read.		
13.	Text is appropriate.		
Animations			
14.	Animation is well used.		
15.	Diagrams are appropriate.		
16.	Animations are clear.		
17.	Animations are relevant.		
18.	Diagrams aid understanding.		
Voice			
19.	Audio is well used		
20.	Sounds are clear to hear.		
21.	Grammar used is appropriate.		
22.	Vocabulary level is accurate.		
23.	Sounds are appropriate.		
24.	Level of language offered is clearly understandable.		
25.	Sounds are relevant and aid understanding.		
Illustrations			
26.	Easy-to-follow on-screen instructions.		
27.	Content is accurate and factual.		
28.	Content is educationally appropriate.		
29.	Content meets learning goals and objectives.		
30.	Content lacks bias (social, ethnic, gender, etc).		
31.	Encourages performances-based learning.		
Assessment			
32.	Provide assessment for learning.		
33.	Self-learning.		
34.	Feedback offered learners for wrong answers is useful.		
35.	Offer something extra that cannot be done more in traditional ways, e.g. chalk and talk.		
36.	Can easily be recommended for use in schools		

APPENDIX V

NAME: ………………………………………………………………………………….

NAME OF SCHOOL: ………………………………………………………………….

CIRCLE GEOMETRY ACHIEVEMENT TEST (CGAT)

TIME: 1½ HOUR.

OBJECTIVE

INSTRUCTION: *Answer all questions in this section and circle the correct option.*

1. A line segment joining any two points on the circumferences is called a …….

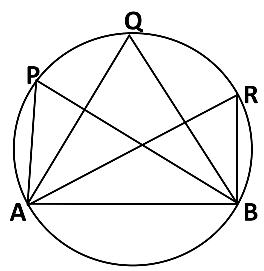
   A. Chord

   B. Radius

   C. Arc

   D. Segment

2. In the diagram below < APB, < AQB, < ARB are



   A. angles on the same line.

   B. angles on the same segment.

   C. angles on the same semi-circle.

   D. angles on the same chord.

3. ABCD is a quadrilateral inscribed in a circle so that $<CBA = 50^0$ and $<ACD = 35^0$ Calculate <CAD.

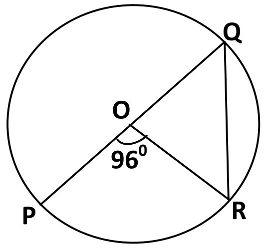
   A. 130^0

   B. 95^0

   C. 50^0

   D. 15^0

4. In the diagram below, O is the centre of the circle and POQ is a diameter. If $<POR = 96^0$. Calculate <ORQ.



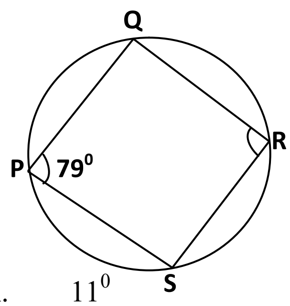
A. 42^0

B. 48^0

C. 82^0

D. 84^0

5. In the diagram <SPQ = 79^0 find <SRQ.



A. 11^0

B. 79^0

C. 101^0

D. 158^0

6. Which of the following statement is correct?

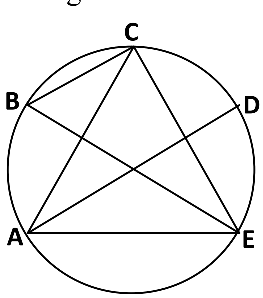
A. Angle at the circumference is half of the angle at the centre.

B. The opposite angles of a cyclic quadrilateral are complementary.

C. Radius of a circle is twice its diameter.

D. The angles in a semicircle are 90^0.

7. In the diagram which chord subtends <CAE?



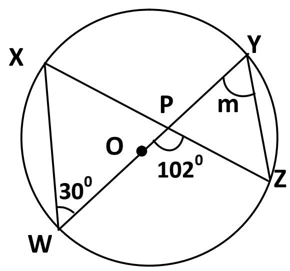
A. /AD/

B. /CE/

C. /BE/

D. /CD/

8. In the diagram, O is the centre of the circle; WY and XZ are straight lines, angle WPZ = 102^0, angle XWY = 30^0 and angle PYZ = m. Find the value of m.



A. 78^0

B. 72^0

C. 51^0

D. 36^0

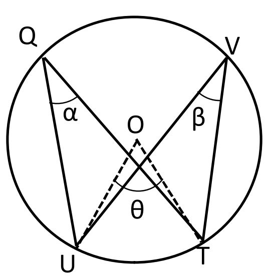
9. In the figure shown with centre O. Q, V, U and T are point on the circumference of the circle, which of the following statement is/are true

I. $\theta = 2\alpha$

II. $\theta = 2\beta$

III. $2\alpha = 2\beta$

IV. $2\alpha + 2\beta = \theta$



A. **I**, **II**, **III** only

B. **II**, **III**, **IV** only

C. **I** and **II** only

D. **I**, **II**, **III** and **IV**

10. The angle in a semi-circle is ….. angle.

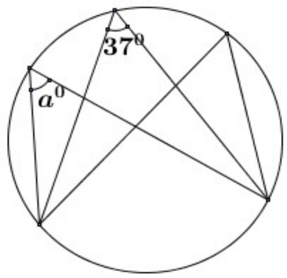
A. an alternate

B. an opposite

C. a right

D. a radius

11. Find the value of angle marked $\mathbf{a^o}$



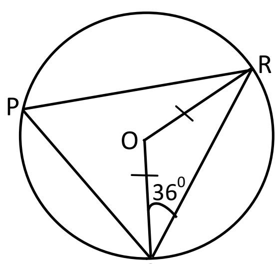
A. 143^o

B. 114^o

C. 37^o

D. 28^o

12. In diagram, O is the centre of the circle and $\angle OQR=36^o$ calculate $\angle QPR$.



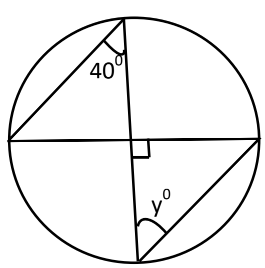
A. 54^o

B. 66^o

C. 72^o

D. 108^o

13. Find the value of y in the diagram below.



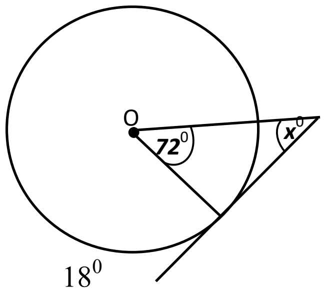
A. 30^0

B. 40^0

C. 50^0

D. 90^0

14. Calculate the size of angle ***x*** in the diagram below.



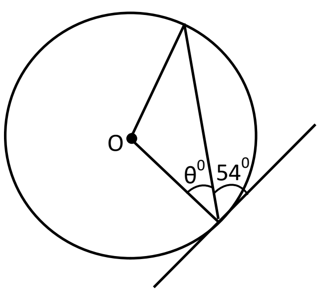
A. 18^0

B. 36^0

C. 45^0

D. 90^0

15. Calculate the size of θ the diagram below. If O is the centre of the circle.



A. 27^0

B. 36^0

C. 90^0

D. 126^0

16. Which of the following terms is **NOT** necessary for the proof, "*angle between a tangent and a chord is equal to any angle in opposite segment*"?

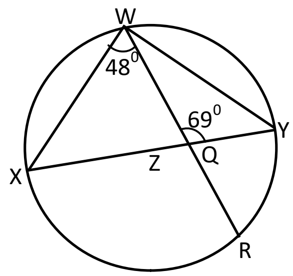
A. Radius $\perp$ Tangent

B. < in a semi-circle

C. < at centre = 2 x < at circumference

D. Opp. < of cyclic quadrilateral

17. In the diagram below XZY is a diameter of the circle. If < XWQ = 48^0 and < YQW = 69^0, calculate < WYQ.



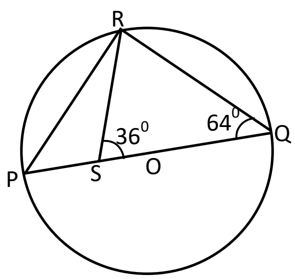
A. 42^0

B. 48^0

C. 56^0

D. 69^0

18. In the diagram, PQ is a diameter of the circle, centre O and RS meets PQ at S. If < RQP = 64^0 and < RSQ=36^0, Calculate < PRS.



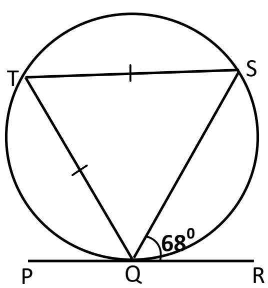
A. 10^0

B. 18^0

C. 22^0

D. 28^0

19. In the diagram, PQR is a tangent to the circle QST at Q. if /QT/ = /ST/ and $\angle$SQR = 68^0, find $\angle$PQT.



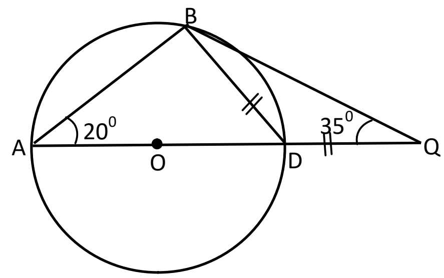
A. 34^o

B. 48^o

C. 56^o

D. 68^o

20. In the diagram, O is the centre of the circle /BD/ = /DC/. If <DCB = 35 and < BAD = 20^0. Find < ABD.



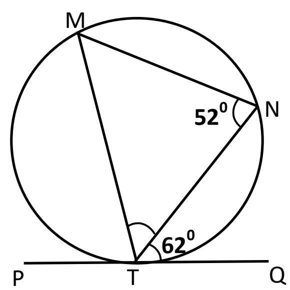
A. 90^o

B. 70^o

C. 45^o

D. 35^o

21. In the diagram, PQ is a tangent to the circle MTN at T. What is the size of <MTN?



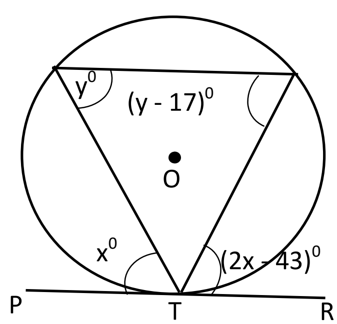
A. 52^0

B. 54^0

C. 66^0

D. 72^0

22. In the diagram, PR is a tangent at T to the circle center O. find the value of $\mathbf{x^0}$.



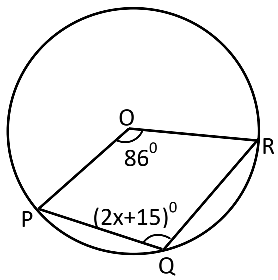
A. 9^0

B. 20^0

C. 26^0

D. 60^0

23. The diagram is a circle centre O. Find the value of x.



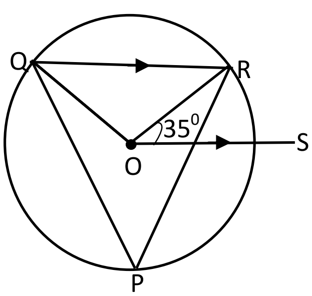
A. 30^o

B. 50^o

C. 61^o

D. 76^o

24. In the diagram, O is the centre of the circle where QR // OS and $S\hat{O}R = 35^0$. Find the value of $\angle QPR$.



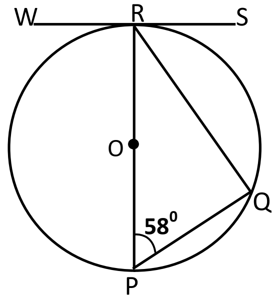
A. 35^o

B. 45^o

C. 55^o

D. 70^o

25. In the diagram, PR is a diameter of the circle centre O. RS is a tangent at R and $Q\hat{P}R = 58^0$. Find <QRS.



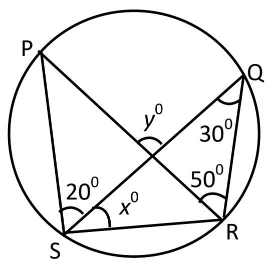
A. 112^0

B. 116^0

C. 122^0

D. 148^0

26. In the diagram P, Q, R, S are points on the circle, $<RQS = 30^0$, $<PRS = 50^0$ and $<PSQ = 20^{0.}$ What is the value of x^0+y^0?



A. 260^0

B. 130^0

C. 100^0

D. 80^0

27. ABCD is a cyclic quadrilateral and the diagonals AC and BD intersect at H. If $<DAC = 41^0$ and $<AHB = 70^0$ calculate <ACB.

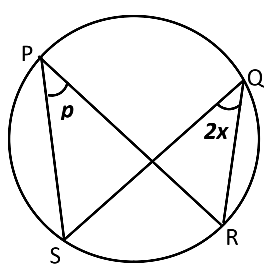
A. 11^0

B. 29^0

C. 41^0

D. 70^0

28. $\angle SPR = \boldsymbol{p}$ and $\angle SQR = 2\boldsymbol{x}$, find $\boldsymbol{x}$.



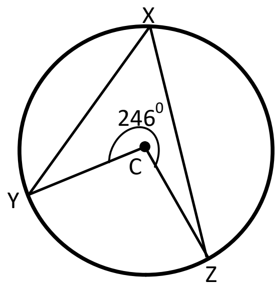
A. $2\boldsymbol{p}$

B. $\boldsymbol{p/2}$

C. $\boldsymbol{p}$

D. $\boldsymbol{p + 2}$

29. C is the centre of the Circle shown in the figure, and reflex angle YCZ = 246^0. Find $\angle$YXZ.



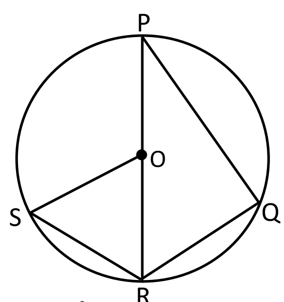
A. 228^0

B. 189^0

C. 114^0

D. 57^0

30. In the diagram, POR is a diameter of the circle centre O. SR//PQ and <RPQ = 58^0. What is <ORQ?



A. 32^0

B. 60^0

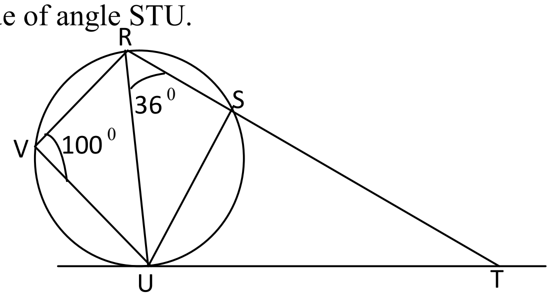
C. 90^0

D. 148^0

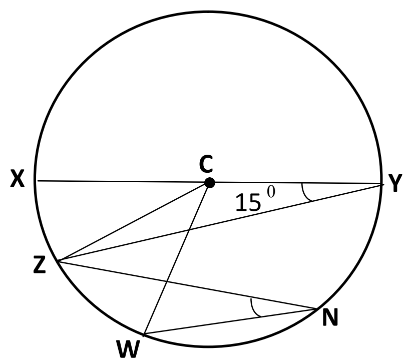
THEORY

INSTRUCTION: Answer **ALL** Questions in Answer sheets provided.

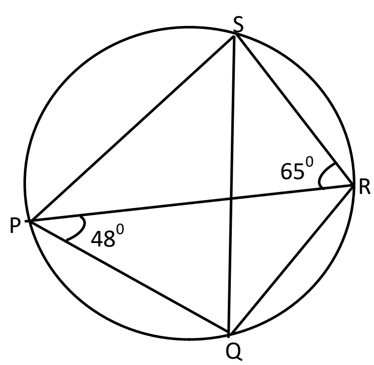
1. In the diagram, $\overline{TU}$ is a tangent to the circle, < RVU= 100^0 and < URS = 36^0. Calculate the value of angle STU.



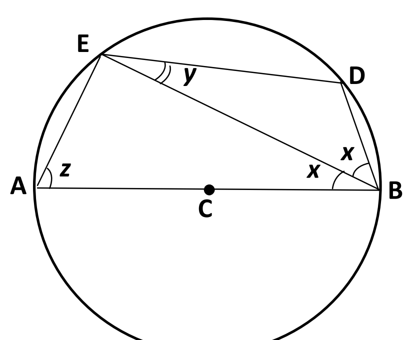
2. In the figure, C is the centre of the circle, < **XYZ** = 15^0 and < **YCW** = 110^0. Calculate < **ZNW.**



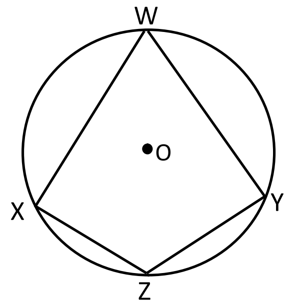
3. PQRS is a cyclic quadrilateral in the diagram below. If /SR/ = /QR/, $\angle$ **SRP** = 65^0 and $\angle$ **RPQ** = 48^0, find $\angle$ **PRQ.**



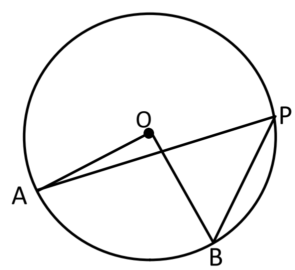
4. If $x = 35^0$ in the figure below, find y and z.



5. a) Given the circle XYZW below with centre O. Prove that **$\angle XWY + \angle XZY = 180^0$**.



b) In the diagram, O is the centre of the Circle A, B and P are points on the circumference. Prove that $A\hat{O}B = 2\ A\hat{P}B$



APPENDIX VI

NAME: …………………………………………………………………………………….

NAME OF SCHOOL ……………………………………………………………………….

POST-TEST CIRCLE GEOMETRY ACHIEVEMENT TEST (PoCGAT)

TIME: 1½ HOUR.

OBJECTIVE

INSTRUCTION: *Answer all questions in this section and circle the correct option.*

1. Which of the following statement is correct?

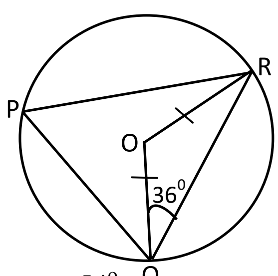
   A. Angle at the circumference is half of the angle at the centre.

   B. The opposite angles of a cyclic quadrilateral are complementary.

   C. Radius of a circle is twice its diameter.

   D. The angles in a semicircle are 90^0.

2. In diagram, O is the centre of the circle and $\angle OQR=36^o$ calculate $\angle QPR$.



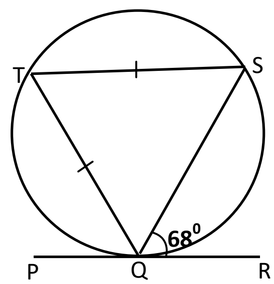
   A. 54^o

   B. 66^o

   C. 72^o

   D. 108^o

3. In the diagram, PQR is a tangent to the circle QST at Q. if /QT/ = /ST/ and $\angle SQR = 68^0$, find $\angle PQT$.



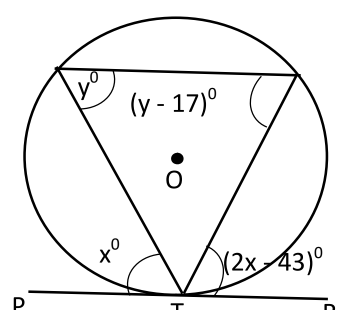
   A. 34^o

   B. 48^o

   C. 56^o

   D. 68^o

4. In the diagram, PR is a tangent at T to the circle center O. find the value of $\mathbf{x^0}$.



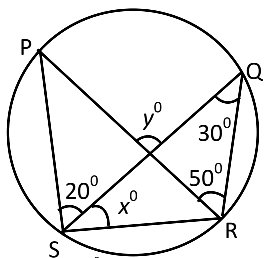
   A. 9^0

B. 20^0

C. 26^0

D. 60^0

5. In the diagram P, Q, R, S are points on the circle, $<RQS = 30^0$, $<PRS = 50^0$ and $<PSQ = 20^0$. What is the value of x^0+y^0?



