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COMPARATIVE EFFECTS OF TEACHING WITH IMPROVISED INSTRUCTIONAL MATERIALS AND STANDARD INSTRUCTIONAL MATERIALS ON SECONDARY SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY

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Abstract

This study investigated the comparative effects of teaching with improvised instructional materials and standard instructional materials on secondary school students' academic achievement in Chemistry. It covered the topics; acids, bases and acid- base reactions. Two research questions and two hypotheses were used to guide the study, relevant literatures were also reviewed. The study was carried out in Awka Education zone in Anambra State. The population of the study consists of eight thousand five hundred and eighty three SS1 Chemistry students in the zone. The sample size for the study comprised of one hundred and ninety two SS1 Chemistry students. The study adopted quasi-experimental design. Four purposively selected co-educational schools were used for the study of which students of chemistry in two schools were assigned to experimental group which received treatment of involvement in teaching Chemistry using improvised instructional materials and the other two schools were assigned to control group which were taught using standard instructional materials. Twenty- five Chemistry achievement test (CAT) was used as the instrument. The instrument was validated by experts in science education department and educational foundation department. One from Nwafor Orizu Collage of Education Nsugbe and the other from Chukwuemeka Odumegwu Ojukwu University Anambra state Nigeria. CAT reliability was established using Kudar Richardson 20 (KR-20) which yield reliability coefficient of 0.81. Mean and standard deviation were used to answer the research questions while analysis of covariance (ANCOVA) was used to test the hypotheses at .05 level of significance. The findings of the study revealed that, students taught Chemistry with improvised instructional materials significantly achieved more than those taught with standard instructional materials. There was no interaction effect of gender and type of instructional

materials on students' achievement in chemistry. It was recommended that teachers in the teaching field should be trained on the skills of the use of improvised instructional materials. Based on the findings of the study, it was concluded that the use of improvised instructional materials in teaching of Chemistry improve the academic achievement of students in Chemistry.

Keywords; Science, Chemistry, Achievement Improvised Instructional Material (IIM) and Standard Instructional Material (SIM)

Introduction

Science is an important tool in the development of any nation. This is because science is directly linked to the tackling of the problems of humanity. The contributions of science and technology to the overall development of nations cannot be overemphasized. This is the reason science holds an important position in the curriculum of the nation's educational system. It was in the bid to further underline the importance of science and technology to modern development that Science, Technology, Engineering and Mathematics (STEM) education was introduced in 2001 by the Scientific Administrators at the US National Science Foundation (NSF) with three major goals; to expand the number of students who ultimately pursue advanced degrees/ careers in STEM fields and broaden participation of woman and minorities in those fields, expand STEM- capable workforce and increase STEM literacy for all students including those who do not pursue STEM related careers or additional studies in STEM disciplines (Hallinen, 2011).

STEM education is an integration of interrelated discipline into a new whole, which gives students the opportunity to understand their environment and exploit it for self and national development (Ibe, Obikezie & Chikendu, 2021). The interdisciplinary nature of STEM makes it unique as it has elements of creativity and objectivity. Strong STEM education is culturally responsive, employs problem-solving and inquiry-based approaches and engages students in hand-on activities that offer opportunities to interact with science professionals (Tera, 2018).

Science, according to Njoku in Dike (2013) is the rational and systematic study of the environment through observation and experimentation with a view to understanding the environment and manipulating the resources of nature for human development. This implies that teaching must be proactive, creative and student centered to achieve the objectives of STEM at secondary school level. Nbina, Viko and Birabil (2010) therefore assert that one of the activities of science subjects like chemistry, is experimenting. They further added that it provides a forum for putting the theoretical knowledge acquired in the classroom into practice and also, to demonstrate the psychomotor skills of the teacher and students. It helps chemistry students to assimilate abstract and difficult concepts associated with the nature of science. Experimenting in science is however dependent on the availability of instructional materials (Ogwo, 2014).

The lack of instructional materials, non-availability of equipped laboratories among others in the teaching of science in schools is an established issue (Njoku, 2011). This is in line with Odigie (2011) and Dike (2013) who agreed that educational instructional materials and equipped laboratories are lacking in schools. Ibe (2014) is of the opinion that the use of instructional materials to facilitate teaching and learning should be a welcome development. This is in conformity with Dike (2013) who asserts that science teachers should work beyond stereotyped science teaching-learning process and utilize the available materials in the environment to

facilitate science teaching-learning process. Therefore for effective teaching of science subjects like chemistry, the use of instructional materials to enrich instruction is very vital.

