International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

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Effectiveness of geometrical instructional teaching strategy on junior secondary school students' Achievement, Gender and Attitude in Plane Geometry in Odeda Local Government, Ogun state, Nigeria

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International Journal of Science and Research Archive, 2024, 11(02), 1306–1315

Publication history: Received on 10 February 2024; revised on 02 April 2024; accepted on 05 April 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.11.2.0485

Abstract

This research study was concerned with the effectiveness of Geometrical Instructional teaching strategy on Junior Secondary School Students' achievement, gender and attitude in Plane geometry in Odeda Local Government, Ogun State, Nigeria. The research study compared the effect of using Geometrical Instructional Teaching Strategy(GITS) and the conventional teaching approach on the achievement, gender and attitude of Junior Secondary School Students in Plane Geometry. The research was a pre-test post-test quasi-experimental control group design. Four (4) Junior secondary schools were purposefully chosen because of the availability of computers in these schools. Stratified random sampling technique was used to select the sample of 240 students (120 males and 120 females) drawn from four schools within the local Government. Four intact classes were used by the researchers for both experimental and the control groups. The experimental group was taught using Geometrical Instructional Teaching strategy package while the control group was taught using conventional teaching approach method. The Geometry Achievement test (G**AT**) consisting of (15) multiple choice items with four options, and Attitude Inventory on Plane Geometry (IIPG) were administered to students as pre-test and post-test before and after the treatment. Data collected was analyzed using descriptive statistics of mean and standard deviation to answer the four (4) research questions while the hypotheses were tested using analysis of covariance(ANCOVA). Result of the study revealed that students taught plane geometry using Geometrical Instructional Teaching Strategy package achieved higher mean scores than those students taught using conventional method. The result also revealed non-significant difference in the mean achievement and the mean attitude scores of males and female's students taught plane geometry using Geometrical Instructional package and those students taught using conventional method. Some recommendations were made among which are that mathematics teachers should include the use of Geometrical Instructional Teaching Strategy to teach plane geometry.

Keywords; Geometry; Geometrical Instructional Strategy; Attitude, Inventory.

1. Introduction

The poor performance of students in mathematics and plane geometry in particular has been a thing of concern to mathematics educators, parents, and the government. The chief examiner's annual reports on students' performance in mathematics have indicated that some topics (e.g plane geometry) have posed a major problem for students at the junior secondary school level. This poor achievement of students in understanding the topic may be associated with the conventional "chalk and talk" approach that teachers use in teaching the concept. (Oribhabor, (2020) and Aprebo, (2002) pointed out that despite all the maximum efforts put up by many mathematics educators aimed at identifying the major problems associated with the teaching and learning of the subject in particular (Plane Geometry) in the nation's schools, the problem of students' poor performance in the topic has continued to rear its head in the nation's public examinations.

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In Nigeria, a close look at the Junior Secondary School syllabus indicates that geometry covers a large portion of the content. Geometry is an aspect of mathematics that deals with the study of different shapes. These shapes may be plane or solid. A plane shape is a geometrical form such that the straight line that joins any two points on it wholly lies on the surface. A solid shape, on the other hand, is bound by surfaces that may not wholly be represented on a plane surface. Plane shapes are shapes with only two dimensions (length and breadth), e.g., quadrilateral (square, rectangle, kite, rhombus, parallelogram, and trapezium), which are all four-sided figures. Also included are triangles of different types and circles in which area and perimeter are calculated. Solid shapes are three-dimensional figures (length, breath, and height), e.g., cubes, cylinders, spheres, cones, pyramids, etc. Total surface area and volume are normally found here. Junior secondary school level reviews the basic geometrical concepts introduced informally at primary level and expands on them for a deeper knowledge of their properties. Constructions of solid shapes from nets; copying of figures (angles and triangles) using protractor and ruler only; an in-depth study of triangles (classification by angles and by sides); and symmetrical plane figures are concepts directly concerned with geometry content. Other curricular contents have application and computational values, e.g., areas, perimeters, and volumes of geometrical shapes (plane or solid), calculation of missing angles, circular faces, sectors, segments, etc.