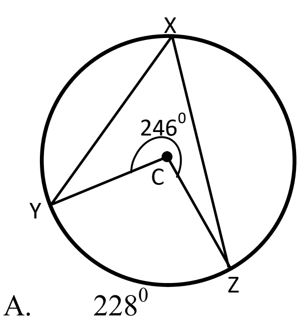
A. 260^0

B. 130^0

C. 100^0

D. 80^0

6. C is the centre of the Circle shown in the figure, and reflex angle YCZ $= 246^0$. Find $\angle YXZ$.



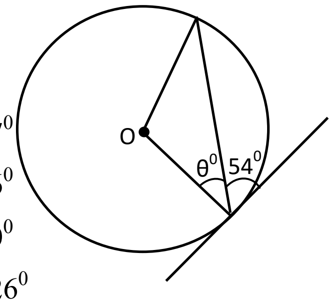
A. 228^0

B. 189^0

C. 114^0

D. 57^0

7. Calculate the size of θ the diagram below. If O is the centre of the circle.



A. 27^0

B. 36^0

C. 90^0

D. 126^0

8. ABCD is a quadrilateral inscribed in a circle so that $<CBA = 50^0$ and $<ACD = 35^0$ Calculate $<CAD$.

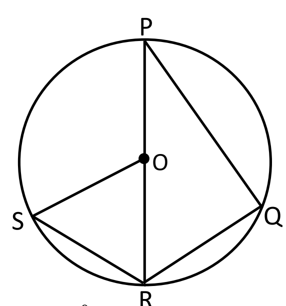
A. 130^0

B. 95^0

C. 50^0

D. 15^0

9. In the diagram, POR is a diameter of the circle centre O. SR//PQ and $<RPQ = 58^0$. What is $<ORQ$?



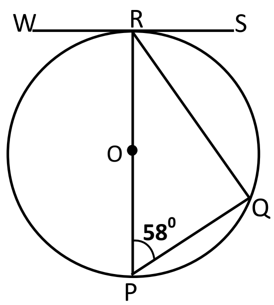
A. 32^0

B. 60^0

C. 90^0

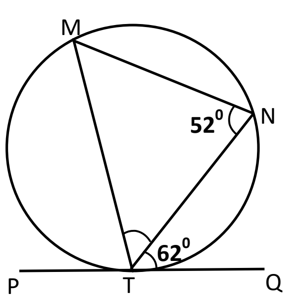
D. 148^0

10. In the diagram, PR is a diameter of the circle centre O. RS is a tangent at R and $\hat{QPR} = 58^0$. Find <QRS.



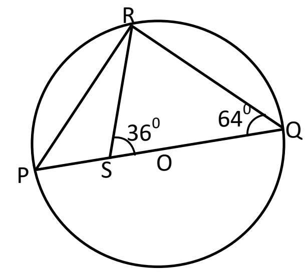
A. 112^0
B. 116^0
C. 122^0
D. 148^0

11. In the diagram, PQ is a tangent to the circle MTN at T. What is the size of <MTN?



A. 52^0
B. 54^0
C. 66^0
D. 72^0

12. In the diagram, PQ is a diameter of the circle, centre O and RS meets PQ at S. If < RQP = 64^0 and < RSQ=36^0, Calculate < PRS.



A. 10^0
B. 18^0
C. 22^0
D. 28^0

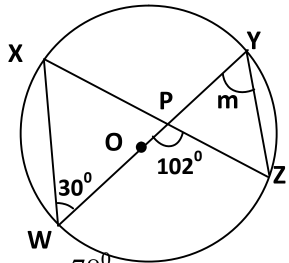
13. Which of the following terms is **NOT** necessary for the proof, "*angle between a tangent and a chord is equal to any angle in opposite segment*"?
A. Radius ⊥ Tangent
B. < in a semi-circle
C. < at centre = 2 x < at circumference
D. Opp. < of cyclic quadrilateral

14. The angle in a semi-circle is ….. angle.
A. an alternate
B. an opposite
C. a right
D. a radius

15. In the diagram, O is the centre of the circle; WY and XZ are straight lines, angle WPZ = 102^0, angle

XWY = 30^0 and angle PYZ = m.

Find the value of m.



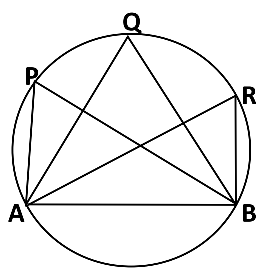
A. 78^0

B. 72^0

C. 51^0

D. 36^0

16. In the diagram below < APB, < AQB, < ARB are



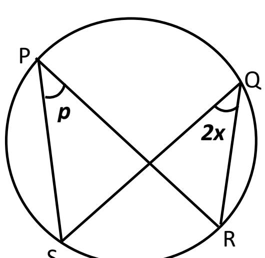
A. angles on the same line.

B. angles on the same segment.

C. angles on the same semi-circle.

D. angles on the same chord.

17. $\angle SPR = \boldsymbol{p}$ and $\angle SQR = 2\boldsymbol{x}$, find $\boldsymbol{x}$.



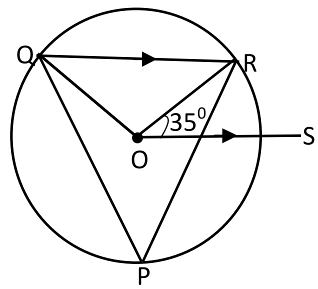
A. 2***p***

B. ***p*/2**

C. ***p***

D. ***p* + 2**

18. In the diagram, O is the centre of the circle where QR // OS and $S\hat{O}R = 35^0$. Find the value of $\angle QPR$.



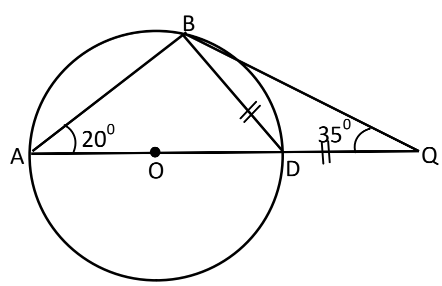
A. 35°

B. 45°

C. 55°

D. 70°

19. In the diagram, O is the centre of the circle /BD/ = /DC/. If <DCB = 35 and < BAD = 20^0. Find < ABD.



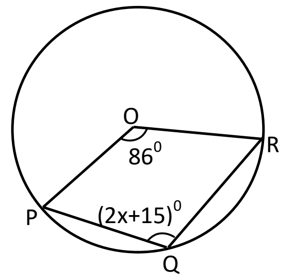
A. 90°

B. 70°

C. 45°

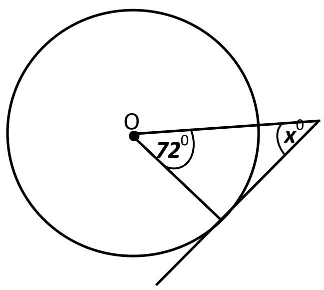
D. 35°

20. The diagram is a circle centre O. Find the value of x.



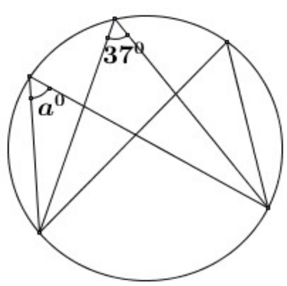
A. 30^o
B. 50^o
C. 61^o
D. 76^o

21. Calculate the size of angle ***x*** in the diagram below.



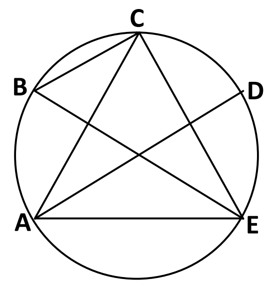
A. 18^0
B. 36^0
C. 45^0
D. 90^0

22. Find the value of angle marked $\mathbf{a^o}$



A. 143^o
B. 114^o
C. 37^o
D. 28^o

23. In the diagram which chord subtends <CAE?



A. /AD/
B. /CE/
C. /BE/
D. /CD/

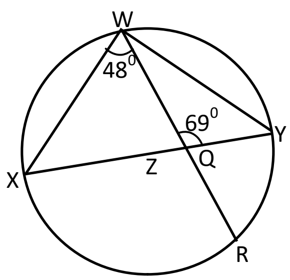
24. A line segment joining any two points on the circumferences is called a …….

A. Chord
B. Radius
C. Arc
D. Segment

25. ABCD is a cyclic quadrilateral and the diagonals AC and BD intersect at H. If <DAC = 41^0 and <AHB = 70^0 calculate <ACB.

A. 11^0
B. 29^0
C. 41^0
D. 70^0

26. In the diagram below XZY is a diameter of the circle. If < XWQ = 48^0 and < YQW = 69^0, calculate < WYQ.



A. 42^0

B. 48^0

C. 56^0

D. 69^0

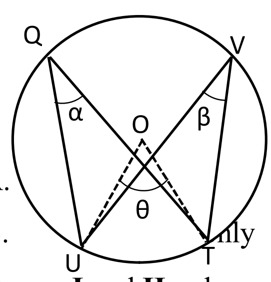
27. In the figure shown with centre O. Q, V, U and T are point on the circumference of the circle, which of the following statement is/are true.

I. $\theta = 2\propto$

II. $\theta = 2\beta$

III. $2\propto = 2\beta$

IV. $2\propto + 2\beta = \theta$



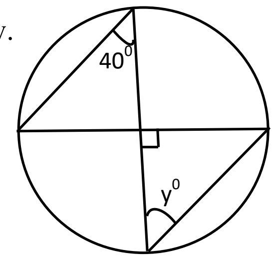
A.

B. nly

C. **I** and **II** only

D. **I**, **II**, **III** and **IV**

28. Find the value of y in the diagram below.



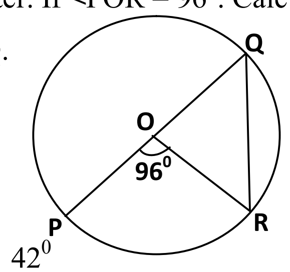
A. 30^0

B. 40^0

C. 50^0

D. 90^0

29. In the diagram below, O is the centre of the circle and POQ is a diameter. If <POR = 96^0. Calculate <ORQ.



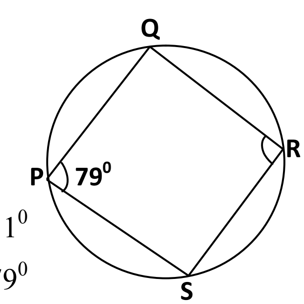
A. 42^0

B. 48^0

C. 82^0

D. 84^0

30. In the diagram <SPQ = 79^0 find <SRQ.



A. 11^0

B. 79^0

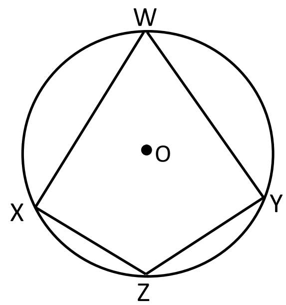
C. 101^0

D. 158^0

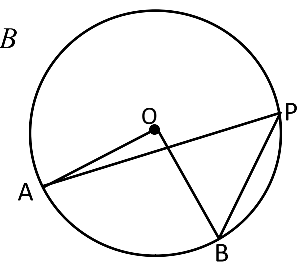
THEORY

INSTRUCTION: Answer **ALL** Questions in the space provided in question paper.

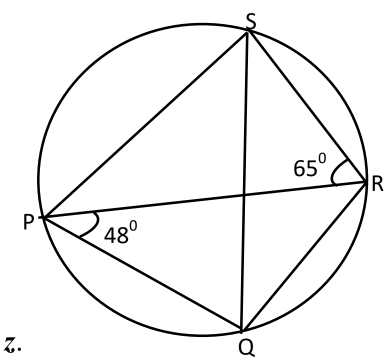
6. a) Given the circle XYZW below with centre O. Prove that **< XWY + < XZY = 180^0**.



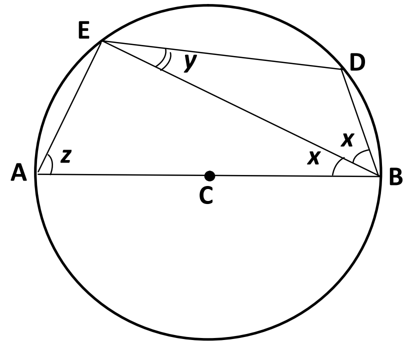
b) In the diagram, O is the centre of the Circle A, B and P are points on the circumference. Prove that $A\hat{O}B = 2 \times A\hat{P}B$



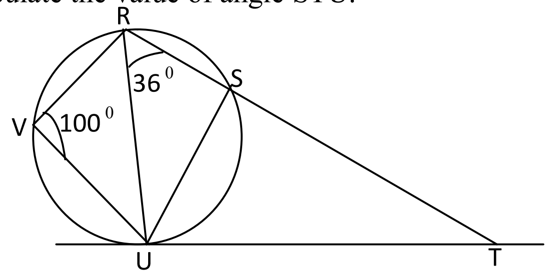
2. PQRS is a cyclic quadrilateral in the diagram below. If /SR/ = /QR/, $\angle$ **SRP** = 65^0 and $\angle$ **RPQ** = 48^0, find $\angle$ **PRQ**.



3. If $x = 35^0$ in the figure below, find y and z.

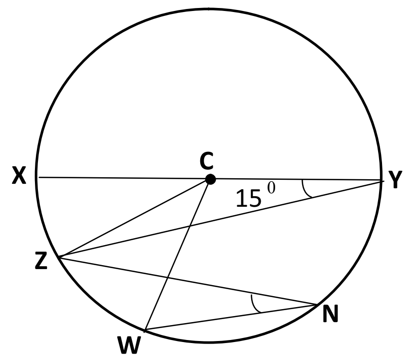


4. In the diagram, $\overline{TU}$ is a tangent to the circle, < RVU= 100^0 and < URS = 36^0. Calculate the value of angle STU.



5. In the figure, C is the centre of the circle, **< XYZ =** 15^0 and **< YCW =** 110^0.

Calculate < **ZNW.**



APPENDIX VII

MANUAL FOR THE USE OF CIRCLE GEOMETRY SOFTWARE PACKAGE (CiGoSPac)

INTRODUCTION

The CiGosPac covers only for major areas of circle Geometry theorems which are Twice angle, Semi-circle, Segment angle and Alternate segment. Below is how to use the CiGosPac in the teaching of Circle Geometry.

Caution

1. Ensure that you have a computer system to yourself.
2. Ensure that the volume of the computer is at the highest
3. Adjust the volume of the Audio Amplifier speakers if you need one to suit yourself.
4. Follow the direction provided to navigate through the package.

Suggested Teaching-Learning Time

Unit 1: Circle Components - 40 minutes

Unit 2: Circle Basic Facts } - 40 minutes
Unit 3: Notation

Unit 4: Circle Theorems - 2 hours 40 minutes

Circle Theorem I - 40 minutes

Circle Theorem II - 40 minutes

Circle Theorem III - 40 minutes

Circle Theorem IV - 40 minutes

However, learners are not restricted to follow the above strictly. They can exit at any time in the process of using the software.

A. General

1. Install at least Microsoft PowerPoint 2013 in a laptop computer/Desktop computer.
2. Install CiGosPac Mathematics software on the system.
3. Open CiGoSPac by clicking on it.
4. Set it on enable content, in case of compatibility.
5. Ensure that you start from Unit one, if this is your first time of using CiGosPac.

6. Follow the direction of the arrows provided to navigate through the package.
7. Ensure that you use the keyboard in typing on the blue box provided in Unit four.
8. Listen to the instructions / directions.
9. To exit at any point, press the escape (Esc) key or Red Button.

Unit 1. COMPONENTS OF A CIRCLE

1. Listen to the teaching on the Circle Components.
2. Repeating is allowed if not satisfied.
3. Click the directional arrow to move to the next page.
4. Answers the Recap questions on Circle Components.
5. Be ready for re-learning if your option is wrong.
6. Attempt the exercises.

Unit 2. NOTATIONS

1. Listen to common notations used in Circle theorem.
2. Click the directional arrow to move to the next page if satisfied.

Unit 3. CIRCLE BASIC FACTS

1. Listen to Circle basic facts.
2. Click the directional arrow to move to the next page if satisfied.
3. Answers the Recap questions on Circle basic facts.
4. Be ready for re-learning if your option is wrong.

Unit 4. CIRCLE THEOREMS

1. Listen to Circle theorems.
2. Listen to prove of the theorems.
3. Answers the Recap questions on the theorems.
4. Listen to the exercises.
5. Attempts the exercises by using the keyboard in typing your responses on blue box provided.
6. Listen to the Solutions to exercises.
7. To exit at any point, press the escape (Esc) key or Red Button.
8. Ensure that you attempt the Take Home Questions to reinforce your learning.

APPENDIX VIII

LESSON GUIDE FOR CONVENTIONAL METHOD (CONTROL GROUP)

SUBJECT: Mathematics

TOPIC: Circle Geometry

CLASS: SS2

REFERENCES

1. Macrae, M. F., Chima, Z. I., Garba, G. U., Ademosu, M. O. and Kalejaiye, A. O. (2011): New General Mathematics for West Africa SS2, 5ed. England: Pearson Education Ltd. Pg. 25 - 34, 126 – 135.
2. Ilori, S. A., Adeniran, S. A., Ibrahim, Y. G., Oyeniran, J. O., Ibironke, M. O and Chukwuma, R. N. (2010): Progressive Mathematics for SSS2. Lagos: Macmillian Nigeria Publishers Ltd.

DAILY LESSON PLAN I

PERIOD: 1st

DURATION: 40 Mins

SUB-TOPIC: Components of a Circle.

PREVIOUS KNOWLEDGE: Students are familiar with circular objects.

INSTRUCTIONAL OBJECTIVES: At the end of the lesson, students should be able to:

1. Define and name components of a circle (Circumference, Centre, Radius, Diameter, Arcs, Sector, Chord, Segments and Tangent).
2. Identify components of a Circle.

INSTRUCTIONAL MATERIALS: Chalkboard, Duster, Textbook, Chart showing components of a Circle and verbal illustration.

CONTENT

- Circle, Circumference, Centre, Radius, Diameter, Arc, Sector, Chord, Segments and Tangent.

PRESENTATION

Step I: The teacher introduces the lesson by telling students to mention different examples of a circular shape.

Step II: The teacher further explains lines and regions of a Circle.

Step III: The teacher defines the components using the chart.

Step IV: Students will be allowed to ask questions after which classwork will be given to them to do.

EVALUATION

1. The distance across the circle, dividing it into two equal halves is called ……….
2. If a man walk round a circle, he has covered the ……………..
3. A line drawn from the centre of a circle is called ……………
4. A line touching the circumference of a circle at a point is called …………

DAILY LESSON PLAN II

PERIOD: 2nd

DURATION: 40 Mins.

SUB-TOPIC: Circle Basic Facts

PREVIOUS KNOWLEDGE: Students have been taught components of a Circle.

INSTRUCTIONAL OBJECTIVES: At the end of the lesson, students should be able to:

1. Identify symbols (Notations) used in Circle theorems (angle, triangle, line, radius, perpendicular and parallel line).
2. Recall and apply Circle basic facts (Circle and Isosceles, Radius and Tangent, Chords, Exterior angle, Cyclic quadrilateral and Two tangents).

INSTRUCTIONAL MATERIALS: Chalkboard, Duster, Textbook, Charts showing Circle theorem symbols and Circle basic facts, and Verbal illustration.

CONTENT

- Notations used in Circle Theorem.
- Circle basic facts regarding:
    - (i) Circle and Isosceles
    - (ii) Radius and Tangent
    - (iii) Chords
    - (iv) Exterior angle
    - (v) Cyclic quadrilateral
    - (vi) Two Tangents

PRESENTATION

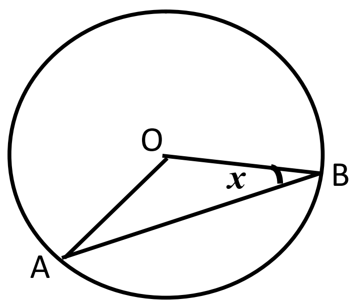
Step I: The teacher introduces the lesson by explaining the symbols used in denoting angle, triangle, line, radius, perpendicular and parallel line in Circle Theorem with the aid of Chart.

Step II: The teacher further explains Circle basic facts, one after the other with the aid of chart.