Chemistry is one of the core subjects of science. As a building block for a range of science disciplines, chemistry has the potential to link other sciences together and to foster greater scientific literacy (Tera, 2018). Chemistry is the basic gateway and the key to modern technology, medicine, engineering and other sciences (Okeke & Nwandinigwe, 2015). The study of chemistry is needed to develop the necessary skills, intellectual and mental training needed to observe measure and apply scientific attitude and skill towards natural phenomena that include the eagerness to learn and the ability to think critically. In contemporary Nigeria, great emphasis is placed on science for technological development and chemistry is an important raw material for science. Students are encouraged to take-up science-related subjects such as chemistry. In spite of the relevance of chemistry in the life of the society, the study of chemistry in our secondary schools is challenged with poor performance and lack of interest in the part of students (Uchegbu, Anozieh, Mbadiugha, Ibe & Njoku, 2015).

According to Onasanya and Omosewa (2010), factors responsible for students' poor performances in Chemistry include – ineffectiveness in teaching process, poor laboratory facilities and inadequate number of learning facilities in schools as against the consistent increase in the number of students. Another reasons adduced for poor achievement in chemistry include abstract nature of chemistry, student and teacher factors, concept difficulty and teaching of chemistry without instructional materials (Nnoli, 2014). Poor funding of schools hinders the school management from providing the chemistry teachers with adequate instructional materials needed for Chemistry teaching. There has been a decline in the performance of students in public examinations conducted by the West African examination council (WAEC) and National Examination Council (NECO) in chemistry across the country over the years (Uchegbu, et al., 2015). This is evidently shown in Table.1. The table shows performance of students in WAEC for ten consecutive years.

Table 1: Statistics of Students' Academic Performance in WAEC Chemistry (2007-2018).

Year	Total Sat	Credit Passed (A1-C6)	% Pass	Below Pass (D7-F9)	% Below Pass
2007	424747	196063	46.16	228684	53.84
2008	456980	202762	44.47	254218	55.53
2009	456980	203365	44.49	253615	55.51
2010	465643	263059	50.7	202584	49.3
2011	565692	280250	49.54	285442	50.46
2012	627302	270570	43.13	356732	56.87
2013	639296	462517	72.34	176779	27.66
2014	639268	397649	62.49	241619	37.51
2015	680357	412323	60.6	268034	39.4
2016	706873	408122	57.74	298751	42.26
2017	704494	441576	62.68	262918	37.32
2018	728998	451614	61.95	277384	38.05

Source: Statistics Section, WAEC Office, Yaba Lagos (2018)

Using the statistics in Table 1 as a case study of performance of students in chemistry examination in secondary schools in Nigeria, it is very clear that general performance of students have not been excellent. It was only in the year 2013 that the percentage performance is above 70% that is 72%. Badmus (2018) pointed out that any country that her students in high school achieved below 70% is bound for technological retardation. Going by that assertion, a good percentage of students failed chemistry and this is tantamount to drop in science related professions.

Furthermore, WAEC Chief Examiners' report (2018) pointed out that Chemistry students have poor knowledge of acids, bases and acid-base reactions and are unable to report results of acid-base titration experiments, unable to make calculations on molar and mass concentration. These topics are fundamental and basic concepts in chemistry which requires instructional materials in teaching them.

