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Research Article

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Ability of Form Four Students on Food Test Laboratory Practicals in the Selected Secondary Schools in Tanzania

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ABSTRACT

This study sought to assess the understanding of form four students on food test practical in the selected secondary schools in Morogoro Municipality, Tanzania. Food test is one of the fundamental skills to be acquired by biology secondary education students. The study involved 252 form four students in from four secondary schools within the vicinity of Morogoro Municipality. Data collection was done by the researcher during teaching practice assessment period, June to July 2022 using food test practical test. The test of 35 items was constructed and validated by the researcher. The overall mean score was 12.0 (34.1%) means that on overage selected students have a "D" class, which means poor knowledge level on food test. An analysis of independent samples t-test based on sex at α=0.05 produced a ρ of 0.233 and a t-value of 0.373, hence failed to reject the null hypothesis. To have a broader understanding of students' ability on food test laboratory practicals and attempt generalization through replication of findings, it is advised that a second study with larger samples across the country be conducted.

Keywords: food test, laboratory practicals, material, procedure, data interpretation

INTRODUCTION

Biology subjects is systematic science that is based on observation and experimentation (Hillis et al., 2020). The Tanzania school biology curriculum, among others, aims at developing in the students the manipulative and experimental skills necessary to make them competent and confident in the investigation, as well as inculcating in them scientific approach to problem-solving (URT, 2010). Biology classes should focus on laboratory works. According to Imanda et al. (2020), practical work is any teaching or learning activity which involve the students in observing and manipulating the materials they are studying. Without including actual practice, no topic in biology can be said to be completely taught. Practicals gave students an opportunity to associate and value the theoretical aspects of biology (Hinton, 2004). This means that biology students need to develop their abilities to conduct experiments and learn to observe, record, calculate, and draw inferences (Athuman, 2017). This is in line with the 2010 Tanzania biology syllabus, which emphasizes inclusion of theory and classroom knowledge to application in everyday life. Practical activities are not only motivational but also, they enable students to apply their knowledge of biology in investigative situations, which in turn aid learning and memory, and stimulate their interest (Hillis et al., 2020).

Tanzania introduced the so-called "competence-based curriculum" in 2005, a program that placed an emphasis on students' competence in scientific and investigative abilities among other things. The present curriculum emphasizes a two-forged strategy to improve students' practical abilities and assess their academic understanding (Athuman, 2017). As a result, laboratory experiences constitute a crucial component of the science curriculum. For instance, according to URT (2010), biology students should be able to plan, record, evaluate, and interpret data from practical studies by the end of form four. They should also be able to provide pertinent scientific knowledge using the right technologies and procedures. The curriculum's other goals state that students should be able to acquire the practical science abilities they need and be able to use those skills and procedures to interpret diverse types of scientific data (URT, 2010).

Students examine various food samples for lipids, proteins, vitamins, and carbohydrates like sugar and starch during these practicals (Paszko & Turner, 2021). Students also analyze a solution of unknown food substances for lipids, protein, starch, and reducing and non-reducing sugars. Many crucial food ingredients can be found using simple chemical tests. Some tests assess the amount of a compound in food, whereas others measure its presence in food (Helmenstine, 2021). Important tests include those for the three main categories of organic compounds: carbohydrates, proteins, and lipids (Helmenstine, 2021). In these practicals, students must first answer questions on digestion and nutrition before recording their process, observations, and conclusions. The term "laboratory activity" is used to describe the hands-on activities that students complete in a lab while using chemicals and equipment (Mshayisa & Basitere, 2021). It is not required to cover biology's theoretical and practical components separately; rather, they should be taught as sections of a subject rather than as a separate discipline (Athuman, 2019).

Problem Statement

The requirement for students to develop practical laboratory skills has been heavily emphasized in Tanzania's recently amended competence-based policy of 2010. Food test is one of the key laboratory practical skill that students must learn. Food tests offer an excellent way to expose students to certain qualitative chemical testing while creating some clear connections between themes within biology and chemistry. However, there is no clear evidence whether or not learners are acquiring competence in these fundamental skills as prescribed in the new curriculum policy. Therefore, it was necessary for this study be conducted to assess the knowledge levels of Tanzania biology in this area. Form four selected students in Morogoro Municipality schools were taken as a case study. The study investigated the ability of students in specific food test practical components namely

1. ability to deduce aim of the experiment,
2. knowledge on the materials needed for the practical,
3. knowledge on procedure for the specific experiment,
4. ability in deducing hypothesis, and
5. ability in interpreting results.

Research Objectives

General objective

The general objective of this research was to assess the knowledge of form four students on food test practicals at the selected secondary schools in Morogoro Municipality.

Specific objectives

1. Examine the general knowledge of form four students on the of food test practicals at the selected secondary schools in Morogoro Municpality.
2. Assess competence of students in deducing aim of the experiment, materials needed for practical, hypothesis formulation and in interpretation of the results.
3. Determine students' knowledge on food test practicals based on their sex.