Step III: Students will be allowed to ask questions after which classwork will be given to them to do.

EVALUATION

1. .... angle equals two opposite interior angles.
2. Angles in opposite ……. are supplementary.
3. Given that O is the centre of the Circle and $\angle AOB = 118^0$, find x.



ASSIGNMENT

Draw them from the Textbook.

DAILY LESSON PLAN III

PERIOD: 3rd

DURATION: 40 Mins.

SUB-TOPIC: Circle Theorem I - Twice Angle

PREVIOUS KNOWLEDGE: Students have taught Circle basic facts.

INSTRUCTIONAL OBJECTIVES: At the end of the lesson, students should be able to:

1. State and recall the theorem – The angle subtended by an arc at the centre of a circle is twice the angle subtended at any point on the remaining part of the circumference (Twice Angle).

2. Prove Twice angle theorem.
3. Apply the Twice angle theorem in solving problems.

INSTRUCTIONAL MATERIALS: Chalkboard, Duster, Textbook, Chart showing different diagrams of Twice angle and Verbal illustrations.

CONTENT

- State Twice angle theorem (Angles at Centre $=2 \times$ angle of circumference).
- Prove Twice angle theorem.
- Apply twice angle theorem.

PRESENTATION

Step I: The teacher reviews the last lesson and allows the students to give corrections to the last assignments on board.

Step II: The teacher introduces the lesson by explaining the arc and circumference of a circle.

Step III: The teacher further state and prove the theorem Twice angle with the aid of chart.

Step IV: The teacher gives various examples relating to Twice angle.

Step V: Students will be allowed to ask questions after which classwork will be given to them to do.

EVALUATION

New General Mathematics SS2 (NGMSS2) Exercise 2b P*g*. 28 questions 1*a* and 1*e*.

ASSIGNMENT

New General Mathematics SS2 (NGMSS2) Exercise 2b P*g*. 28 questions 1*f*, 3 and 4.

DAILY LESSON PLAN IV

PERIOD: 4th

DURATION: 40 Mins.

SUB-TOPIC: Circle Theorem II - Semi-Circle

PREVIOUS KNOWLEDGE: Students have been taught theorems on Twice angle.

INSTRUCTIONAL OBJECTIVES: At the end of the lesson, students should be able to:

1. State and recall the theorem – The angle in a semi-circle is a right angle.
2. Prove Semi-Circle Theorem.
3. Apply the Semi-Circle theorem in solving problems.

INSTRUCTIONAL MATERIALS: Chalkboard, Duster, Textbook, Chart showing Semi-Circle diagrams and Verbal illustrations.

CONTENT

- State Semi-Circle theorem (Angle in a semicircle = 90^0).
- Prove Semi-Circle theorem.
- Apply Semi-Circle theorem.

PRESENTATION

Step I: The teacher reviews the last lesson and allows the students to provide corrections of the last assignment on the board.

Step II: The teacher introduces the lesson by explaining the meaning of semi-circle in a Circle and state its theorem with the aid of chart.

Step III: The teacher further prove the theorem relating to semi-circle with examples.

Step IV: Students will be allowed to ask questions after which classwork will be given to them to do.

EVALUATION

NGMSS2 Exercise 2c Pg. 30 questions 2 and 3.

ASSIGNMENT

NGMSS2 Exercise 2c Pg. 30 questions 4, 5 and 6.

DAILY LESSON PLAN V

PERIOD: 5^{th}

DURATION: 40 Mins

SUB-TOPIC: Circle Theorem III – Segment Angles

PREVIOUS KNOWLEDGE: Students have been taught theorem on Semi-Circle.

INSTRUCTIONAL OBJECTIVES: At the end of the lesson, students should be able to:

1. State and recall the theorem - Angles in the same segment of a circle are equal.
2. Prove Segment angles theorem.
3. Solve problems involving segment angles theorem.

INSTRUCTIONAL MATERIALS: Chalkboard, Duster, Textbook, Chart showing segment angles diagrams and verbal illustrations.

CONTENT

- State Segment angles theorem (Angles in the same segment of a circle are equal).
- Prove Segment angles theorem.
- Apply Segment angles theorem.

PRESENTATION

Step I: The teacher reviews the last lesson and provide corrections to the last assignment on the board.

Step II: The teacher introduces the lesson by explaining the meaning of segment and state segment angles theorem with aid of chart.

Step III: The teacher further prove the theorem relating to angles in the same segment with examples.

Step IV: Students will be allowed to ask questions after which classwork will be given to them to do.

EVALUATION

NGMSS2 Exercise 2c Pg. 30 question 1.

ASSIGNMENT

NGMSS2 Exercise 2c Pg. 30 questions 7 and 8.

DAILY LESSON PLAN VI

PERIOD: 6th

DURATION: 40 Mins.

SUB-TOPIC: Circle Theorem IV – Alternate Segment

PREVIOUS KNOWLEDGE: Students have been taught segment angles theorem.

INSTRUCTIONAL OBJECTIVES: At the end of the lesson, students should be able to:

1. State and recall the theorem – The angle between a tangent and a chord is equal to any angle in alternate (opposite) segment.
2. Prove Alternate segment theorem.
3. Solve problems involving Alternate segment theorem.

INSTRUCTIONAL MATERIALS: Chalkboard, Duster, Textbook, Chart showing Alternate segment diagrams and Verbal illustration.

CONTENT

- State Alternate segment theorem (The angle between a tangent and a chord is equal to any angle in alternate segment or Opposite angles of Cyclic quadrilateral are equal).
- Prove Alternate segment theorem.
- Apply Alternate segment theorem in solving problems.

PRESENTATION

Step I: The teacher reviews the last lesson and provide corrections to the last assignment.

Step II: The teacher introduces the lesson by explaining the properties with chart of:

- Cyclic quadrilateral as: Opposite angles are supplementary and Exterior angle = opposite interior angle.
- Contact to a Chord and alternate segment.

Step III: The teacher further state, prove and apply the theorem on alternate segment of a Circle.

Step IV: Students will be allowed to ask questions after which classwork will be given to them to do.

EVALUATION

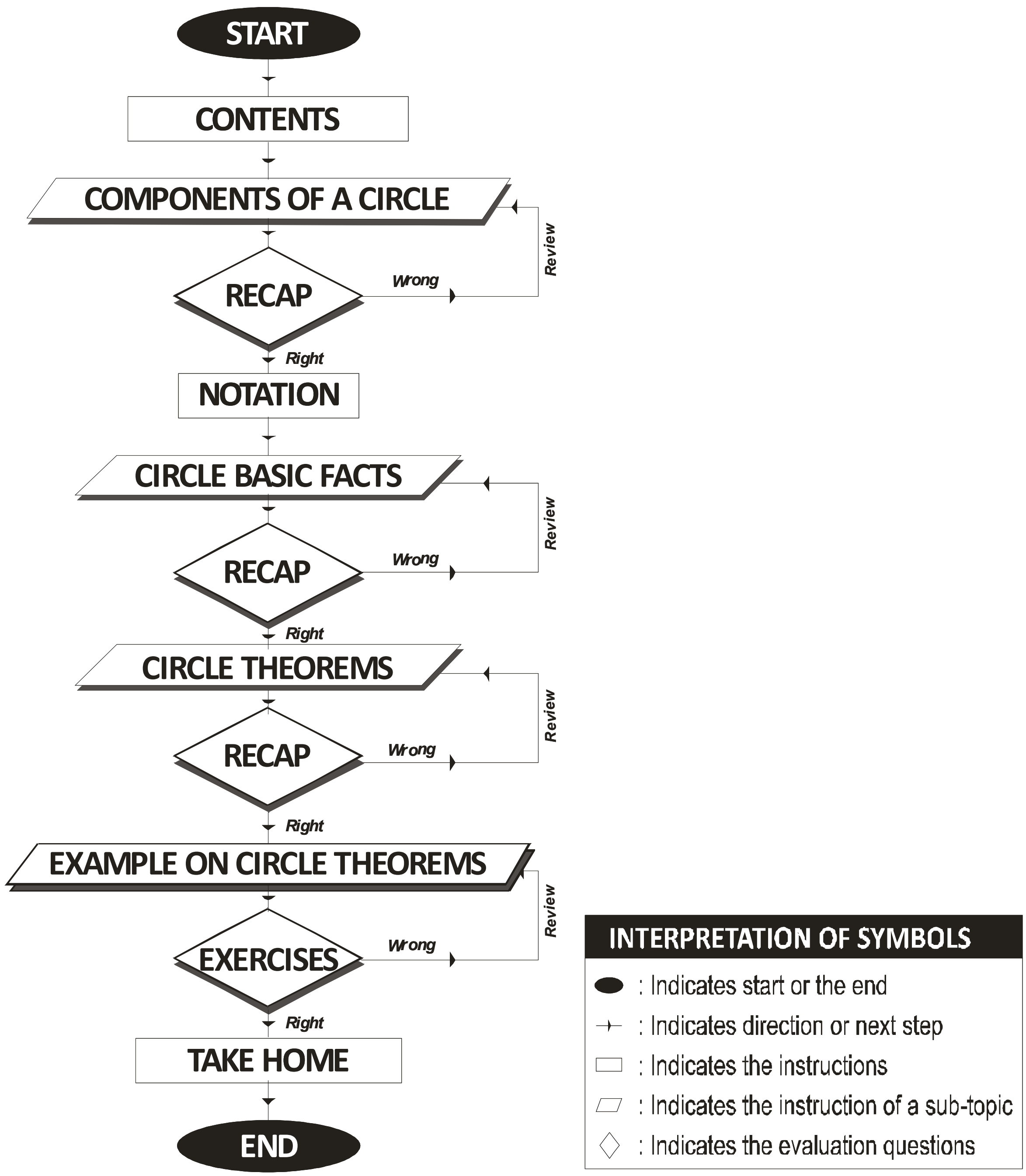
NGMSS2 Exercise 12d Pg. 132 questions 1, 4 and 7.

ASSIGNMENT

NGMSS2 Exercise 12d Pg. 132 questions 8, 9 and 10.

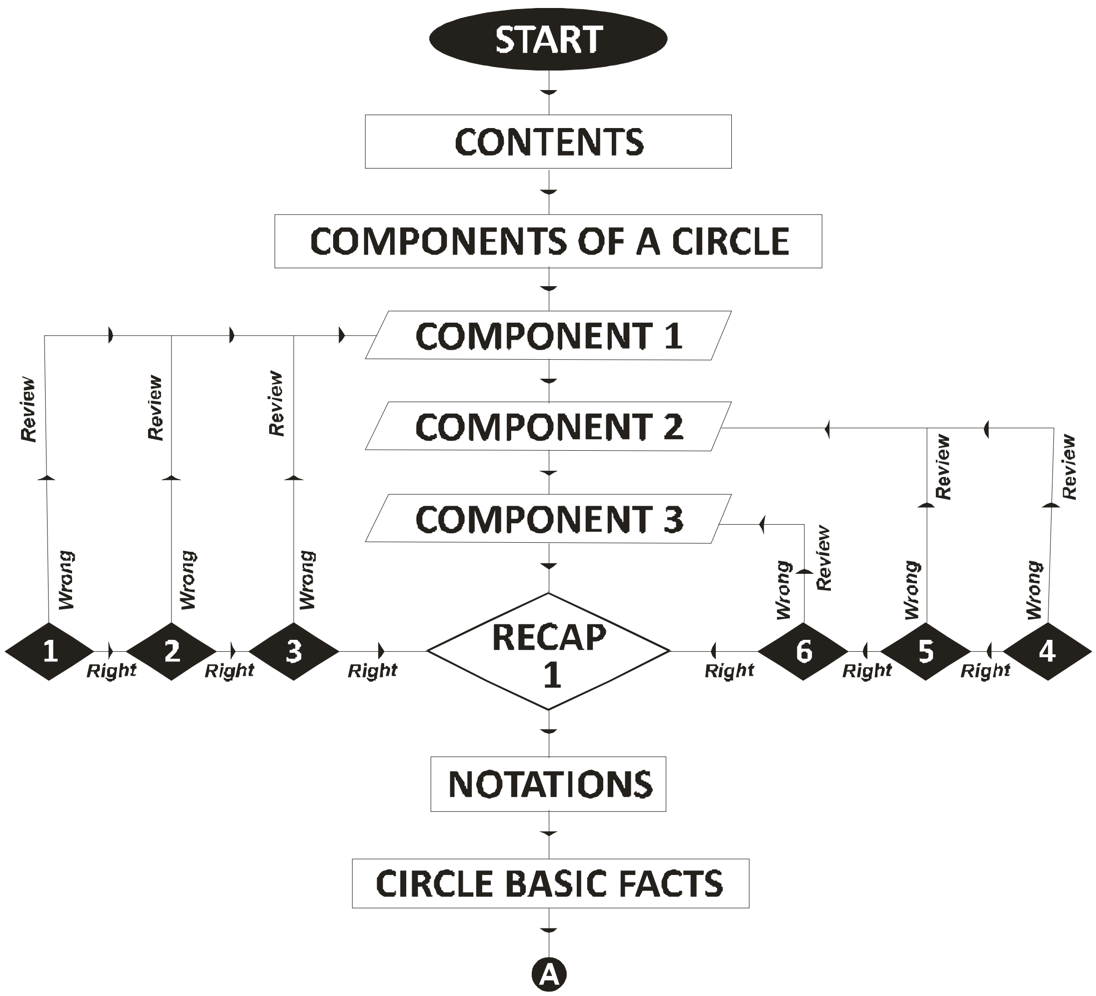
APPENDIX IX

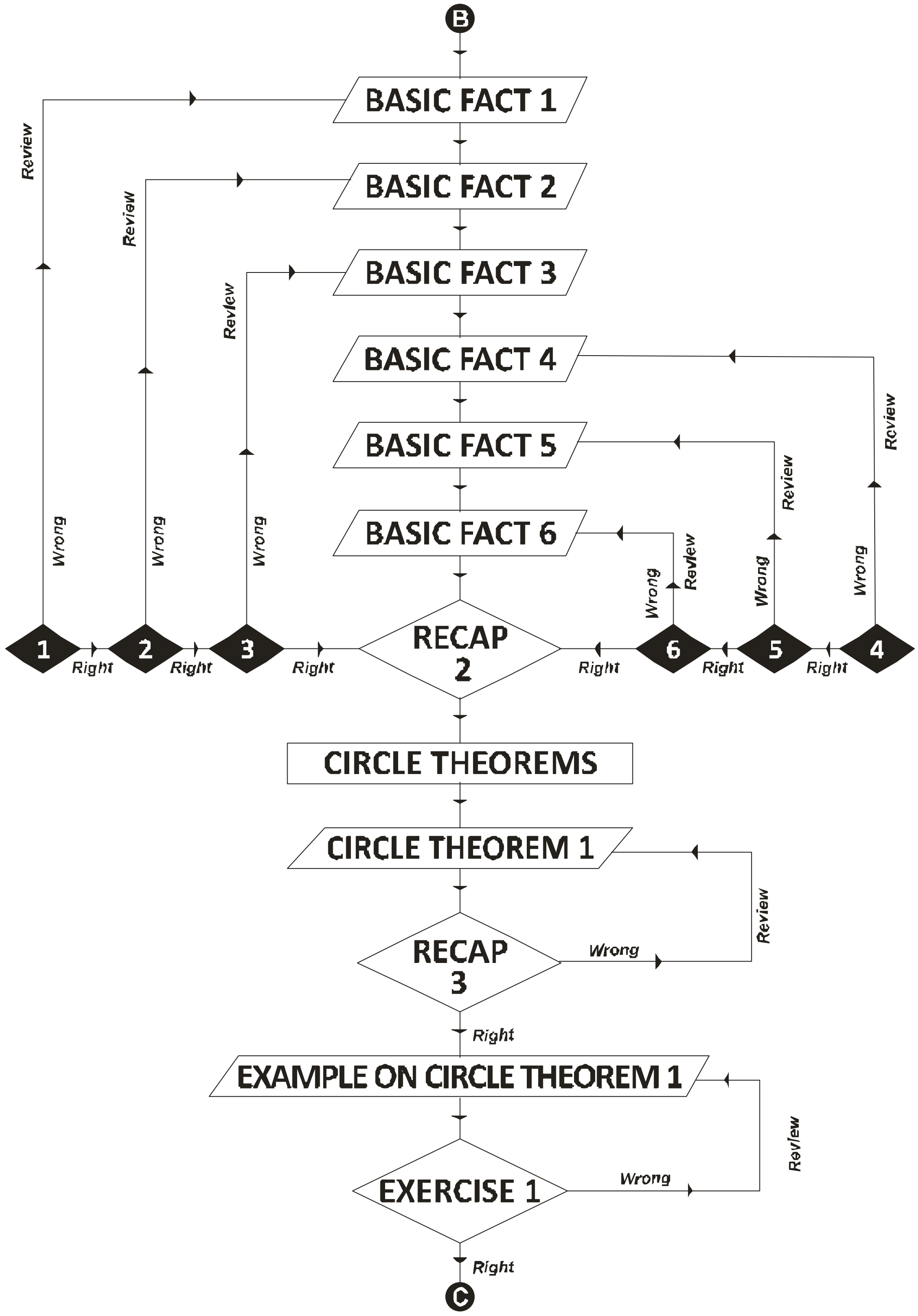
SIMPLE FLOW CHART FOR CIRCLE GEOMETRY SOFTWARE PACKAGE (CiGoSPac) FOR CIRCLE GEOMETRY

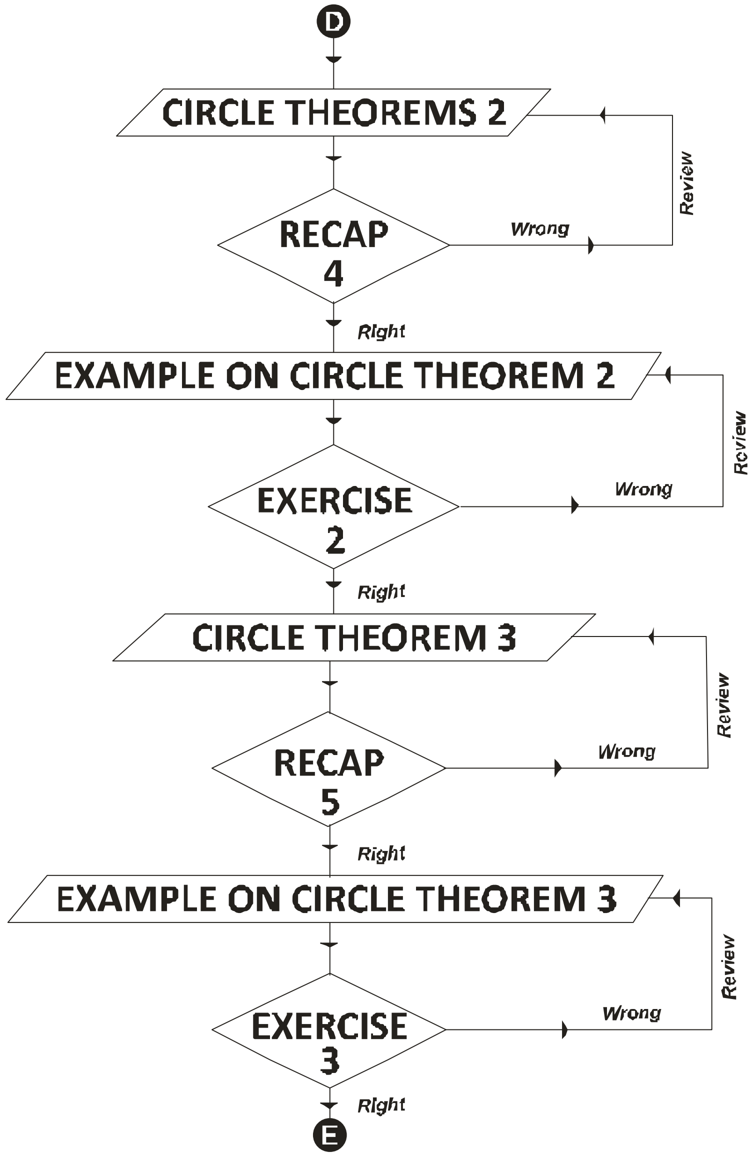


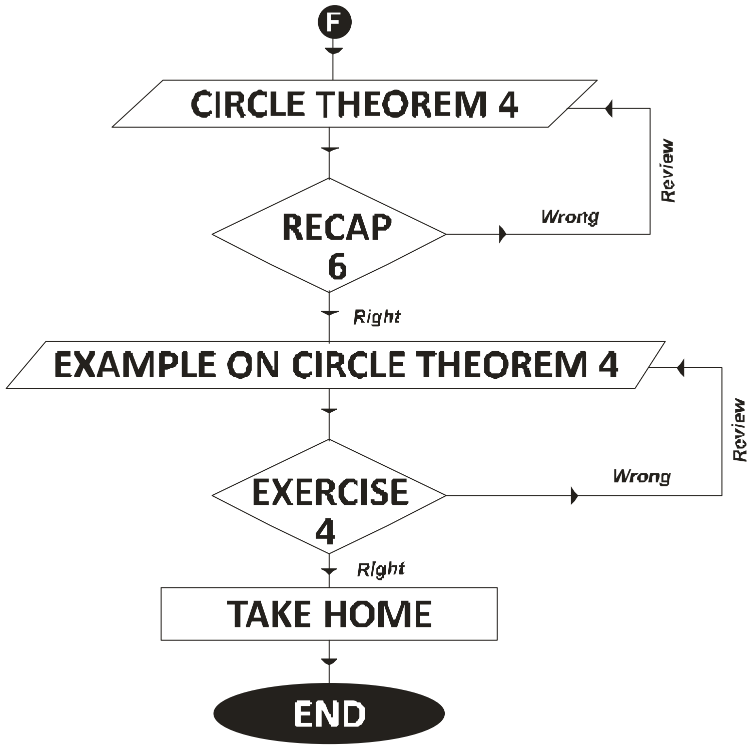
APPENDIX X

EXPONENTIAL SUB-SYSTEM FLOW CHART FOR CIRCLE GEOMETRY SOFTWARE PACKAGE (CiGoSPac) FOR CIRCLE GEOMETRY




B
BASIC FACT 1
BASIC FACT 2
BASIC FACT 3
BASIC FACT 4
BASIC FACT 5
BASIC FACT 6
RECAP 2
1
2
3
4
5
6
Review
Wrong
Right
CIRCLE THEOREMS
CIRCLE THEOREM 1
RECAP 3
EXAMPLE ON CIRCLE THEOREM 1
EXERCISE 1
C