According to the Principles and Standards for School Plane geometry (National Council of Teachers of Plane geometry, (2000), grade 6–8 students, (equivalent of JSS1&2 i.e age 13–15 years) should come to the study of geometry with informal knowledge about points, lines, planes, and a variety of two- and three-dimensional shapes with geometric relationships. Similarly, the Turkish elementary and middle school plane geometry curriculum includes the study of definitions of plane, identifying plane and solid figures, and learning about their properties. According to Ukwu (2000), geometry happens to be the main point of call if the mind of man is appropriately developed. The reason is that, at birth, man finds himself surrounded by shapes, patterns, and forms. He immediately becomes aware of these things, which are really the major constituents of his environment, and in no time, willingly or instructively, he becomes curious and inquisitive or begins to demand explanation with regard to the patterns, shapes, and all forms around him.

Plane geometry as a subject is used in all aspects of life, from counting numbers and figures to manipulating them for meaningful decision-making. Due to its importance to man and society at large, the teaching of plane geometry was made compulsory from the primary level up to the secondary school level in Nigeria (National Policy on Education, 2004). Agommuoh, and Ifeanacho, (2013) in their studies used a student-based experimental method in which students are active and aims at learning through drill and practice, proving, and induction in geometry on students' success compared to a teacher-centered traditional teaching method where students are passive.

Different methods of teaching plane geometry have been proposed by different educators, and the knowledge of these methods may help in working out a better teaching strategy. It is not appropriate for a teacher to commit to one particular method. A teacher should adopt a teaching approach after considering the nature of the children, their attitudes and maturity, and the resources available. Every method has certain merits and few demerits, and it is the work of a teacher to decide which method is best for the students. Therefore, teachers of plane geometry should start thinking of various ways to improve their teaching methods. According to Penick (2006), teaching methods are changing as we renew our focus on students and meaningful learning in a broad set of intellectual domains. The new concern of teachers for students is how they can learn and develop knowledge and ideas, while at the same time we are setting our sights on expanding or additional goals for them. In the traditional teaching method, most students graduate with memorized information as they are not given chances of problem solving using information, that is, reforming the knowledge, and they are not provided with activities that help them use their thinking skills and that are directed to research skills (Açikgöz, 2002). The National Policy on Education (FRN, 2004) stipulates that education at all levels "shall be structured to develop the practice of self-learning," and as a result, "teaching shall be by practical, exploratory, and experimental methods." Specifically, the policy (FRN, 2004) posits that at the primary level, "the medium of instruction shall be the language of the environment for the first three years." and "from the fourth year, English shall progressively be used as a medium of instruction." That is to say, with this, they will have a sound background in plane geometry right from primary school, which will help them perform better in their junior secondary schools.

As the world is ever-changing, the lecture method is no longer the most effective method of teaching; as such, we need a student-centered method to suit the changing world. Polya (1954) also very strongly emphasizes the importance of experimental methods and exploration in the discovery or invention of new method of solving problems in the mathematics classroom, and he was quoted as one of the most productive mathematicians of all time. There have been some changes in the curriculum of primary school plane geometry education applied in the 2005–2006 educational year. It is, in principle, adopted in the new program that activity-based learning methods used in plane geometry education make students more active in learning. One of these teaching methods is the experimental teaching method. Through experimental teaching, we can attain generalizations, as can be seen in discovery learning. The method used is

actually the discovery learning method, but sometimes there is a need to use some materials(experimental) to be able to make some discoveries by students.

It is generally believed and commonly accepted that mathematics is a subject that only exceptionally good students can learn successfully. Such beliefs have gone a long way toward affecting the attitude of students about the subject and geometry in particular. Attitudes are fundamental to the dynamics of behaviors, and they are the determining factor in what students learn. If a student has a positive attitude towards mathematics, he will not only enjoy studying it but also derive satisfaction from the knowledge of mathematical ideas he gains. It is unfortunate that many students hate geometry in mathematics. This apathy towards mathematics can be traced, among other things, to the instructional process and perhaps to the influence of society and peers in schools. According to Cetingöz and Özkal (2009), attitudes affect the students' interactions with their friends, families, school, and lessons. Unlike intelligence, which is a mental ability, attitudes are learned, and they are an emotionally toned predisposition to react in a consistent way towards a person, object, or idea. This reaction could be positive or negative. The student learns this attitude in school, at home, and from his peers.