Ogwo (2014) stated that the basic tools that science uses in the learning of science processes are instructional materials. Instructional materials are wide varieties of equipment and materials used for teaching and learning processes to stimulate self-activity on the part of the students. According to Engida (2012), instructional materials increase the rate and quantity of learning by students and at the same time allow the teacher to use more time on other gainful activities. They make abstract terms, concepts and generalizations more practical and realistic. Instructional materials create in the learners' awareness of problem, open up possibilities for exploration, present meaningful interactions which naturally lead to provision of solutions. Chemistry as a science subject is hands on activity based and must be taught with instructional materials. Teaching of chemistry without instructional materials result to rote learning. Due to the galloping inflation in the country, foreign exchange rate is high and makes it impossible for schools to purchase already made instructional materials which are often imported into the country. For these reasons and even more, chemistry teachers have been called upon to be creative in improvising these instructional materials. So that in the absence of standard ones or when the number is not adequate, the teacher can locally make use of resources from the environment as an alternative. The importance of using instructional materials whether standard or improvised according to Oriade (2008) is that no matter how good a curriculum may be, the absence of the use of instructional materials can jeopardize its effective implementation. Instructional resources help the teachers to improve their instruction. They make the message clearer, more interesting, standard and easier for the learners to assimilate (Onasanya & Adegbija, 2012). The application and provision of instructional resources should be reinforced in the school system.

There are two major types of instructional materials: conventional (standard) and improvised. The standard materials are conventional instructional materials that are imported or factory made laboratory equipment for teaching science. They are standardized because they adapt to all conditions and serve the same purpose wherever they are used. Examples are laboratory chemicals, laboratory glassware, bunsen burners, tripod stand etc. While Improvised materials refer to a diversity of educational resources that can easily be obtained from the environment, with high local content and relevance to the curriculum (Engida, 2012). They are used as instructional materials for teaching and learning purposes. They are made by the teacher or students. Improvised materials include; sodium rich materials as base, such as akanwu, ngu, dyes of plants and flowers (zobo) as acid base indicators.

The teaching of chemistry without instructional materials may certainly result in poor academic achievement. Lack of instructional material in the teaching and learning process of chemistry maybe a contributing factor to poor achievement of the concepts taught. Improvisation according to Ikwuanusi (2011) is the process or act of providing or using alternative instructional resources in the absence of a standard or already made one. Landu (2010) defines improvisation as an act of using materials from local environment designed either by the teacher, students or with the help of local personnel to enhance instruction. Improvisation of instructional resources in secondary school for the teaching and learning of science especially chemistry cannot be overemphasized. National policy on education (2014) stated that the provision and use of available instructional materials for teaching lay a sound basis for scientific and reflective thinking among students. It enables the students to connect abstract concepts taught, to real life experiences known to them. It also encourages students towards the development of creative abilities, strengthens enquiry, discovery, and investigative methods in science. Furthermore, It provides a frame of reference on which students can key their attention during classroom

activities, enables teachers to think of cheaper, better and faster methods of making teaching and learning process easier for students, affords students the opportunity of becoming familiar with resources in their environments. Attah (2014) stated that improvised materials may be superior to standard material in eliciting higher achievement and in chemistry students because it constitutes materials made from immediate environment.

Achievement is the result, the successfulness, the extent or ability, the progress in learning educational experiences that the individuals indicate in relation with his/her educational learning (Engida,2012). Academic achievement has been described by Dike (2013) as the scholastic standing of a student at a given moment, which states individual abilities. Students' academic achievement can be explained in the form of grades, obtained from tests or examinations on courses taken. The poor achievement in chemistry basically may largely be attributed to the inadequate or total absence of instructional materials and teacher's attitude towards improvisation as seen in several types of research on achievement (Attah, 2014). The use of instructional materials in teaching and learning chemistry improves academic achievement. However, poor learning environmental conditions without instructional materials contributes a lot to forgetfulness which lead to poor performance in chemistry among gender.

Gender as an important determinant factor in an educational setting constitutes a hindrance to students' achievement in chemistry and has received research attention for some years (Attah, 2014). Gender in achievement and retention is inconclusive. According to Attah (2014), gender is not a significant factor in students' achievement in science. In the other hand, Aninweze (2014) identified sex-role stereotyping and masculine image of science as the origin of the differences between male and female achievement in sciences. In relation to the present study, since gender has proved a significant determinant of academic achievement and retention in chemistry and in other science subjects. This study wishes to investigate the comparative effect of teaching with improvised instructional materials and standard instructional material on male and female students' academic achievement in chemistry.