D
CIRCLE THEOREMS 2
RECAP 4
Wrong
Review
Right
EXAMPLE ON CIRCLE THEOREM 2
EXERCISE 2
Wrong
Review
Right
CIRCLE THEOREM 3
RECAP 5
Wrong
Review
Right
EXAMPLE ON CIRCLE THEOREM 3
EXERCISE 3
Wrong
Review
Right
E



INTERPRETATION OF SYMBOLS

: Indicates start or the end
: Indicates direction or next step
: Indicates the instructions
: Indicates the instruction of a sub-topic
: Indicates the evaluation questions
: Indicates the connectives

APPENDIX XI

PRE- TEST CIRCLE GEOMETRY ACHIEVEMENT TEST (PeCGAT)

MARKING SCHEME

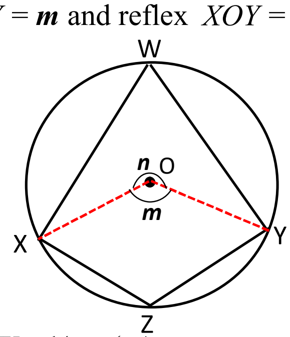
OBJECTIVE

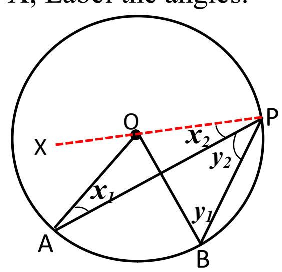
1.**A**	6.**A**	11.**C**	16.**C**	21.**C**	26.**B**
2.**B**	7.**B**	12.**A**	17.**D**	22.**D**	27.**B**
3.**C**	8.**B**	13.**C**	18.**A**	23.**C**	28.**B**
4.**B**	9.**A**	14.**A**	19.**C**	24.**C**	29.**D**
5.**C**	10.**C**	15.**B**	20.**A**	25.**C**	30.**B**

1 mark each × 30 = 30 marks

THEORY

S/N	DETAILED SOLUTION	ALLOCATION OF MARKS	MARKS
1.	$U\hat{S}T = R\hat{V}U = 100^0$ (ext. angle of a cyclic quad.) $\angle SUT = \angle URS = 36^0$ (angle in alternate segment) $36^0 + 100^0 + \angle STU = 180^0$ (sum of angle of a triangle) $\angle STU = 180^0 - 136^0 = 44^0$	**B_1** for $U\hat{S}T = 100^0$ **B_1** for $\angle SUT = 36^0$ **B_1** for applying sum angle of a triangle. **M_1** for solving **A_1** for $\angle STU = 44^0$	**5**
2.	Since |CZ| = |CY|, <CZY = <CYZ = 15^0 (Base < of Isos Δ) $\angle ZCW + \angle WCY + \angle CYZ + \angle CZY = 180^0$ (Sum angles of a Δ) $\angle ZCW = 180^0 - 15^0 - 15^0 - 110^0 = 40^0$ $\angle ZCW = 2(\angle ZNW)$ ($\angle$ at centre is twice at circumference) $\angle ZNW = 40^0 / 2 = 20^0$	**B_1** for $C\hat{Z}Y = C\hat{Y}Z = 15^0$ **B_1** for applying sum angle of a triangle. **M_1** for solving **A_1** for $Z\hat{C}W = 40^0$ **B_1** for $Z\hat{N}W = 20^0$	**5**

3.	$R\hat{S}Q = R\hat{P}Q = 48^0$ ($\angle$ in same segment) $S\hat{Q}R = R\hat{S}Q = 48^0$ (Base $\angle$ s Isos. Δ) $P\hat{R}Q + P\hat{R}S + S\hat{Q}R + R\hat{S}Q = 180^0$ (Sum angles of a Δ) $P\hat{R}Q = 180^0 - 65^0 - 48^0 - 48^0 = 19^0$	**B$_1$** for $R\hat{S}Q = R\hat{P}Q = 48^0$ **B$_2$** for $S\hat{Q}R = R\hat{S}Q = 48^0$ **B$_1$** for applying sum angle of a triangle. **M$_1$** for solving **A$_1$** for $P\hat{R}Q = 19^0$	**5**
4.	$C\hat{B}D = 2x = 2(35^0) = 70^0$ $A\hat{E}D = 180^0 - C\hat{B}D$ (Opp. $\angle$ s Cyclic. Quad.) $= 180^0 - 70^0 = 110^0$ $A\hat{E}B = 90^0$ ($\angle$ in a semi-circle) **y** $= A\hat{E}D - A\hat{E}B = 110^0 - 90^0 = 20^0$ In Δ $A\hat{E}B$, $x + z + A\hat{E}B = 180^0$ $z = 180^0 - 90^0 - 35^0 = 55^0$	**B$_1$ A$_1$** for $C\hat{B}D = 70^0$ **B$_1$** for applying opposite angle of a Cyclic quad are supplementary. **M$_1$** for solving **A$_1$** for $A\hat{E}D = 110^0$ **B$_1$** for $A\hat{E}B = 90^0$ **M$_1$** for solving **A$_1$** for **y** $= 20^0$ **M$_1$** for solving **A$_1$** for $z = 55^0$	**10**
5 a	**<u>Given</u>**: A Circle XYZW with centre O. **<u>To prove</u>**: $X\hat{W}Y + X\hat{Z}Y = 180^0$ **<u>Construction</u>**: Join OX, OY and label angles $X\hat{O}Y = \boldsymbol{m}$ and reflex $X\hat{O}Y = \boldsymbol{n}$  **<u>Proof</u>**: $X\hat{W}Y = ½\,\boldsymbol{m}$ ($\angle$ at centre is twice at circumference)	**B$_1$** for stating what is given. **B$_1$** for stating what to prove. **B$_1$** for drawing circle and joining of lines. **B$_1$** for labeling either $X\hat{O}Y = \boldsymbol{m}$ or reflex $X\hat{O}Y = \boldsymbol{n}$ (equiv). **B$_1$** for applying $\angle$ at centre is twice at circumference **B$_1$** for $X\hat{W}Y = ½\,\boldsymbol{m}$ or	**10**

	$X\hat{Z}Y = \frac{1}{2}\,\boldsymbol{n}$ ($\angle$ at centre is twice at circumference) ∴ $X\hat{W}Y + X\hat{Z}Y = \frac{1}{2}(\boldsymbol{m} + \boldsymbol{n})$ But $\boldsymbol{m} + \boldsymbol{n} = 360^0$ (angles at a point) ∴ $X\hat{W}Y + X\hat{Z}Y = \frac{1}{2}(360^0)$ $X\hat{W}Y + X\hat{Z}Y = 180^0$ (Proved)	$X\hat{Z}Y = \frac{1}{2}\,\boldsymbol{n}$ **B$_1$** for adding **B$_1$** for applying angles at a point is 360^0 **M$_1$** for resolving **A$_1$** for $X\hat{W}Y + X\hat{Z}Y = 180^0$	
5b	**<u>Given</u>**: ABP is an arc of a Circle centre O. P is any point on the remaining arc. **<u>To prove</u>**: $A\hat{O}B = 2\,(A\hat{P}B)$ **<u>Construction</u>**: Join PO and produce it to any point X, Label the angles.  **<u>Proof</u>**: $\|OA\| = \|OP\|$ (radii) $x_1 = x_2$ (base angles of Isos.Δ) $A\hat{O}X = x_1 + x_2$ (ext. angle of Δ AOP) $A\hat{O}X = 2x_2$ ($x_1 = x_2$) Similarly, $B\hat{O}X = 2y_2$ ($y_1 = y_2$) $A\hat{O}B = B\hat{O}X - A\hat{O}X$ $A\hat{O}B = 2y_2 - 2x_2$ $A\hat{O}B = 2(y_2 - x_2)$ $A\hat{O}B = 2(A\hat{P}B)$ (Proved)	**B$_1$** for stating what is given. **B$_1$** for stating what to prove. **B$_1$** for drawing circle and joining of line produce at X. **B$_1$** for labeling the angles (equiv). **B$_1$** for $\|OA\| = \|OP\|$ (radii) **B$_1$** for applying base angles of Isos.Δ. **B$_1$** for $x_1 = x_2$ **B$_1$** for applying ext. angle of Δ AOP. **B$_1$** for $A\hat{O}X = x_1 + x_2$ **M$_1$** for resolving **A$_1$** for $A\hat{O}X = 2x_2$ **B$_1$** for $B\hat{O}X = 2y_2$ **B$_1$** for correct substitution $A\hat{O}B = 2y_2 - 2x_2$ **B$_1$** for factorization $A\hat{O}B = 2(y_2 - x_2)$ **B$_1$** for $A\hat{O}B = 2(A\hat{P}B)$	**15** **50**

APPENDIX XII

POST- TEST CIRCLE GEOMETRY ACHIEVEMENT TEST (PoCGAT)

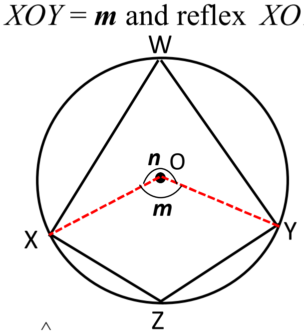
MARKING SCHEME

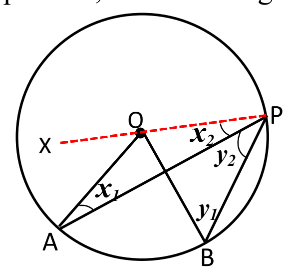
OBJECTIVE

1.**A**	6.**D**	11.**C**	16.**B**	21.**A**	26.**D**
2.**A**	7.**B**	12.**A**	17.**B**	22.**C**	27.**A**
3.**C**	8.**C**	13.**C**	18.**C**	23.**B**	28.**C**
4.**D**	9.**B**	14.**C**	19.**A**	24.**A**	29.**B**
5.**B**	10.**C**	15.**B**	20.**C**	25.**B**	30.**C**

1 mark each × 30 = 30 marks

<u>THEORY</u>

S/N	DETAILED SOLUTION	ALLOCATION OF MARKS	MARKS
1a	**<u>Given</u>**: A Circle XYZW with centre O. **<u>To prove</u>**: $X\hat{W}Y + X\hat{Z}Y = 180^0$ **<u>Construction</u>**: Join OX, OY and label angles $X\hat{O}Y = \boldsymbol{m}$ and reflex $X\hat{O}Y = \boldsymbol{n}$  **<u>Proof</u>**: $X\hat{W}Y = ½\,\boldsymbol{m}$ ($\angle$ at centre is twice at circumference) $X\hat{Z}Y = ½\,\boldsymbol{n}$ ($\angle$ at centre is twice at circumference) $\therefore\ X\hat{W}Y + X\hat{Z}Y = ½\,(\boldsymbol{m} + \boldsymbol{n})$ But $\boldsymbol{m} + \boldsymbol{n} = 360^0$ (angles at a	**B_1** for stating what is given. **B_1** for stating what to prove. **B_1** for drawing circle and joining of lines. **B_1** for labeling either $X\hat{O}Y = \boldsymbol{m}$ or reflex $X\hat{O}Y = \boldsymbol{n}$ (equiv). **B_1** for applying $\angle$ at centre is twice at circumference **B_1** for $X\hat{W}Y = ½\,\boldsymbol{m}$ or $X\hat{Z}Y = ½\,\boldsymbol{n}$ **B_1** for adding **B_1** for applying angles at a	**10**

	point) $\therefore \hat{XWY} + \hat{XZY} = \frac{1}{2}(360^0)$ $\hat{XWY} + \hat{XZY} = 180^0$ (Proved)	point is 360^0 **M_1** for resolving **A_1** for $\hat{XWY} + \hat{XZY} =$ 180^0	
b	**<u>Given</u>**: ABP is an arc of a Circle centre O. P is any point on the remaining arc. **<u>To prove</u>**: $\hat{AOB} = 2(\hat{APB})$ **<u>Construction</u>**: Join PO and produce it to any point X, Label the angles.  **<u>Proof</u>**: |OA| = |OP| (radii) $x_1 = x_2$ (base angles of Isos.Δ) $\hat{AOX} = x_1 + x_2$ (ext. angle of Δ AOP) $\hat{AOX} = 2x_2$ $(x_1 = x_2)$ Similarly, $\hat{BOX} = 2y_2$ $(y_1 = y_2)$ $\hat{AOB} = \hat{BOX} - \hat{AOX}$ $\hat{AOB} = 2y_2 - 2x_2$ $\hat{AOB} = 2(y_2 - x_2)$ $\hat{AOB} = 2(\hat{APB})$ (Proved)	**B_1** for stating what is given. **B_1** for stating what to prove. **B_1** for drawing circle and joining of line produce at X. **B_1** for labeling the angles (equiv). **B_1** for |OA| = |OP| (radii) **B_1** for applying base angles of Isos.Δ. **B_1** for $x_1 = x_2$ **B_1** for applying ext. angle of Δ AOP. **B_1** for $\hat{AOX} = x_1 + x_2$ **M_1** for resolving **A_1** for $\hat{AOX} = 2x_2$ **B_1** for $\hat{BOX} = 2y_2$ **B_1** for correct substitution $\hat{AOB} = 2y_2 - 2x_2$ **B_1** for factorization $\hat{AOB} = 2(y_2 - x_2)$ **B_1** for $\hat{AOB} = 2(\hat{APB})$	**15**
2.	$\hat{RSQ} = \hat{RPQ} = 48^0$ (∠ in same segment)	**B_1** for $\hat{RSQ} = \hat{RPQ} = 48^0$	

	$S\hat{Q}R = R\hat{S}Q = 48^0$ (Base $\angle$ s Isos. Δ) $P\hat{R}Q + P\hat{R}S + S\hat{Q}R + R\hat{S}Q = 180^0$ (Sum angles of a Δ) $P\hat{R}Q = 180^0 - 65^0 - 48^0 - 48^0 = 19^0$	**B₂** for $S\hat{Q}R = R\hat{S}Q = 48^0$ **B₁** for applying sum angle of a triangle. **M₁** for solving **A₁** for $P\hat{R}Q = 19^0$	**6**
3.	$C\hat{B}D = 2x = 2(35^0) = 70^0$ $A\hat{E}D = 180^0 - C\hat{B}D$ (Opp. $\angle$ s Cyclic. Quad.) $= 180^0 - 70^0 = 110^0$ $A\hat{E}B = 90^0$ ($\angle$ in a semi-circle) **y** $= A\hat{E}D - A\hat{E}B = 110^0 - 90^0 = 20^0$ In Δ $A\hat{E}B$, $x + z + A\hat{E}B = 180^0$ $z = 180^0 - 90^0 - 35^0 = 55^0$	**B₁ A₁** for $C\hat{B}D = 70^0$ **B₁** for applying opposite angle of a Cyclic quad are supplementary. **M₁** for solving **A₁** for $A\hat{E}D = 110^0$ **B₁** for $A\hat{E}B = 90^0$ **M₁** for solving **A₁** for **y** $= 20^0$ **M₁** for solving **A₁** for $z = 55^0$	**9**
4.	$U\hat{S}T = R\hat{V}U = 100^0$ (ext. angle of a cyclic quad.) $\angle SUT = \angle URS = 36^0$ (angle in alternate segment) $36^0 + 100^0 + \angle STU = 180^0$ (sum of angle of a triangle) $\angle STU = 180^0 - 136^0 = 44^0$	**B₁** for $U\hat{S}T = 100^0$ **B₁** for $\angle SUT = 36^0$ **B₁** for applying sum angle of a triangle. **M₁** for solving **A₁** for $\angle STU = 44^0$	**5**
5.	Since |CZ| = |CY|, <CZY = <CYZ = 15^0 (Base < of Isos Δ) $\angle ZCW + \angle WCY + \angle CYZ + \angle CZY = 180^0$ (Sum angles of a Δ)	**B₁** for $C\hat{Z}Y = C\hat{Y}Z = 15^0$ **B₁** for applying sum angle of a triangle. **M₁** for solving **A₁** for $Z\hat{C}W = 40^0$	**5**

	$\angle ZCW = 180^0 - 15^0 - 15^0 - 110^0 = 40^0$ $\angle ZCW = 2(\angle ZNW)$ ($\angle$ at centre is twice at circumference) $\angle ZNW = 40^0 / 2 = 20^0$	$\mathbf{B_1}$ for $Z\hat{N}W = 20^0$	**50**

APPENDIX XIII

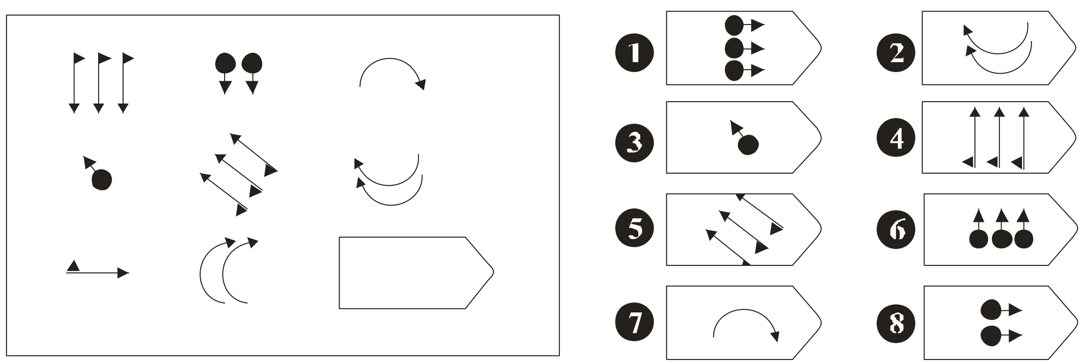
PERCEPTUAL REASONING ABILITY TEST (PRAT)

INTRODUCTION

This test assesses how easily you can reason with symbols and shapes. After each question there are six or eight options. When you have found the correct answer tick (√) on the number which correspond to it on the answer sheet provided.