According to Effandi and Normah (2009), students' attitudes towards plane geometry are very much related to their attitude towards problem solving in general. However, these negative attitudes need to be overcome so that later in life, students will not suffer from poor problem-solving skills. It is important to master problem-solving skills, as these skills are essential for dealing competently with our everyday lives. Their claim is supported by O'Connell (2000), who posited that students must have a positive attitude towards problem solving if they are to succeed. He proposes that solving problems requires patience, persistence, perseverance, and the willingness to accept risks. Some plane geometry teachers in the manipulation of numbers and subsequent interpretation for decision-making, especially at the primary level, had made many hate the subject. The inconsistencies in the application of abstract terms and symbols had worsened the situation, thereby leading to underachieving in the subject.

2. Review of related Literature

Several researchers (Arigbabu & Mji, 2004; Fatade, 2012; Nicolaidou & Philippou, 2004, Akintade, 2017), have reported on junior secondary school students' poor performance in geometry but not much emphasis was on the effectiveness of geometrical instructional teaching strategy on students' achievement, gender and attitudes in junior secondary schools. Bature and Bature (2006) examined the effect of gender and school type on S.S.C.E. plane geometry achievement in Bauchi Metropolis. The result showed non-significant difference between the students' attitude and their achievements. Ahmed (2001) investigated students' relationship between visual perception of geometric shapes and achievement in junior secondary schools in Minna metropolis using Pearson product moment correlation coefficient to test the hypotheses. The result revealed that a significant relationship exists between visual perception of geometric shapes and achievement. Achor, Imoko, and Jimin (2012), in their study on improving some Nigerian secondary students' achievement in geometry, used a non-equivalent pre-test, post-test control group quasi-experimental design on intact classes assigned to the experimental and control groups. Their findings revealed a significant difference between the mean achievement of the group taught geometry using a team approach and the group that interacted with their class teachers using a problem-solving approach only. Lawal and Samson (2010), in their studies of the model method of teaching mathematics, concluded that generally, a mathematical model is a mathematical idealization in the form of a system, proposition, formula, or equation of a physical, biological, or social phenomenon.

The issue of gender differences, according to Ewhrudjakpor (2006), has attracted attention from educators and researchers. Gender is a socio-cultural category that sorts and organizes the social relationships between women and men; it plays a significant role in an educational setting that could militate against learners' superior achievement in mathematics (Akinsola &Igwe, 2002; Johnson, 1984). Some investigators (O'Connon-Petruso et al., 2004; Leigh, 2006) have pointed out that females often exhibit less confidence in performing problem-solving and high-level mathematical tasks when compared with their male counterparts. Despite the giant steps taken by various organizations to bridge the gap, gender inequality in mathematical achievement has remained a perpetual, universal phenomenon (Abiam&Odok, 2006). Various research studies (for example, Arigbabu&Mji, 2003; Ungwuanyi, 2002; Olawoye&Salman, 2008) have confirmed male superiority in mathematical achievement at virtually all levels of education. These research findings have revealed that boys show a more positive attitude towards mathematics and science-related subjects and perform better on achievement measures than girls' students. Notwithstanding, other research studies (for example, Agommuoh&Nzewi, 2003; Ogunleye&Babajide, 2011) have argued against male superiority in mathematical achievement. Ding, Song and Richardson (2007) reported an equivalent growth trend in mathematical achievement between the two genders from their longitudinal research study. This research study, therefore, has sought to examine whether gender has any effect on student learning of plane geometry when exposed to GITS in the mathematics classroom.

2.2 Theoretical framework of the study

The study adopts Social constructivism theoretical framework. Social constructivism developed by Vygotsky (1978), emphasizes how meanings and understandings grow out of social encounters. This learning theory claims that knowledge is constructed based on personal experience and hypotheses of the environment and that learners continuously test these hypotheses through social negotiations (Kozulin, 2003). It argues further, that knowledge is not necessarily received but actively built up by the cognizing subject and that the function of cognition is adaptive and serves the organization of the experimental world (Adendoff & Etten, 2015). In reaction to didactic approaches, behaviorists such as Vygotsky, (1978), and Brunner, (1966) believed that learning is an active, contextualized process of constructing knowledge rather than acquiring it.