Jerome Bruner postulated the Theory of Discovery Learning (TDL) in 1960. Bruner's theory of discovery learning states that active learning process is one in which the students are directly involved in the structuring and restructuring of their environment and learning experiences. Bruner believes that students selectively perceive certain aspects of their environments, represent those perceptions internally and then act on those internal representations. The theory stresses cognitive effectiveness. Bruner believes that learning by discovery begins when a science teacher intentionally creates a problem and presents it to the students by introducing some contradictions among sources of information which are given in the process of instruction. According to Bruner, such contradictions lead to intellectual discomfort which will motivate the students to initiate individual discoveries through an internal reorganization (cognitive restructuring).

At the enactive stage, the child manipulates the learning materials directly by neuromuscular activities such as experimentation. At the ionic stage, the child deals with mental images of the objects but does not manipulate them directly. At the symbolic stage, the child uses language to manipulate and interpret his/her learning materials. The interpretation of the above is that when a child at secondary school level shows incompetence in his/her learning capability especially in symbolic representation, it could be that he/she was deficient in early stages (that is, enactive and ionic stages) which he/she skipped. It is, therefore, necessary to fill in the missing gap by

providing concrete support that will make up for the deficiency. Discovery learning, when encouraged in science instruction also aids problem-solving because learning by discovery starts with problem-solving (Aknmoyewa, 1992 in Mberekpe 2013). Some researchers like Ibrahim (2012) investigated the effects of improvised and conventional instructional materials on pupils' academic achievements and attitude to basic science in Wase supervisor zone of WaseIga Plateau state using Theory of Discovery Learning (TDL). 120 sampled primary 5 pupils were used for the study. Three research questions and hypotheses guided the study. Instrument used for data collection were Basic Science Achievement Test (BSAT) and Basic Science Attitude Questionnaire (BSAQ) which were validated by experts and with a reliabilitycoefficient of 0.73 and 0.83 respectively. Data obtained for the study was analysed using analysis of variance (ANOVA), t-test and Wilcoxon signed rank test. The findings showed that pupils taught with improvised and standard materials showed no significant difference in their mean scores but showed significant difference with the control group that is the pupils taught without instructional materials. In addition, there was no significant difference in the pupils' attitude before and after exposure to either. Based on these findings, it was recommended that basic science teachers should be trained through workshops on how to effectively design and use improvised materials in teaching basic science. The above research was done at Plateau State Nigeria in Basic Science subject but the present research was done in Chemistry in Awka education zone.

Purpose of the Study

The purpose of the study is to investigate the comparative effect of improvised instructional materials and standard instructional materials on secondary school students' academic achievement in chemistry. Specifically the study sought to examine the:

1. Mean achievement scores of students taught Chemistry using improvised instructional materials (IIM) and those taught using standard instructional material (SIM).

2. Mean achievement scores of male and female students taught Chemistry using improvised instructional materials (IIM).

Research Questions

The following research questions guided the study;

1. What is the difference in the mean achievement scores of students taught Chemistry using improvised instructional materials and those taught using standard instructional materials?

2. To what extent do the mean achievement scores differ among male and female students taught Chemistry using improvised instructional materials?

Hypotheses

The study tested the following null hypotheses at 0.05 level of significance.

1. There is no significant difference in the mean achievement scores between students taught Chemistry using improvised instructional materials and those taught using standard instructional materials.

2. There is no significant difference in the mean achievement scores between male and female students taught Chemistry using improvised instructional materials.

Methodology

The design of the study was quasi-experimental design of pretest-posttest non-equivalent control group design. Quasi-experimental design is where random assignment of subjects to experimental or control groups is not possible (Nworgu, 2015). In such research, intact classes were used. The design is considered appropriate for the study because treatment and control groups are used.

The study was carried out in Awka Education Zone of Anambra state, Nigeria. Awka Education Zone is in Anambra Central Senatorial District of Anambra state. Greater percentage of occupants in Awka Education Zone are involved in professions like agriculture, and civil servants. In Awka Education zone there are higher institutions both state and federal which are Nnamdi Azikiwe University, Awka, Anambra State Polythechnic, Mgbakwu. Also there is a seat of Government of Anambra State situated in Awka Education zone. Awka Education Zone comprises of five Local Government Areas namely; Awka North, Awka South, Anaocha, Dunukofia and Njikoka local government area respectively. To obtain this study, four co-educational government owned secondary schools were chosen out of forty nine (49) co-educational government schools in the area. Two schools were assigned to control group, the other two were also assigned to experimental group. Out of 8583 SS1 students in Awka education zone 192 SS1 students were used. One hundred and four students (104) were assigned to experimental group with fifty four (54) male students and fifty (50) female students. In like manner, eighty eight students (88) were assigned to control group forty eight (48) male students and forty (40) female students.