The full test begins on page three. Examine the example first to be able to do the test. Now do as much as you can do.

EXAMPLE:

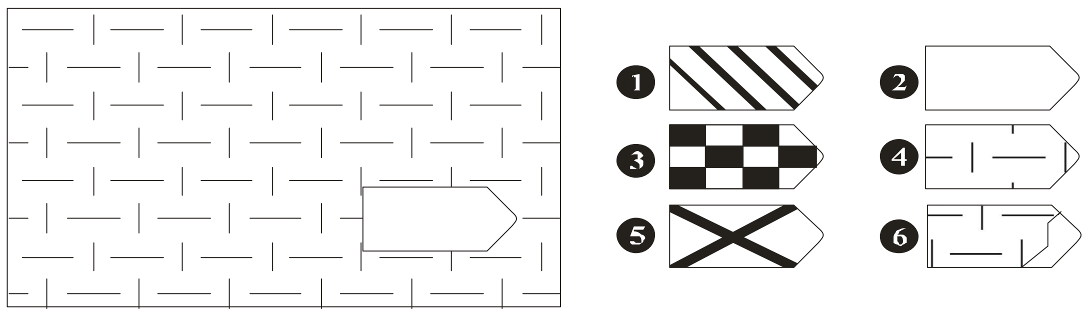


ANSWER:

	Options							
	1	2	3	4	5	6	7	8
EXAMPLE	√							

SET A

A1



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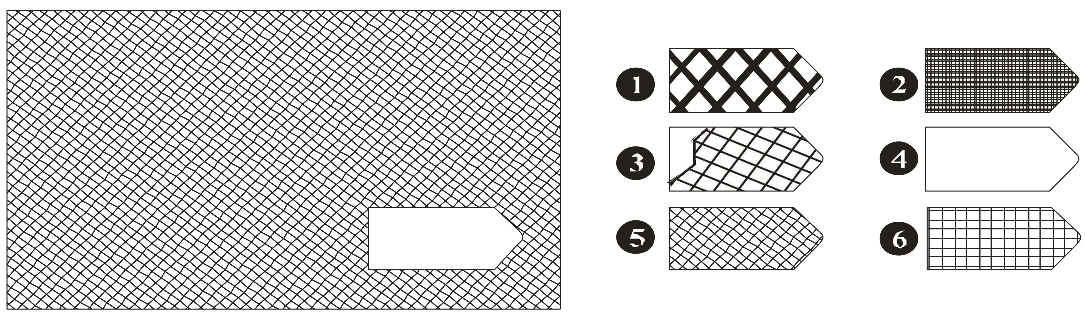

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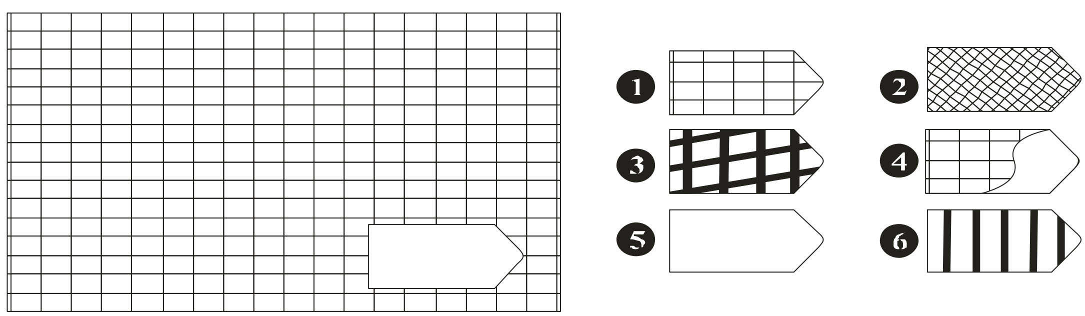

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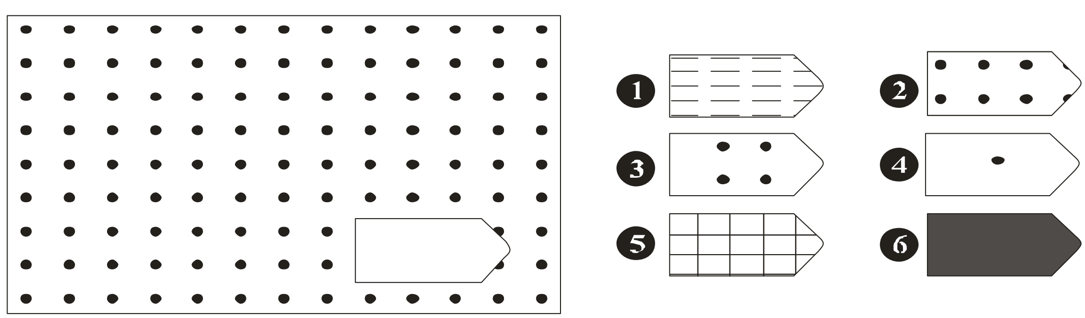
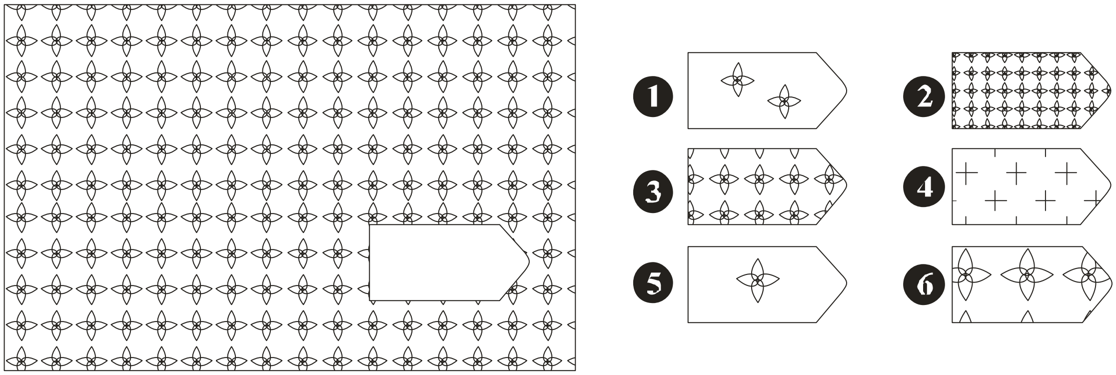


SET A

A5



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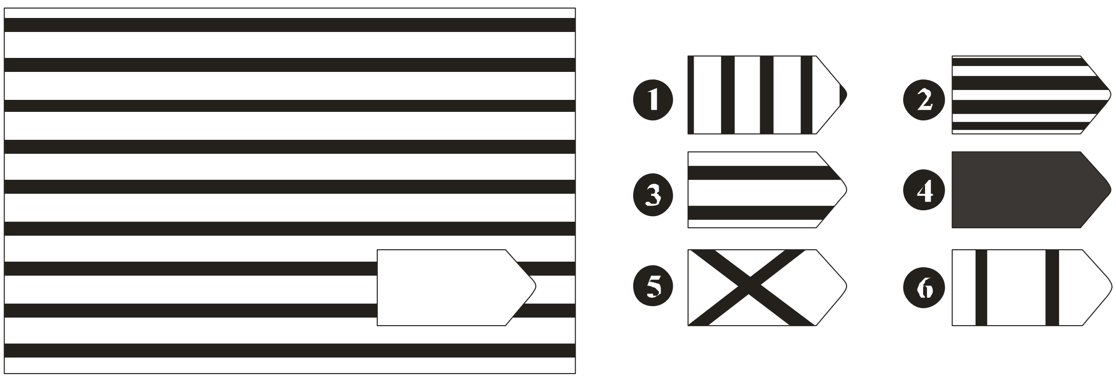

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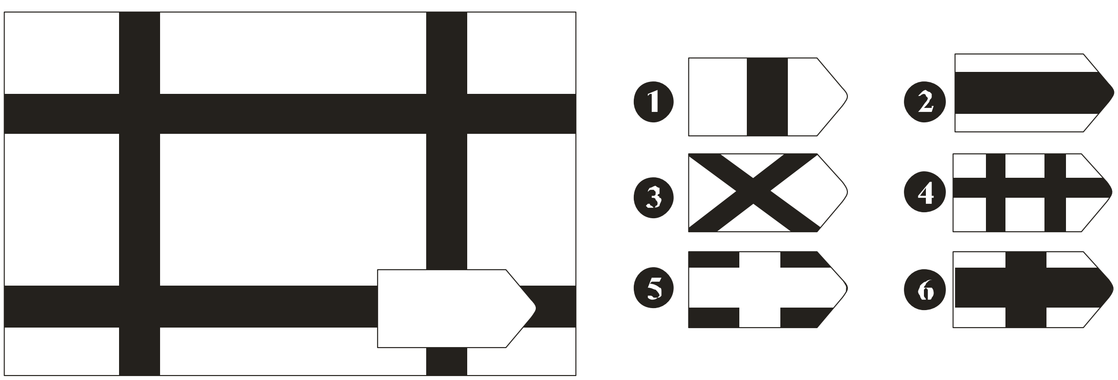

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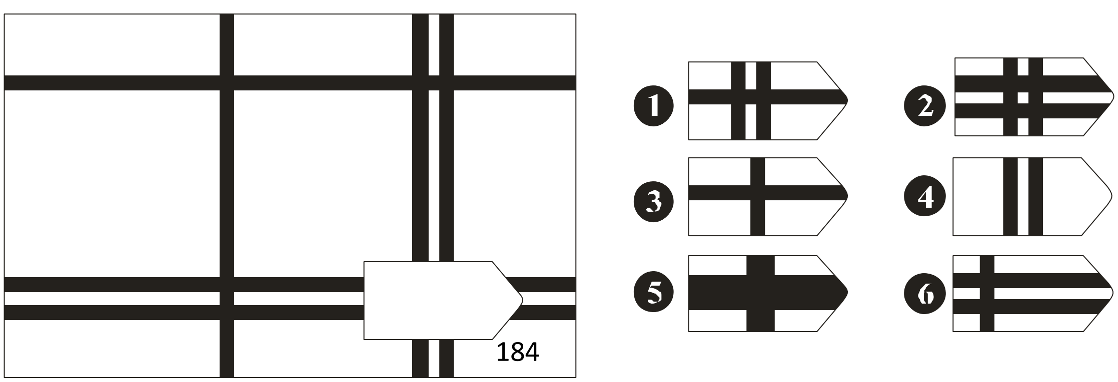
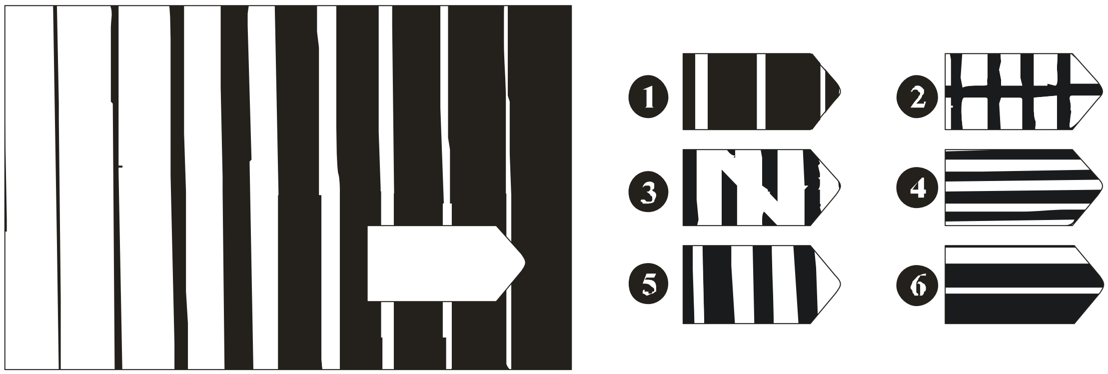


SET A

A9



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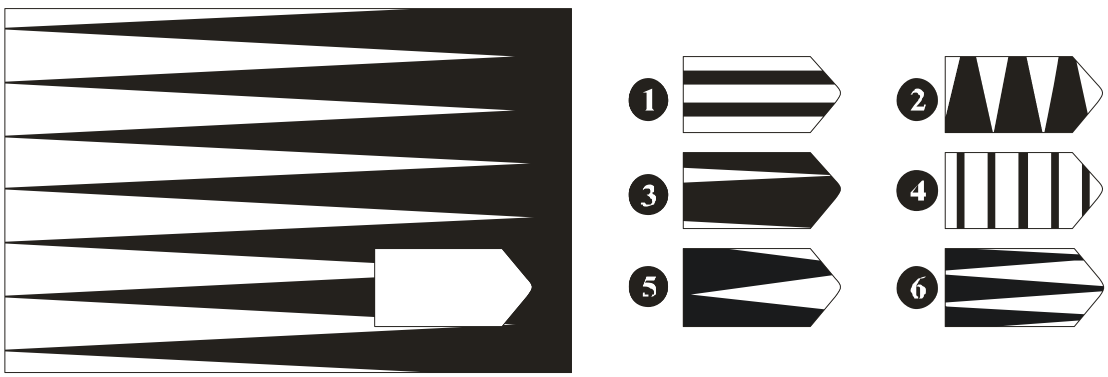

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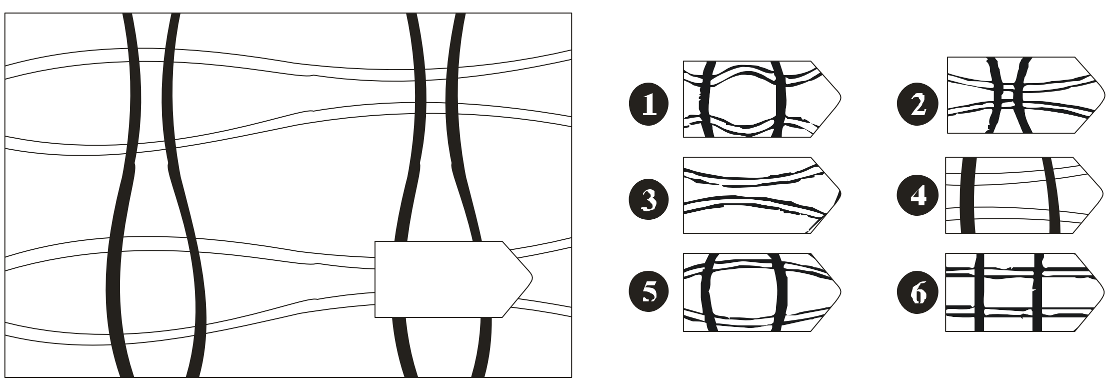

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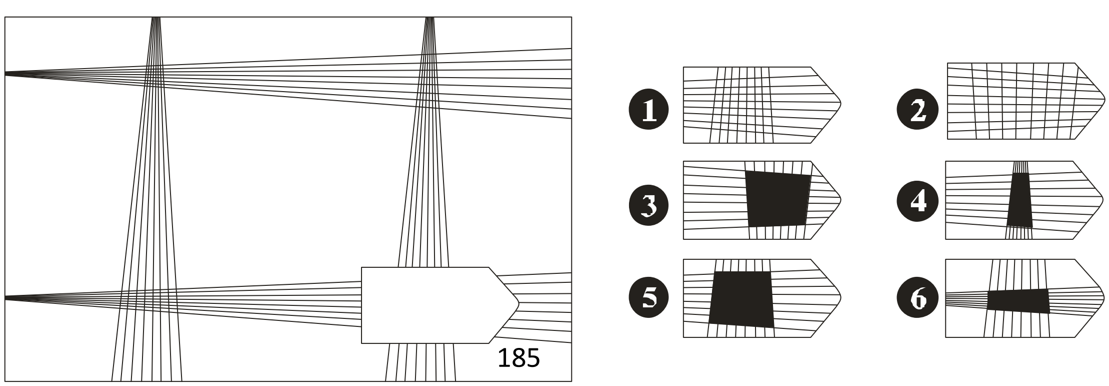

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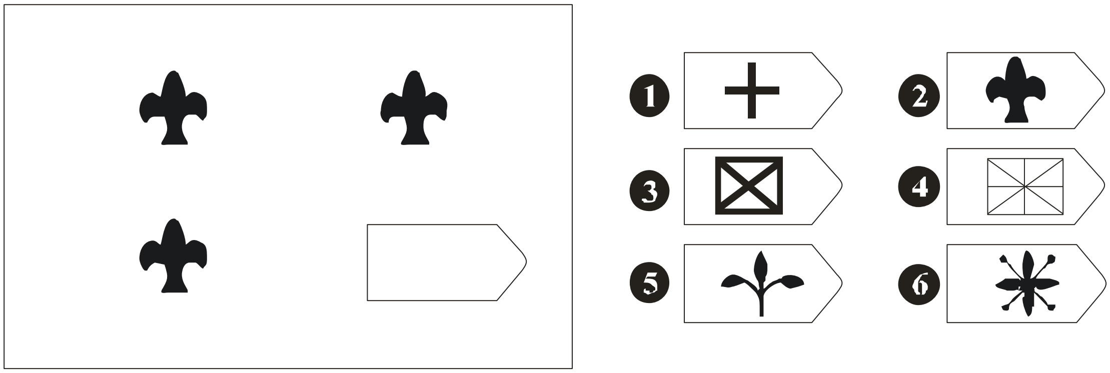

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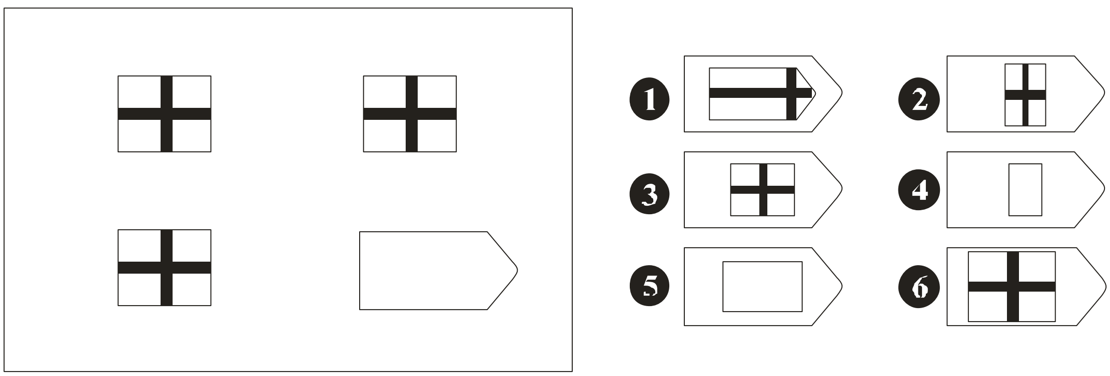

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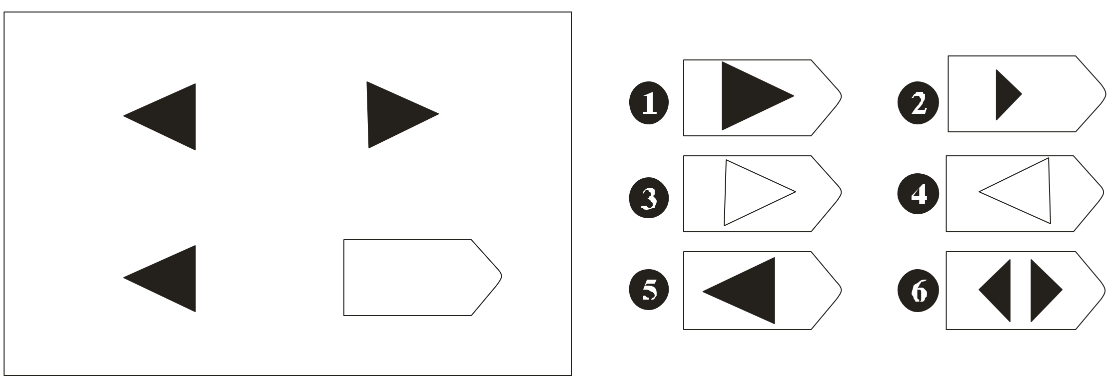