2.3 Significance of the Study

The researchers aimed at improving the teaching and learning of plane geometry among junior secondary school students. Junior secondary level reviews the basic geometrical concepts introduced informally at primary level and expands on them for a deeper knowledge of their properties. Constructions of solid shapes from nets; copying of figures (angles and triangles) using protractor and ruler only; an in-depth study of triangles (classification by angles and by sides); and symmetrical plane figures are concepts d determine the effectiveness of Geometrical Instructional teaching strategy on Junior Secondary School Students' achievement, gender and attitude in plane geometry in Odeda Local Government, Ogun State, Nigeria.

2.4 Objectives of the study

The purpose of this study was to determine the effectiveness of Geometrical Instructional teaching strategy on Junior Secondary School Students' achievement, gender and attitude in plane geometry in Odeda Local Government, Ogun State, Nigeria.

Specifically, the study sought to:

- Determine the effectiveness of Geometrical Instructional teaching strategy on Junior Secondary School Students' achievement in plane geometry.
- Examine the mean achievement scores of male and female students taught plane geometry using Geometrical Instructional teaching strategy.
- Examine the effectiveness of Geometrical Instructional teaching strategy on Junior Secondary School Students' attitude in plane geometry.

1.1. Research Questions

The following research questions were raised to guide this study:

- What are the mean achievement scores of students taught using Geometrical Instructional Teaching Strategy and those taught using conventional method?
- What are the mean achievement scores of male and female students taught plane geometry using Geometrical Instructional Teaching Strategy?
- How does students' attitude affect their level of achievement in plane geometry when taught using Geometrical Instructional Teaching Strategy?

1.2. Research hypotheses

The following hypotheses were formulated and tested at 0.05 level of significance.

- There is no significant difference in the mean achievement scores of students taught plane geometry using Geometrical Instructional Teaching Strategy and those taught using conventional method.
- There is no significant difference in the mean achievement scores of male and female students taught plane geometry using Geometrical Instructional Teaching Strategy.
- There is no significant main effect of Geometrical Instructional Teaching Strategy on students' attitudes in plane Geometry.

3. Methodology

The study adopted a pre-test, post-test quasi-experimental design method to investigate the effectiveness of Geometrical Instructional Teaching Strategy on students' learning of plane geometry (Creswell, 2013; Cohen Manion, & Morrison, 2007). This is symbolically represented below.

O_1 X_1 O_2 Experimental Group (Geometrical Instructional Teaching Strategy)

O O_2 Control Group (Conventional Teaching Instruction (CTI)

O_1 – represents pre-test measure, O_2 – represent post-test measure, X_1 – (Geometrical Instructional Strategy)

The effectiveness of the developed package was determined using a quasi-experimental procedure (pre-test, post-test, non-randomized, experimental and control groups) used at two levels of independent primary variable. The independent variables were the Geometrical Instructional Teaching Strategy (GITS) and the Conventional Teaching Instruction (CTI) while the dependent variable was the post-test performance of the students. Achievement Test in plane geometry (ATPG) administered on both the Control and Experimental groups as pre-test and post-test. The Experimental Group was subjected to a treatment using GITS while the Control Group was taught using Conventional Teaching method.

1.3. Population, Sample and Sampling Technique

Population for the study was all 2nd year Junior Secondary School students in Odeda Local Government Area in Ogun state, Nigeria. The selection of the 240 participants for the study was through simple random sample. The researchers randomly assigned two schools as experimental schools and were taught using Geometrical Instructional Teaching Strategy designed by the researchers, while the other two schools categorized as control schools were taught using (chalk& talk) conventional method.

1.4. Instrumentation

Instrument for data collection was Achievement Test in plane geometry (ATPG) and was used as Pre and Post-test for the study. Experts in mathematics validated the instrument in terms of (i) language clarity to the targeted audience (ii) relevance to the aims of the study, and (iii) coverage of the topics in the study. The reliability coefficient (r =0.84) was considered appropriate for the study.