Instrument

The instrument for data collection was Chemistry Achievement Test (CAT). CAT was developed by the researchers from the West Africa Examination Council (WAEC) past questions. The instrument was validated by two experts one from department of chemistry Nwafor Orizu Collage of education Nsugbe and one from department of education foundation Chukwuemeka Odumegwu Ojukwu University Igbariam Campus at reliability of 0.81 using Kuder-Richardson formular 20 (KR-20).Twenty-five (25) multiple choice objective questions covering acids, bases and acid-base reaction. The questions have options lettered A-D for students to choose the correct option; any correct answer earns the student four marks. CAT is divided into two sections; section A designed to determine the demographic information of the students and section B contained the objective questions**.** CAT was used for achievement tests. Mean and standard deviation were used to answer research questions while analysis of covariance (ANCOVA) was used to test the hypothesis 0.05 level of significance.

Results

Research Question 1

What is the difference in the mean achievement scores of students taught Chemistry using improvised instructional materials and those taught using standard instructional materials?

Table 2: Mean and Standard Deviation Scores of the Achievement scores of Students Taught Chemistry with Improvised Instructional Materials and those Taught with Standard Instructional Materials.

Instructional Materials	Pre-test			Post-test			Mean Gain Score $\bar{X}$
	N	Mean $\bar{X}$	SD	N	Mean $\bar{X}$	SD	
Experimental Group	104	23.10	14.45	104	63.04	9.87	39.94
Control Group	88	24.11	14.95	88	55.18	10.21	31.07

The results in table 2 showed that the pre-test and posttest mean achievement scores of students taught with improvised instructional materials were 23.10 and 63.04 respectively while the standard deviation scores were 14.45 and 9.87 respectively. On the other hand, pre-test and posttest mean scores of those taught with standard instructional materials were 24.11 and 55.18; and the standard deviations were 14.95 and 10.21. The standard deviation scores for the pretest for both groups were higher than the standard deviations for the posttest. This suggests more variability in the pretest scores of the students than the post test scores.

The mean gain score for students taught with improvised instructional materials was 39.94 while that of their counterpart was 31.07. This represents a mean difference of 8.87 in favour of students taught chemistry with improvised instructional materials which implies that students taught with improvised instructional materials achieved better in chemistry than those taught using standard instructional materials.

Research Question 2

To what extent do the mean achievement scores differ among male and female students taught Chemistry using improvised instructional materials?

Table 3: Mean and Standard Deviation Scores of the Achievement score for Male and Female Students Taught Chemistry with Improvised Instructional Materials.

Gender	Pre-test			Post-test			Mean Gain Score $\bar{X}$
	N	Mean $\bar{X}$	SD	N	Mean $\bar{X}$	SD	
Male	54	24.44	15.53	54	68.19	9.75	43.75
Female	50	20.64	13.19	50	60.72	9.55	40.08

Table 3 shows mean and standard deviation of the achievement scores of male and female participants taught chemistry with improvised instructional materials. From the result the mean achievement score and standard deviation of male students taught chemistry with improvised instructional materials were 68.19 and 9.75 respectively. This gave a mean gain scores of 43.75. Also, the mean achievement score and standard deviation of the female students taught chemistry with improvised instructional materials were 60.72 and 9.55. This gave a mean gain scores of 40.08. However, the mean gain difference between male and female students was 3.67 in favour of male students. This implies that using improvised instructional materials, male students achieved higher in chemistry than their female counterpart.

Hypothesis 1

There is no significant difference in the mean achievement scores between students taught Chemistry using improvised instructional materials and those taught using standard instructional materials.

Table 4. Summary of Analysis of Covariance of the Mean Achievement Scores of Students instructional Taught Chemistry with Improvised Instructional Materials and those Taught with standard Materials.