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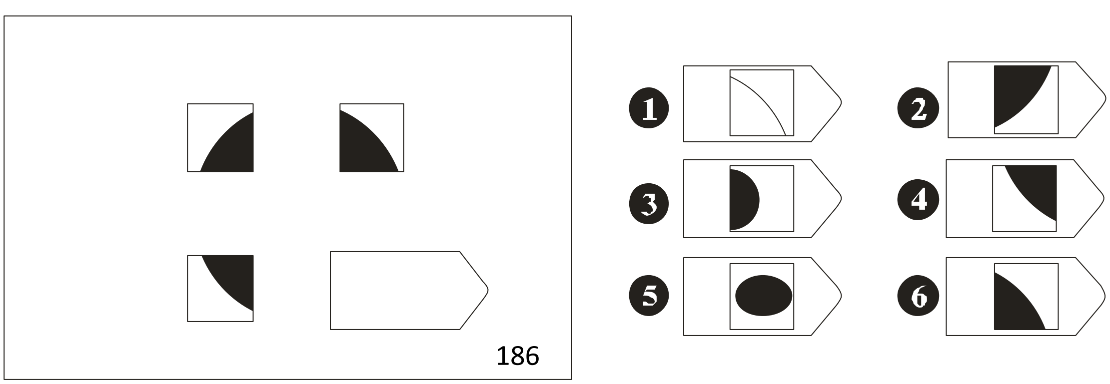

SET B

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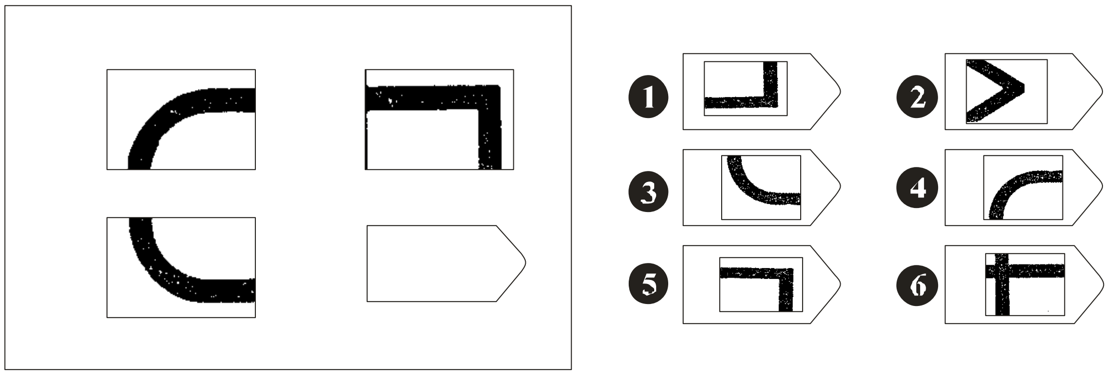

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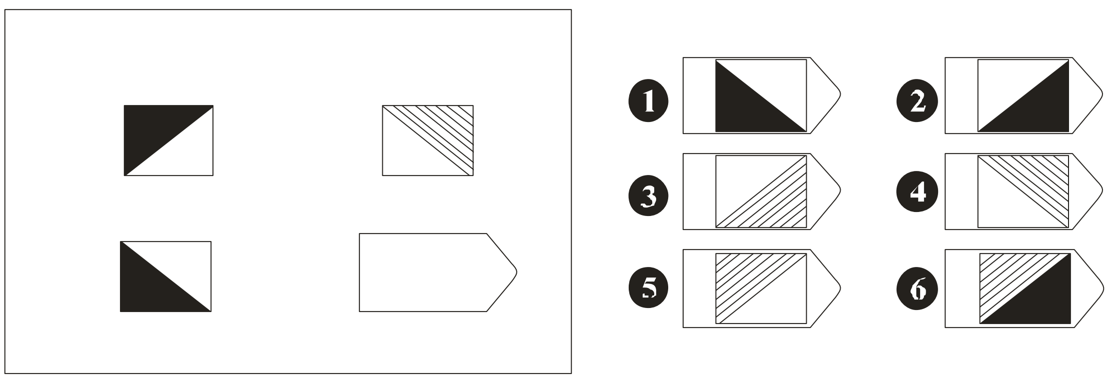

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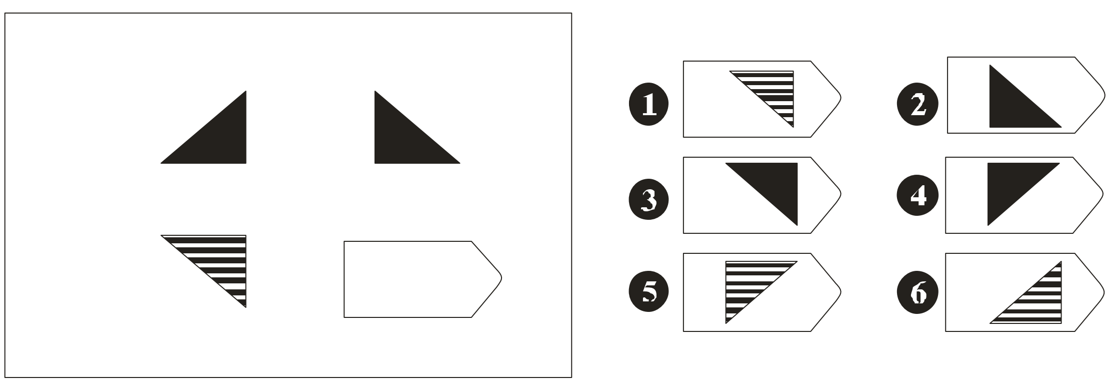

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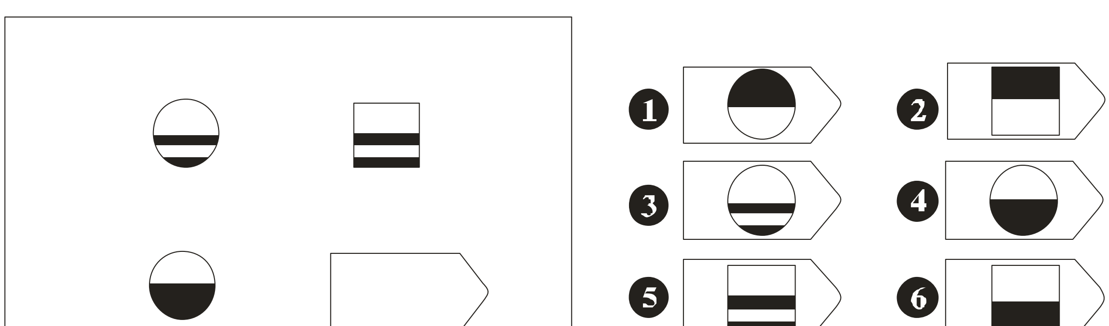

SET B

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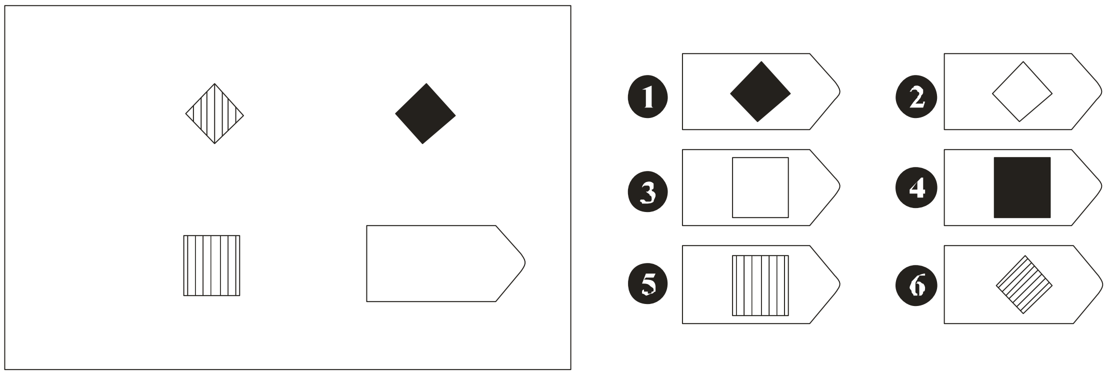

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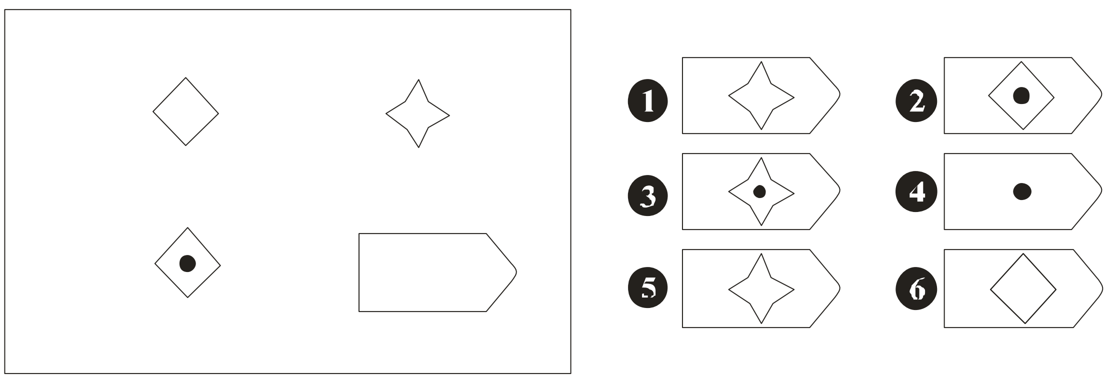

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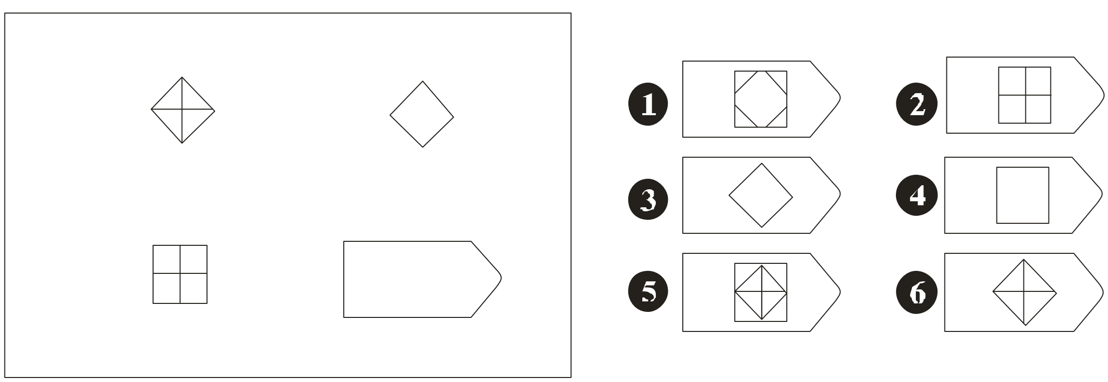

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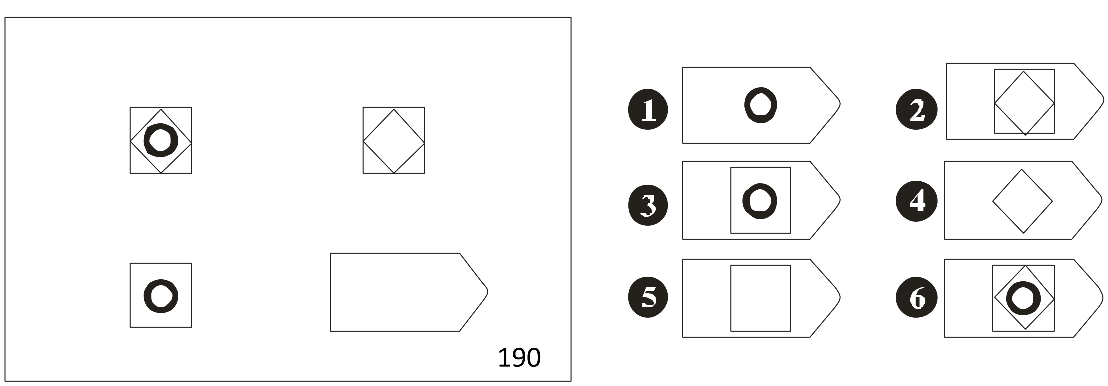

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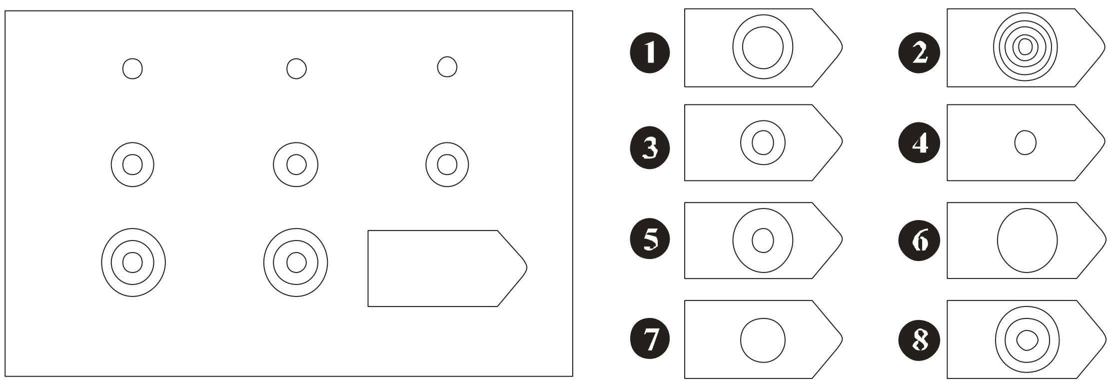

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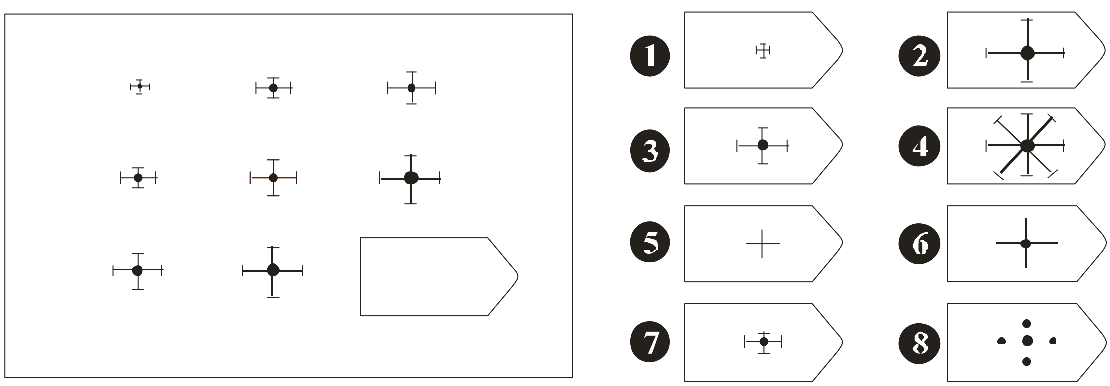

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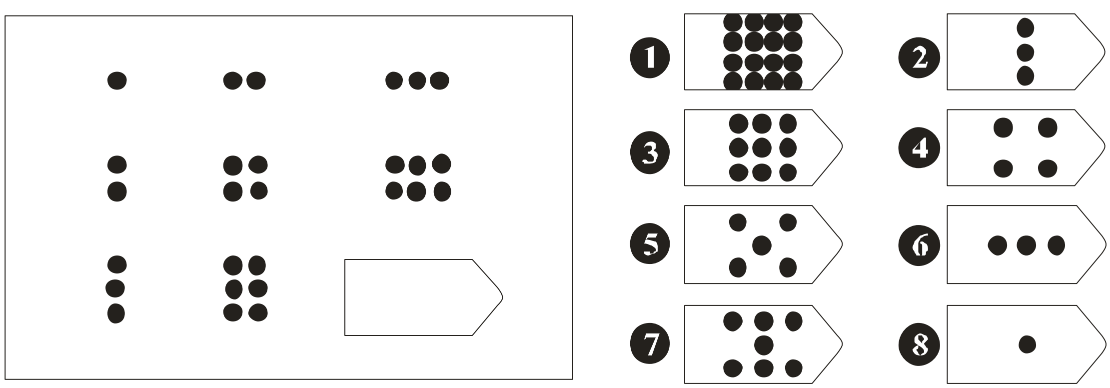

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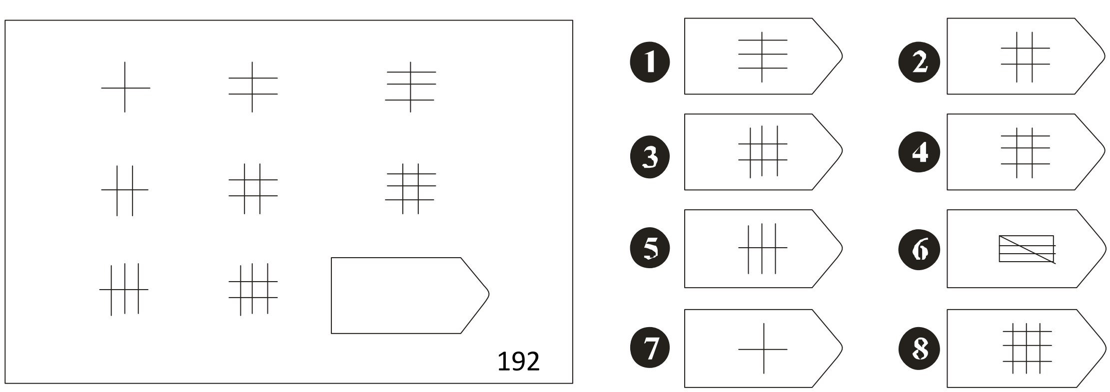

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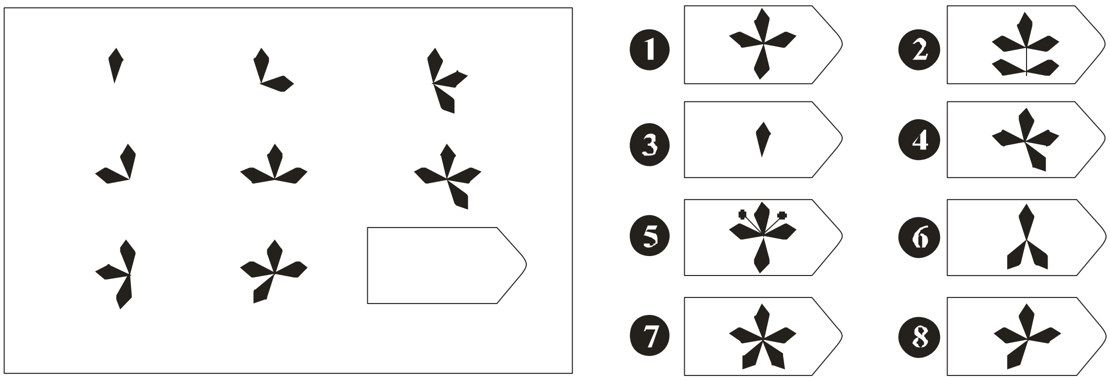

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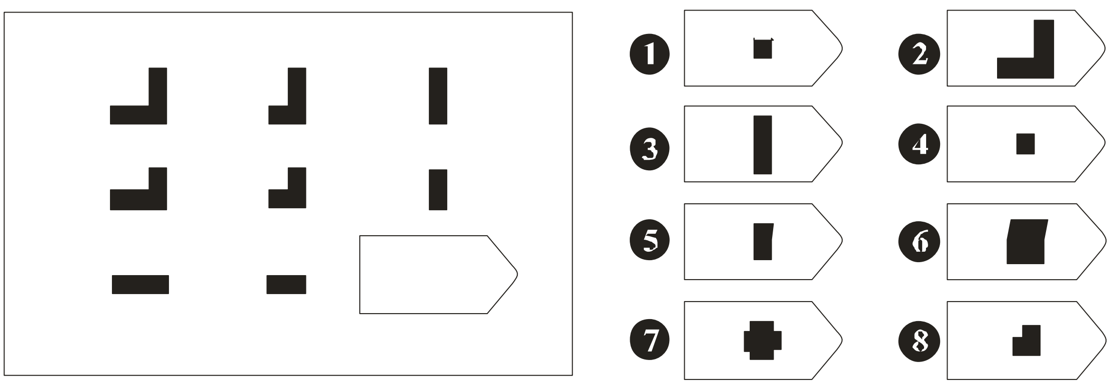