1.5. Method of Data Analysis

Data collected for the study was analyzed using both descriptive and inferential statistics. However, Analysis of Covariance (ANCOVA) was adopted to analyze the research hypotheses raised for the study.

4. Result

Students in the control and the experimental groups were both pre -tested to determine their base knowledge and equivalence in the topic. From the table1, the mean scores of students from the Experimental group were *(M=12.64, S. D= 8.83)* while mean scores of students for the control group were (M=10.86, *S. D=7.92).* The results revealed that none of the groups have gained any knowledge of the topic before now.

Table 1 Pre-Test Mean Achievement scores of students in the two groups

Groups	N	Mean	S.D	S.E
Experimental	120	12.64	6.83	0.77
Control	120	10.86	5.92	0.58

A comparison of the experimental group post-test means scores (65.68) and the control group post-test mean scores (54.73) as illustrated in the Table 2 shows that the Geometrical Instructional Teaching Strategy (GITS) improved students' performance in the Experimental group. The difference in the post-test means score for the two groups showed the impact of the GITS intervention in favor of the experimental group.

Table 2 Post-Test Mean Achievement scores of students in the two groups

Groups	N	Mean	S.D	S.E
Experimental	120	65.68	8.71	0.73
Control	120	54.73	7.56	0.62

Table 3 shows students' pre achievement-test results for both males and females in the two groups. The students' pre-test scores in the groups were compared using the t-test at 0.05 significant levels.

Table 3 Pre t-test results based on gender

Grp	Male						Female					
	N	X	S.D	t-value	*P*	Sig	N	X	S.D	t-value	*p*	Sig
Exp.	65	10.56	7.96	4.47	3.66	NS	55	10.26	8.94	4.42	3.75	NS
Con	65	10.17	7.84				55	10.88	8.86			

In the Table, the probability of error is greater than 0.05 *(P* = 3.66> 0.05) for the males and (*P* = 3.75>0.05) for the females. The non-significance of the results reveals that neither males nor their females' counterparts have been taught on plane geometry topic before the treatment. Hence, the null hypothesis is not rejected but accepted.

After the intervention, the post- t-test results for the two groups (experimental and control group) for both male and the female students were analyzed and presented in table 4

Table 4 Post t-test results based on gender

Grp	Male						Female					
	N	X	S.D	t-value	*P*	Sig	N	X	S.D	t-value	*P*	Sig
Exp.	65	54.41	9.46	4.57	3.65	NS	65	53.98	9.47	4.54	3.71	NS
Con	55	40.15	9.43				55	4.87	9.53			

From the table, the probability of error is greater than 0.05 *(P*= 3.65>0.05) for the males, and (*P* = 3.71>0.05) for the females. The results reveal that both males and their females' counterparts in the two groups were not significantly different. This indicates that the treatment was statistically not significant on either males or their females' counterparts for better performance towards the learning of Plane Geometry. Therefore, the null hypothesis is not rejected but accepted.

Table 5 Summary of (ANCOVA) of post-test achievement scores by treatment, Gender and attitude.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	24263.488[a]	8	3032.936	16.134	0.000	0.293
Intercept	56810.582	1	56810.582	302.211	0.000	0.493
Pre-test	240.476	1	240.476	1.279	0.259	0.004
Main	10959.825	1	10959.825	58.302	0.000	0.158
Treatment						

Gender	416.397	1	416.397	2.215	0.138	0.007
Attitude	1788.219	1	1788.219	9.513	0.002	0.130
Interaction	232.637	1	232.637	1.238	0.267	0.004
Treatment * Gender						
Treatment * Attitude	.985	1	.985	.005	0.942	0.000
Gender * Attitude	64.765	1	64.765	.345	0.558	0.001
2nd Interaction	12.295	1	12.295	.065	0.798	0.000
Treat * Gender * Attitude						
Error	58462.699	311	187.983			
Total	573354.000	320				
Corrected Total	82726.187	319				

The table 5 reveals that after adjusting for the covariance, the effect of treatment on students' achievement was statistically significant, $F_{(1,311)} = 58.302$, $p < 0.05$. The table further showed that the Partial Eta Square ($\eta^{2)}$ was .158, which was considered to be medium effect size. The simple implication of this is that 15.8% of the variance experienced in students' achievement in plane geometry was accounted for by the treatment. The table also revealed non-significant main effect of Gender on students' achievement in plane geometry ($F_{(1,311)} = 0.138$, $p = .138$, $p < 0.05$).