Source of Variation	Sum of Squares	Df	Mean Square	*F*	*p*-value
Pretest	3388.78	1	3388.78	40.80	.000*
Instructional Materials	3161.79	1	3161.79	38.07	.000*
Error	15696.16	189	83.05		
Total	22027.25	191			

*Significant

The result in table 4 shows that there was a significant difference in chemistry mean achievement scores of students taught with improvised instructional materials and those taught with standard instructional materials, $F(1, 189) = 38.07$, $p=.000$. Since the obtained p-value was less than the stipulated .05 level of significance, the null hypothesis which stated that students taught with improvised instructional materials and those taught with standard instructional materials will not differ in chemistry achievement was rejected. This implies that the mean achievement score of students taught with improvised instructional materials was higher than the mean achievement score of those taught with standard instructional materials. This implies that the significant differences are in favour of those taught chemistry with improvised materials.

Hypothesis 2

There is no significant difference in the mean achievement scores between male and female students taught Chemistry using improvised instructional materials

Table 5. Summary of Analysis of Covariance of the Mean Achievement Scores of Male and Female Students Taught Chemistry with Improvised Instructional Materials

Source of Variation	Sum of Squares	Df	Mean Square	*F*	*p*-value
Pretest	1617.95	1	1617.95	20.72	.000*
Gender	350.62	1	350.62	4.49	.037*
Error	7888.27	101	78.10		
Total	10023.85	103			

*Significant

As shown in table 5, there was a significant difference in mean achievement scores of male and female students taught chemistry using improvised instructional materials, $F(1,101) = 4.49$, $P = .000$. Since the obtained *p*-value was less than 0.05 level of significance, it was decided that the null hypothesis which indicated that there will be no significant difference in the mean achievement scores of male and female students taught chemistry with improvised instructional materials was rejected. Hence the alternative hypothesis was accepted. The mean achievement scores of the male students were higher than their female counterpart. This implies that the significance difference was in favour of male students.

Discussion

The findings of the study showed that students taught Chemistry with improvised instructional materials scored higher in achievement than those taught Chemistry with standard instructional materials. Also the treatment using improvised instructional materials showed significant difference on students' achievement in Chemistry than those taught using standard instructional materials. The finding was in conformity with the findings of Mberekpe (2013), Onasanya and Omosewo (2010), who in a similar studies observed that students taught using improvised instructional materials performed better than students taught using standard instructional materials. Also, the findings of the study were in line with the studies of Uchegbu et al. (2015), who reported that there was a significant effect in students' achievement when they are taught with improvised instructional than those taught without instructional materials

The finding of this study was in contrary to the work done by Attah (2014) and Ibrahim (2012) who reported that there was no significant effect on students' achievement in Physics between students taught using improvised instructional material and those taught using standard instructional materials. Thus the effects of the different instructional materials showed equal

effect on students' achievement. The significant difference was attributed to the use of improvised instructional materials in the teaching and learning of chemistry. This showed that, these improvised materials were of high quality chemical content. Secondly, the students participated in the process of the producing materials without being afraid of harm or damage. Since these materials are of local relevance of them and appealed to their different senses, the students were able to understand the chemistry concepts taught. Hence their experiences enhanced the students' achievement. They were able to taste acids in unripe orange lime to know that its taste is truly sour or were able to feel a base that is slippery. Having these experiences, it was easy to recall that an acid has a sour taste or that a base feels slippery when felt. Therefore, the use of improvised instructional materials encourages creativity, brings learning home wards and better suits the climatic conditions of the local environment, which improves and enhances students' achievement.

Conclusion

Based on the findings of this study, the following conclusions were drawn: The use of improvised instructional materials is effective for meaningful learning to occur. The chemistry students taught with improvised instructional materials achieved higher than those taught with standard instructional materials.

Recommendations

The following recommendations are made in the light of the findings of the study:

1. Chemistry teachers should use as an alternative to standard instructional materials, improvised instructional materials in the teaching and learning of chemistry.
2. Seminars should be organized by the Science Teachers Association of Nigeria (STAN) on how chemistry teachers could use improvised instructional materials to achieve similar results as standard instructional materials.
3. School administrators should also provide financial support for the acquisition of the materials from which improvised instructional materials can be made since they are cheap and readily available.
4. There is need for the teachers to be resourceful in materials selection and planning.
5. Chemistry teachers should seek individual knowledge on how they can convert local materials in their immediate environment as alternatives to standard materials needed for chemistry instructions.

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