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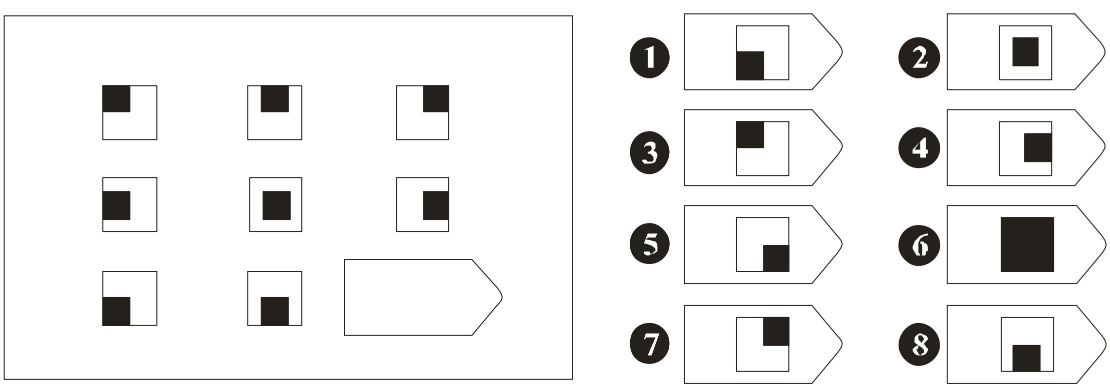

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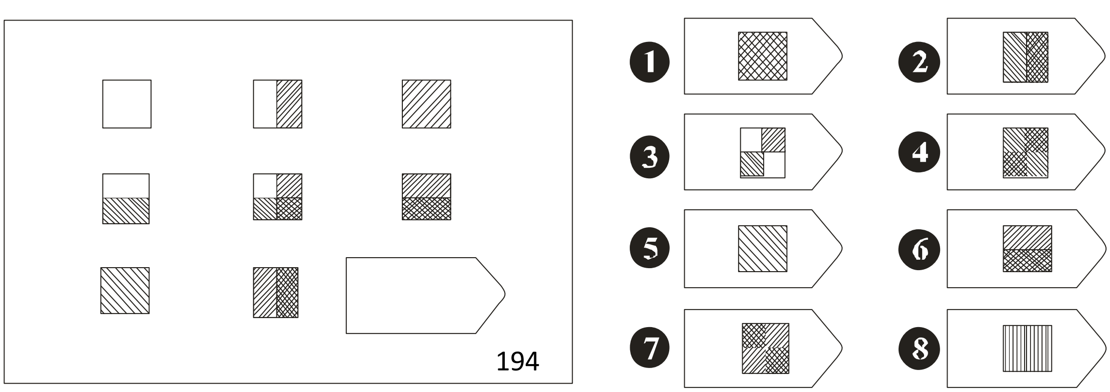

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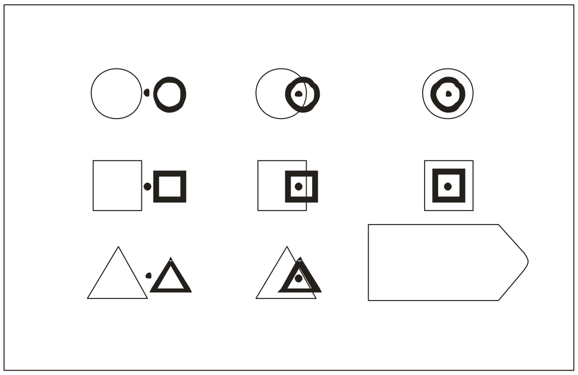

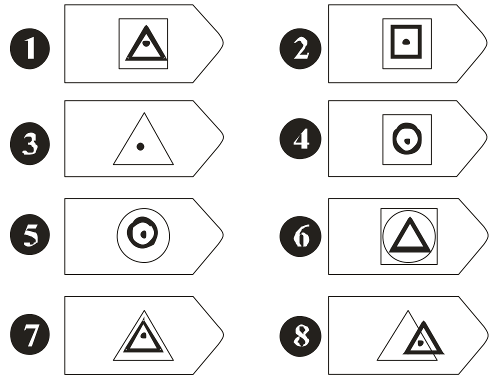

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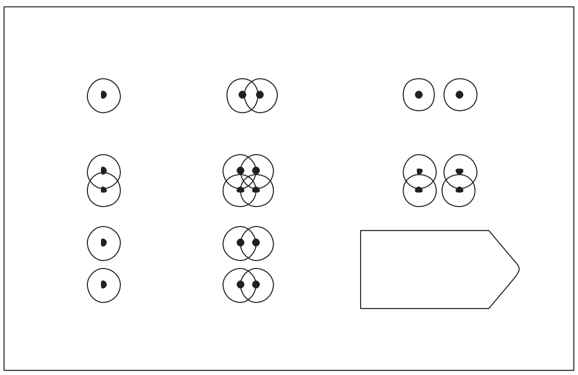

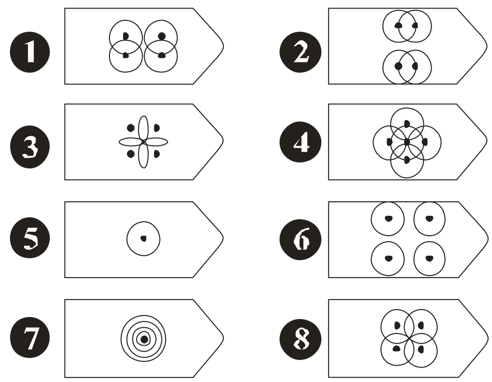

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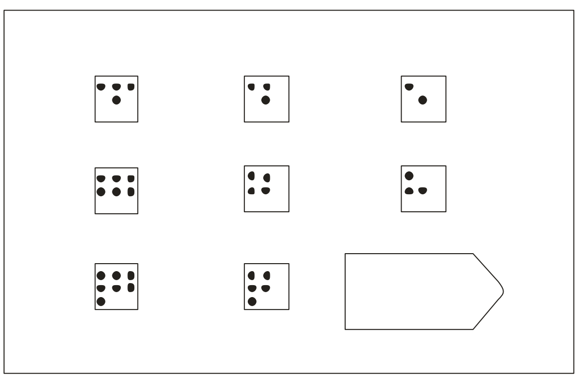

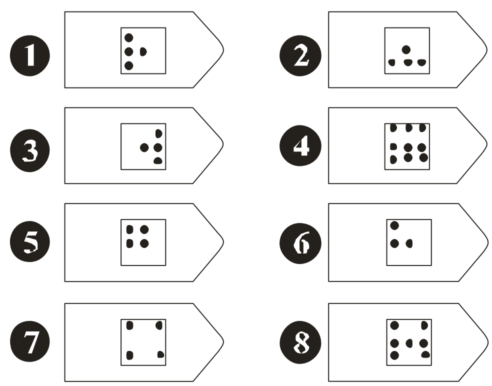

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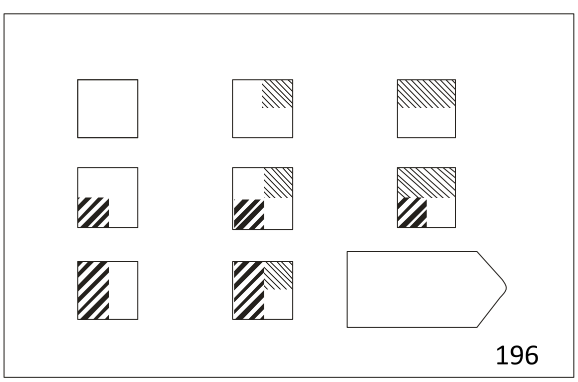

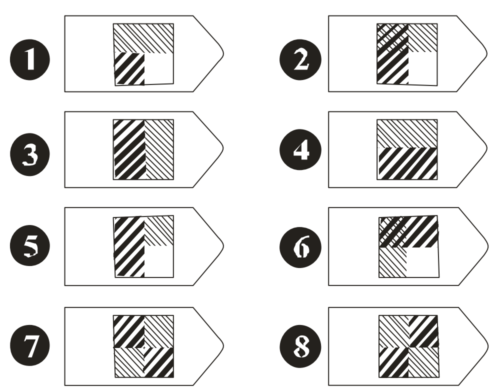

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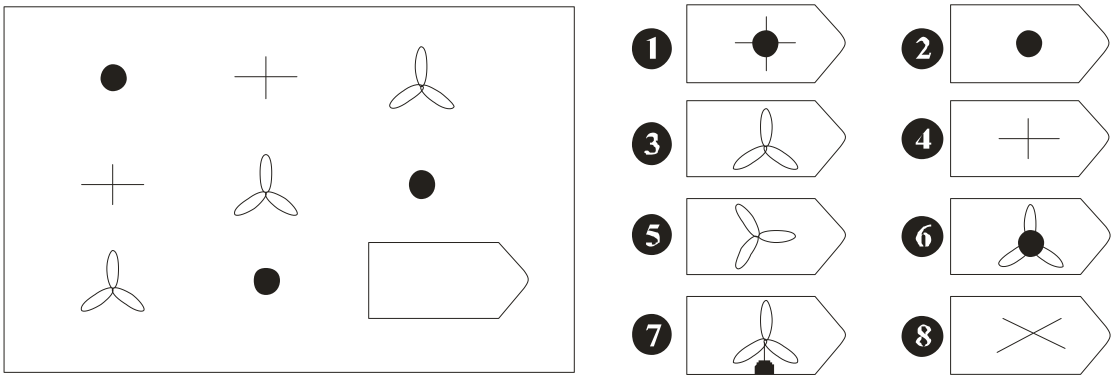

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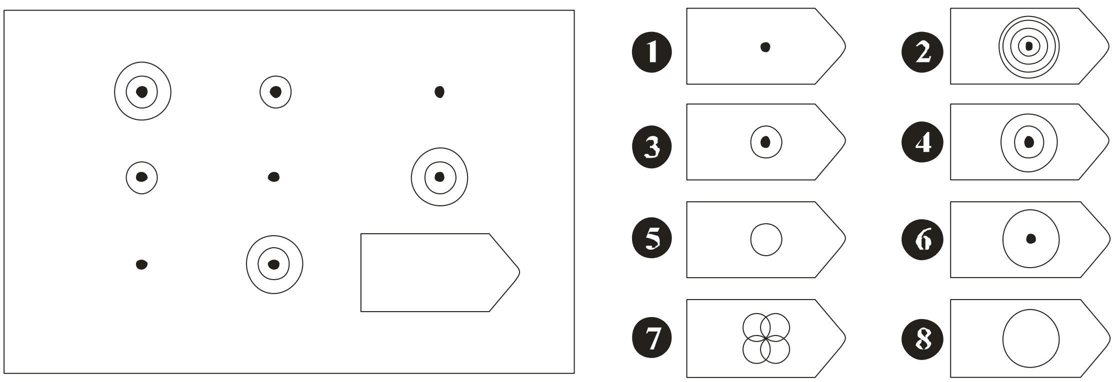

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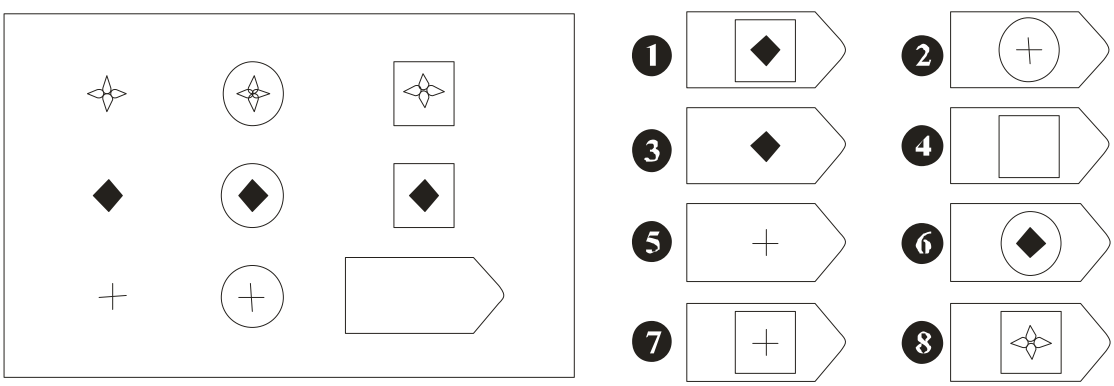

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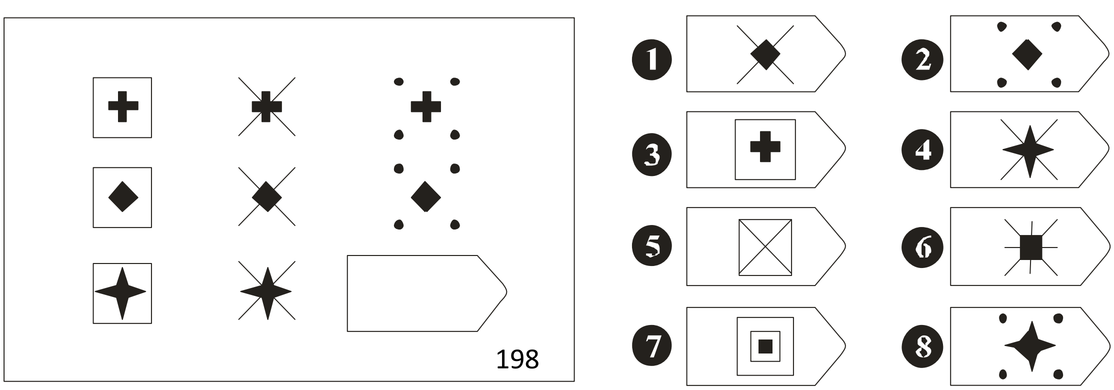

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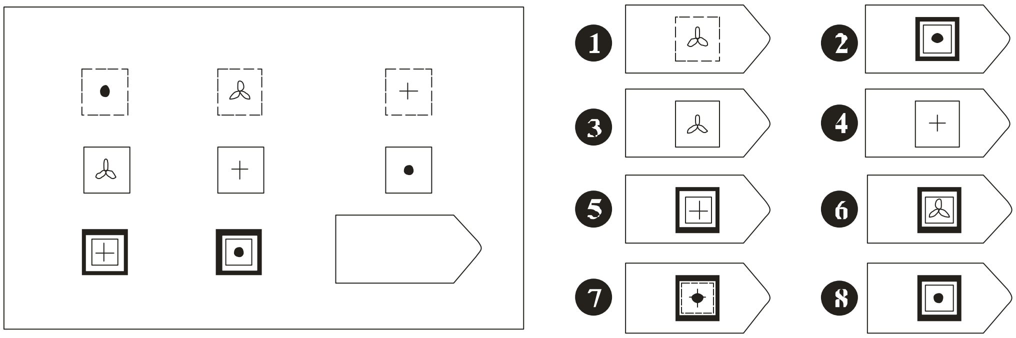

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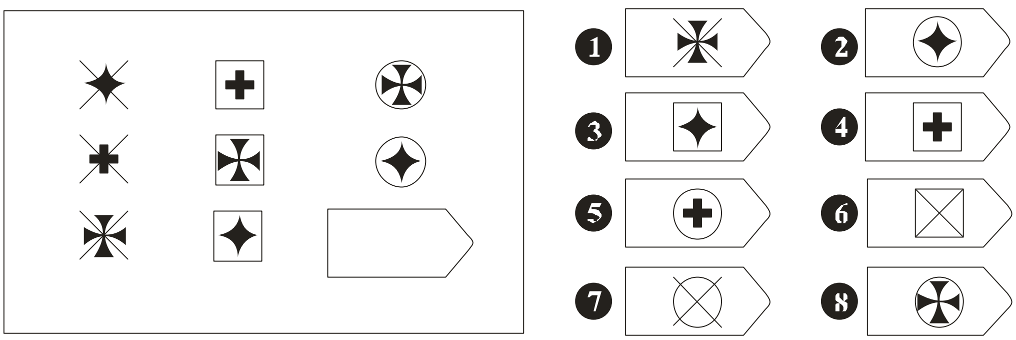

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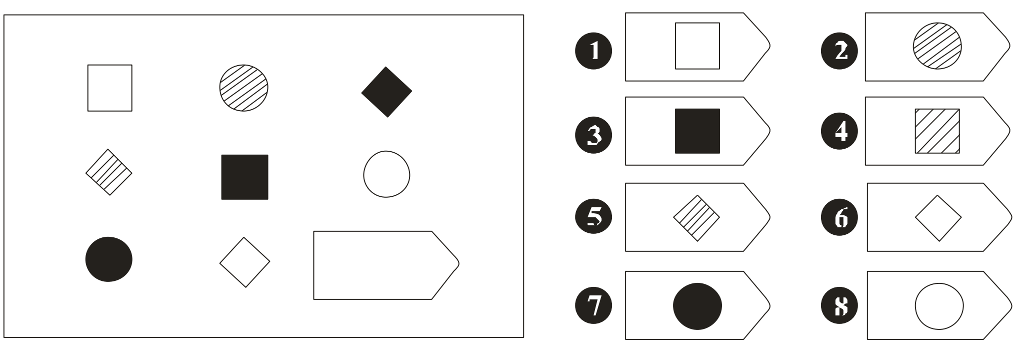

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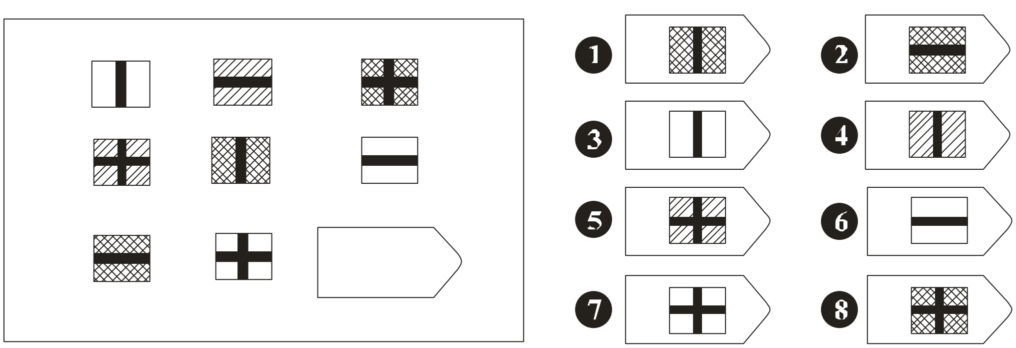

SET D

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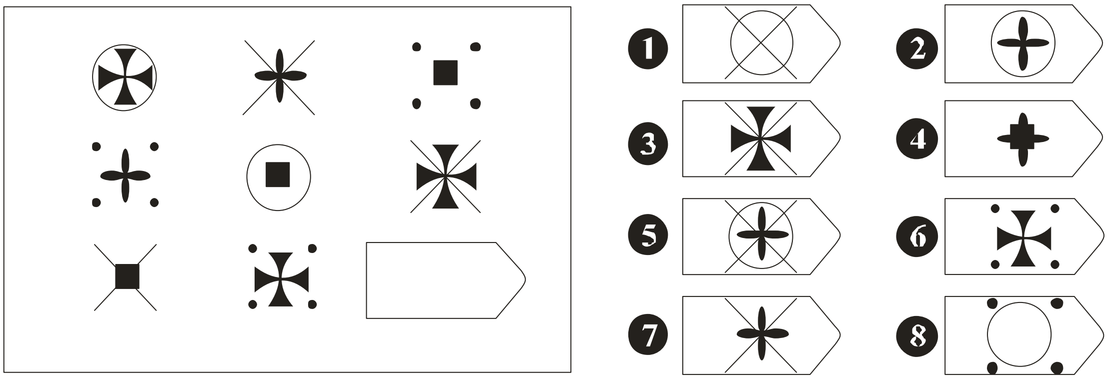