The partial Eta square ($\eta^{2)} = .007$) which means a low effect size. The implication of this is that students' gender accounted for 0.7% of the variance experienced in students' achievement in plane geometry. Hence, there is no significant main effect of gender on students' achievement in the topic. Furthermore, the table shows a significant main effect of attitude on students' achievement in plane geometry ($F_{(1,311)} = 9.513$, $p < 0.05$). The partial Eta square ($\eta^{2)} = .130$, which means moderate medium effect size. The implication of this is that students' attitude accounted for 13.0% of the variance experienced in students' achievement in plane geometry.

5. Discussion of Finding

Results of this study revealed a significant difference between the post-test achievement means scores of the experimental and control the group. Therefore, using GITS is effective on students' learning of Plane Geometry in Nigerian Junior Secondary schools. Finding of this study supports earlier findings (Adetula, 2006; Adetula, 2001; Akay & Boz, 2010; Aiyegbusi,2005; Uyoata, 2006; Yadar. 2008)which opined that content learning can be associated to learners'-centered teaching strategy. The finding is consistent with the assertion of Akintade, Ogbonnaya, &Mogari, (2013); Agommuoh, &Ifeanacho, (2013); Akintade, Ogunrinade &Akintade, (2019) that such a strategy can promote students' achievements significantly in subject content. The non-significant main effect of gender on students' achievement in plane geometry is in line with previous studies (Akintade 2017, Akintade, Ogunrinade and Campbell 2018, Fatade, 2012) who reported a non-significant main effect of gender on students' performance in science and plane geometry. Findings of the present study revealed a significant difference between students' leaning attitude and their academic achievement in plane geometry as supported (Agommuoh, and Ifeanacho,2013) when they were exposed to GITS strategy to teach them. With all the beneficial effect of Geometrical Instructional Teaching Strategy as discussed in the study, it is reasonable to conclude that the approach contributed largely to the development of students' achievement and attitude towards the learning of Plane Geometry.

6. Conclusion

In conclusion, typically teachers are too often satisfied with teaching plane geometry as manipulating symbols and focus on learning rules and procedures and doing routine problems without ever ensuring that their students acquire deep, conceptual understanding. However, the use of Geometrical Instructional Teaching Strategy in Nigerian Junior secondary school create opportunities for students to investigate, discover, examine, apply, prove and communicate plane geometry. It is therefore necessary for teachers of mathematics to review their approaches and methods of

teaching geometry in the school in light of the present findings. This study has an influence on the initiation of using a mathematics laboratory in the teaching of mathematics at both junior and senior secondary school levels as there is a need for a good strategy for teaching mathematics so as to improve the results and performance of students in board examinations.

Recommendation

Findings from the study have revealed that the GITS strategy improves the performance, learning achievement and attitudes of students in plane geometry. The researchers, therefore, recommend the following proposals.

- The GITS strategy should be implemented in the teaching and learning of plane geometry and mathematics in Nigerian secondary schools in order to enhance students' performance on the topic.
- The adoption of the GITS teaching strategy in Nigerian secondary schools would motivate students to learn, arouse their interest and consequently, improve their performances in mathematics.
- Federal Government should emphasize the need for teachers to be more computer literate because lack of computer knowledge among teachers will decelerate the implementation of GITS strategy programs in schools.
- Government and school authority should provide computer laboratory with enough computer system and good and conducive environment for learning.
- Parents are to encourage their children with various and relevant computer gargets with plane geometry applications to enhance their interest in the topic.

Compliance with ethical standards

Acknowledgement

The authors wish to thank the Sponsor, Tertiary Education Trust Fund, Abuja, Nigeria.

The grant number is TETF/DR&D/CE/COE/OSIELE/IBR/2021/VOL 1.

Disclosure of conflict of interest

There is no conflict of interest to be disclosed in this paper.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study by the authors.

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