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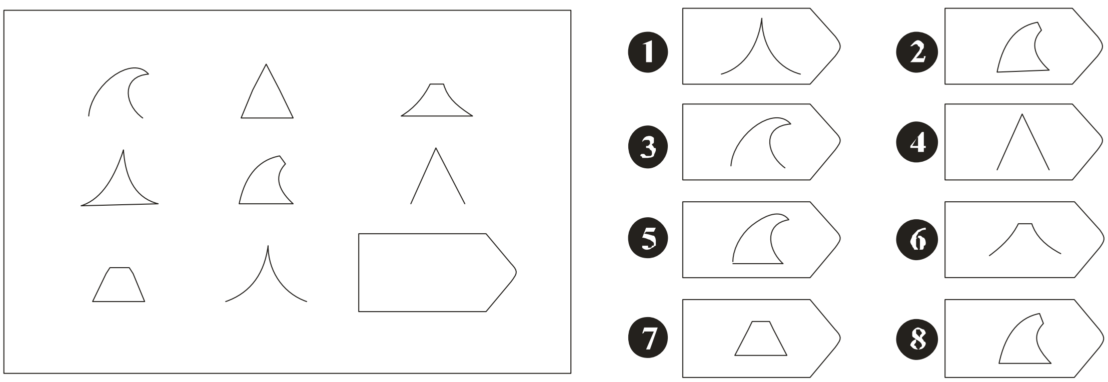

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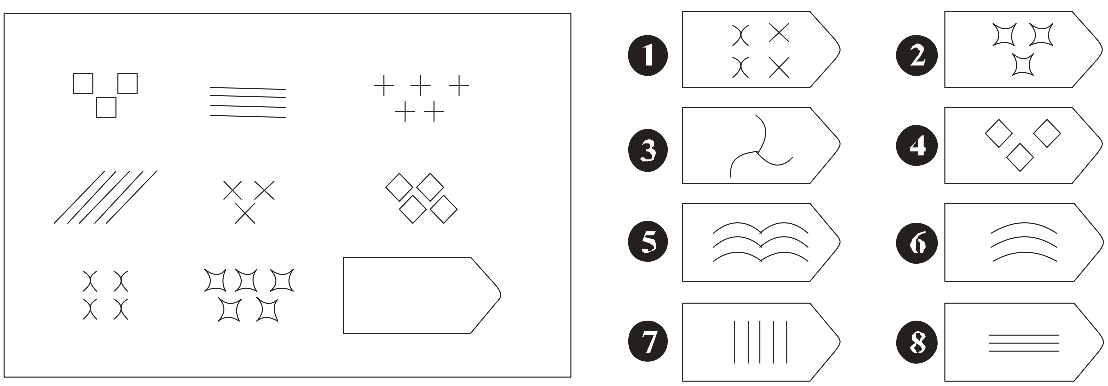

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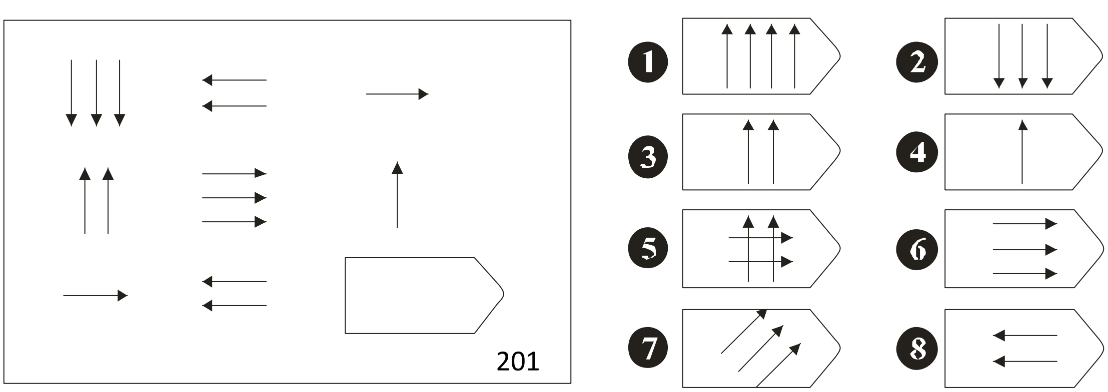

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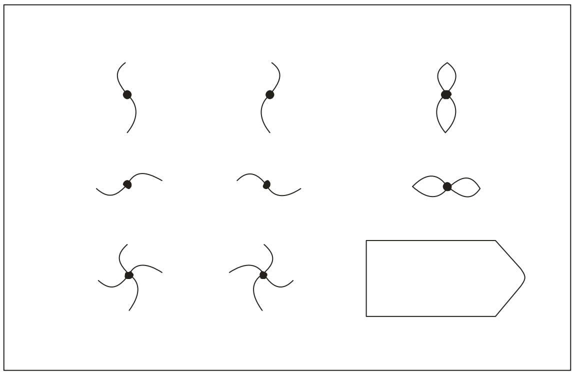

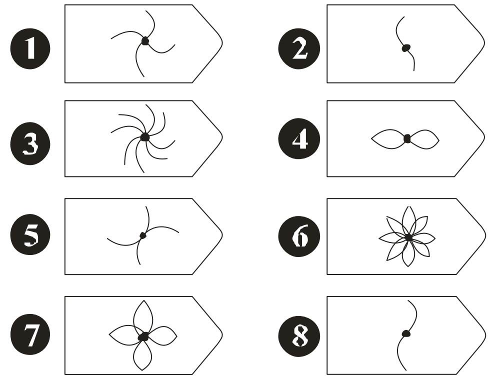

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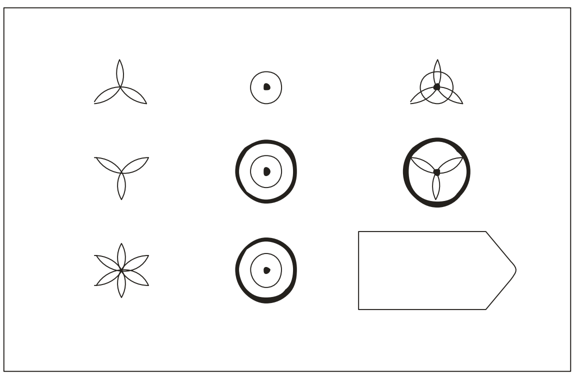

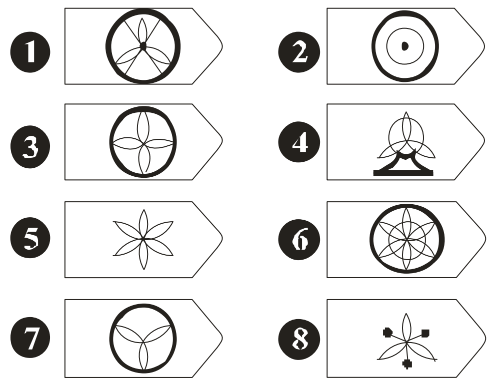

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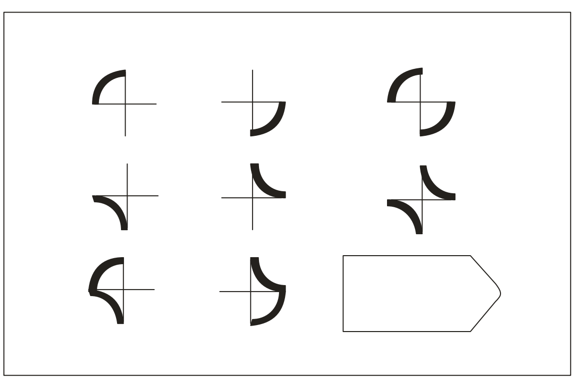

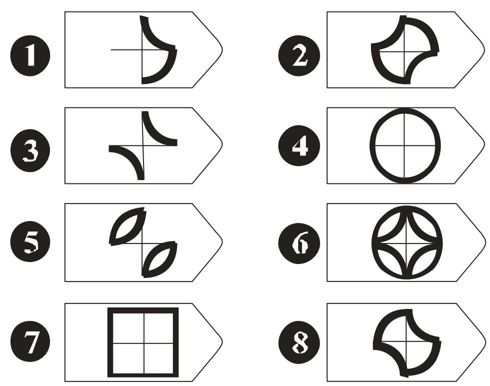

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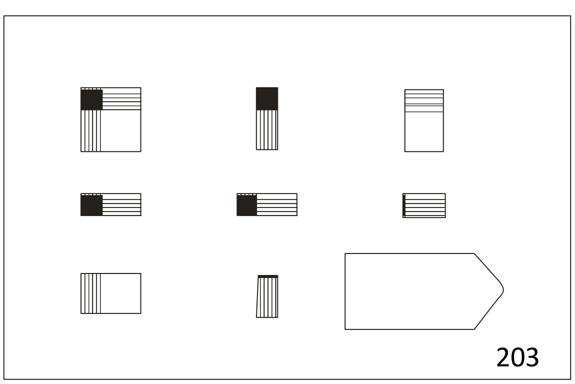

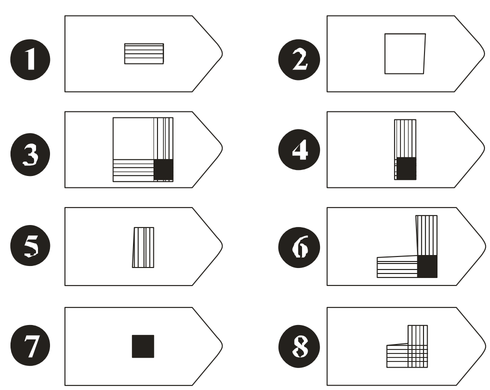

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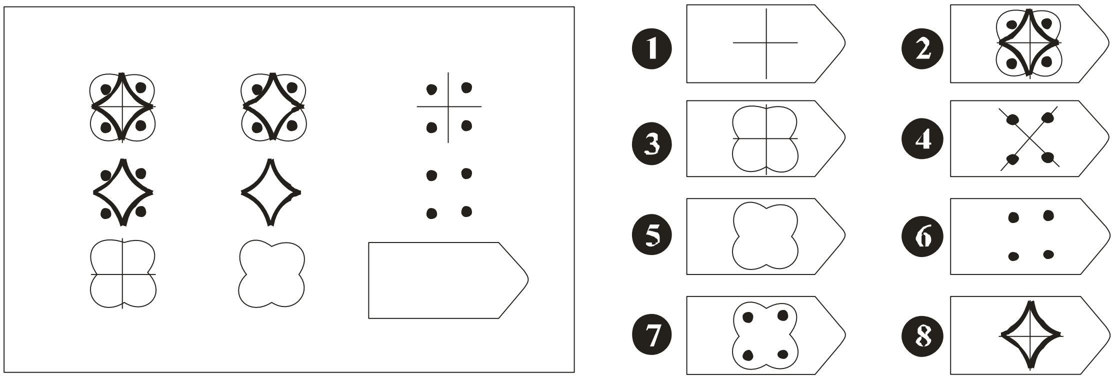

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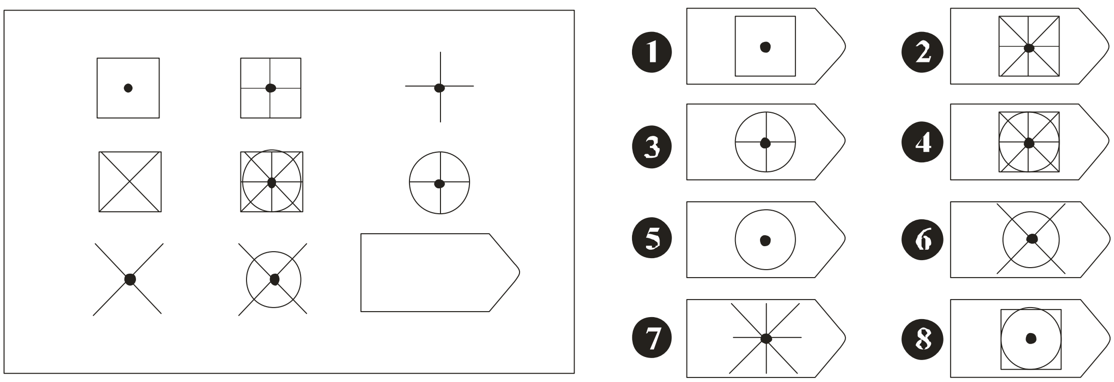

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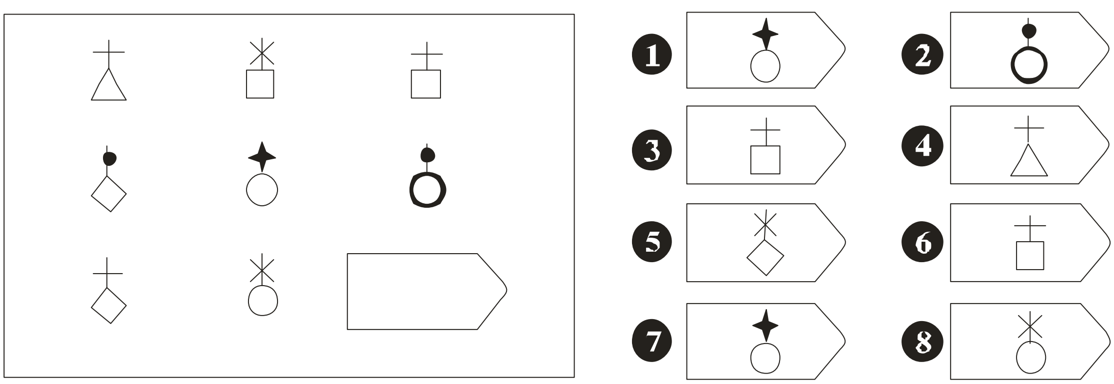

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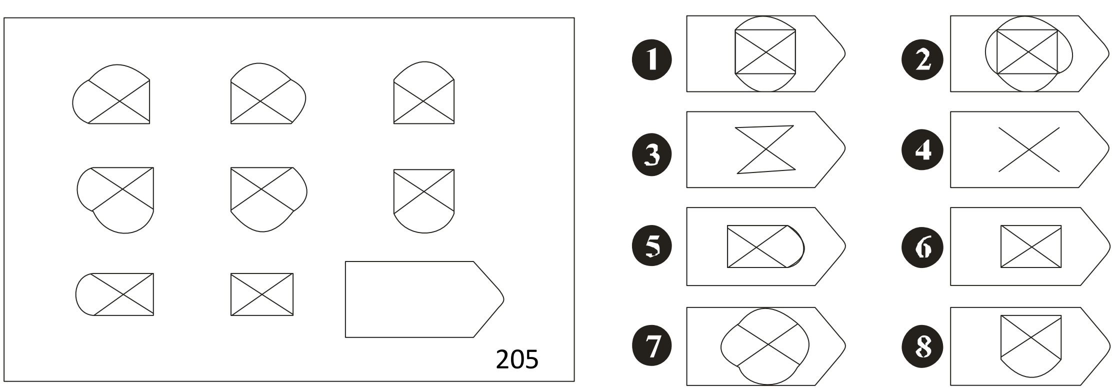

SET E

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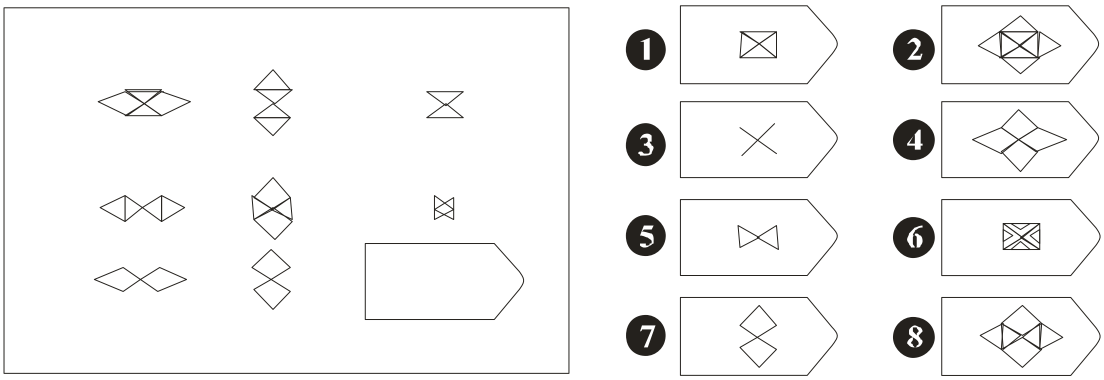

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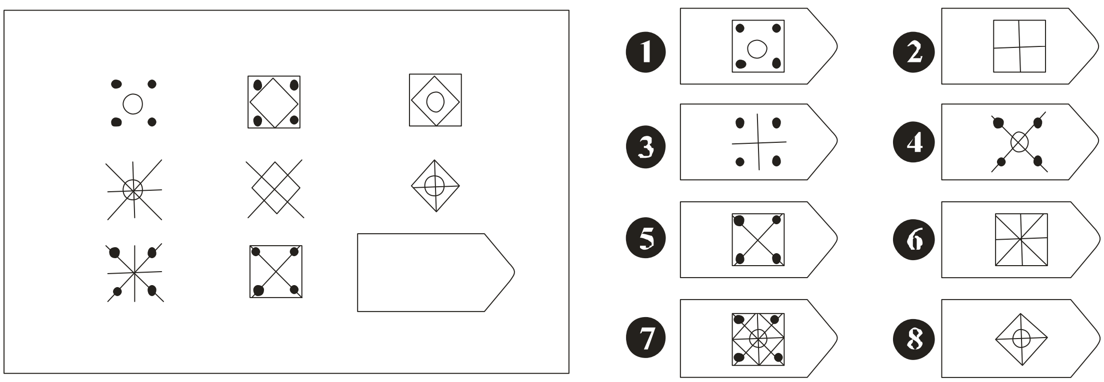

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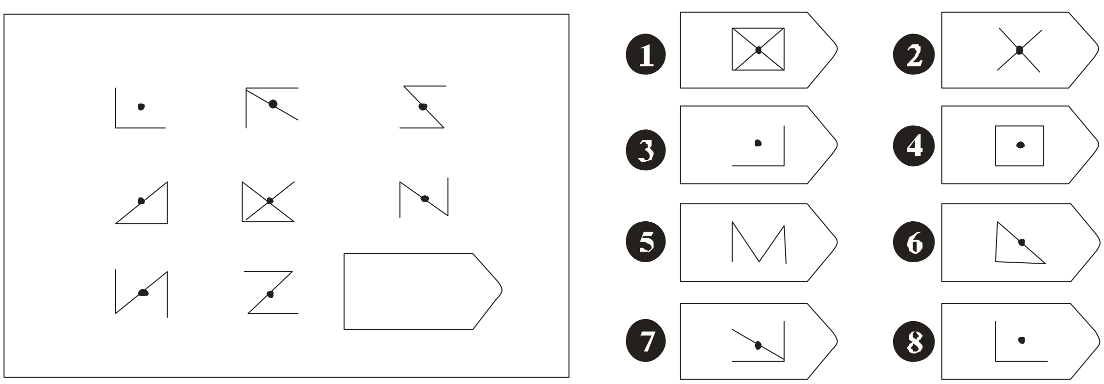

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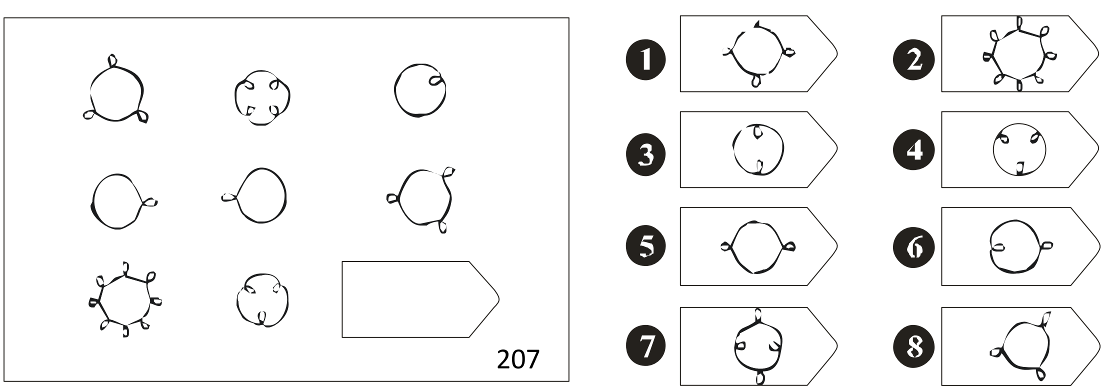

APPENDIX XIV

MENU PAGE OF CIRCLE GEOMETRY SOFTWARE PACKAGE (CiGoSPac)