Significance of the Study

Examining the microbiological, biochemical, and physical properties of food is the responsibility of a food scientist. Food is categorized primarily into three groups: proteins, lipids, and carbohydrates. Holistic understanding biological themes requires students to take biology laboratory practical training. According to recent studies, teaching strategies should adapt to encourage students to actively participate in and comprehend complex scientific ideas (Millar, 2010). Students should comprehend processes and structures, as well as learn how to manipulate objects, process scientific data, and carry out scientific experiments. One of the foundational experiments for students in biology is the food test. In these practicals, students examine a mixture of unidentified food materials for lipids, starch, protein, reducing and non-reducing sugars, and starch. These experiments should be done once pupils have a broader knowledge of how to test foods for proteins, carbohydrates, and fats. They record their material, procedure, observation, and conclusions, then answer questions about nutrition and the human digestive system. This study explored the competence of students in this very basic practicals. These findings are as alert for the stakeholders on the extent to which students are acquiring competence and skills as prescribed by the current education policy so that necessary measures can be taken.

LITERATURE REVIEW

Meaning and Importance of Test to Students

Several biologist have defined the meaning of food test. Helmenstine (2021) define food test as the process of identifying a number of important compounds in food. Some tests measure the presence of a substance in food, while others can determine the amount of a compound (Helmenstine, 2021). Examples of important tests are those for the major types of organic compounds: carbohydrates, proteins, and fats. Vats (2014) maintain that food tests provide a great opportunity to introduce students to some qualitative chemical tests, making some explicit links between Biology and Chemistry topics. All of these chemical tests can be learnt, but it's even better if the chemistry behind them is understood. According to Vats (2014), the main food tests include Benedict's test for glucose, the iodine test for starch, testing a potato to prove the presence of starch, the Biuret test for protein and the test for vitamin C. Food tests enable an experimenter to find out what food types a food contains. There are different tests which can be used to detect carbohydrates, proteins, and lipids. They involve adding a reagent to a food sample which changes color depending on what biological molecules are present (Whittle & Bickerdike, 2015). Sometimes it may be necessary to crush the food or add water to the food, as done in this experiment, before adding the reagent. Learners should then be allowed to use these tests on more complex foods e.g., a whole meal (Vats, 2014). These can be obtained from a school kitchen or from a fast-food restaurant. A single meal typically provides enough material for a class to test. This allows learners to test for foods where the results are not already obvious before the experiment e.g., fat in oil; but may introduce some interesting results for example testing a burger bun for fat (Mshayisa & Basitere, 2021). Another advantage of using a meal is that the food is often more 'colorful' than the standard examples. Learners can therefore evaluate the results and use their problem-solving skills to try and find appropriate solutions to testing colored food (Vats, 2014).

Table 1. Color changes during food testing (Helmenstine, 2021)

Food sample	Reagent	Method	Initial color	Color of positive result
Reducing sugar	Benedict's	Add Benedict's reagent to the food & boil in a water bath	Blue	Brick red precipitate
Starch	Iodine	Add iodine reagent to the food	Yellow-brown	Blue-black
Protein/amino acids	Biuret	Add Biuret reagent to the food	Blue	Lilac/purple
Fat	Ethanol	Add ethanol to the food to dissolve the fat, then add water	Colorless	White emulsion

Note. Biuret: A mixture of sodium hydroxide and copper sulfate

Methods of Food Test

There are different tests which can be used to detect carbohydrates, proteins, and lipids. According to Vats (2014), these tests involve adding a reagent to a food sample which changes color depending on what biological molecules are present. Sometimes it may be necessary to crush the food or add water to the food before adding the reagent (Vats, 2014). According to Whittle and Bickerdike (2015), carbohydrates include starch, which is made of glucose and reducing sugars are the compounds, which provide energy to living cells. Reducing sugar is defined as "the sugar contains aldehyde groups that are oxidized to carboxylic acids" (Vats, 2014). Proteins are essential compositions of all living cells which are made of amino acids. For instance, enzymes, hormones, and antibodies those are necessary for the regular functioning of human beings (Mshayisa & Basitere, 2021). The lipid is a huge and various group of the organic compounds which has ionic water-soluble heads and a chain of organic tails. Besides, their solubility depends on non-polar organic solvents (Mshayisa & Basitere, 2021).

Color Changes and Detection of Food Presence

Each kind of substances reacts with the different reagent. For instance, starch becomes blue-black color when iodine solution is added (Vats, 2014). The principle of it is that starch focus helices form around iodine anions, which can form a dark blue or black color (Mshayisa & Basitere, 2021). Vats (2014) also suggests that glucose becomes yellow or red when added to Fehling's reagent at elevated temperatures (Mshayisa & Basitere, 2021). In testing for the presence of starch, color is obtained as a result of a characteristic chemical reaction between the iodine and starch molecules. If no blue-black color is observed, then this would have been a negative test meaning no starch is present (Whittle & Bickerdike, 2015). Another test is done for reducing sugars. Benedict's solution is usually added to solution. The test tube was placed in a boiling water bath in order to facilitate the reduction of copper ions in the Benedict's solution by carbohydrates (Whittle & Bickerdike, 2015). This is the main principle of Benedict's test. This is a positive test for reducing sugars the solution if a brick red precipitate is observed (Whittle & Bickerdike, 2015). If a blue color is obtained, then the test is said to be negative. The test for fats and oils is done using an ethanol test (Mshayisa & Basitere, 2021). This test is called an emulsion test because it causes test solutions to be suspended in the ethanol, allowing lipids present to dissolve since fats are soluble in alcohol (Helmenstine, 2021). When water is added the fats "fallout" the solution since they are not soluble in water. This forms a cloudy emulsion. This is taken as a positive test since a yellow creamy substance is observed (Whittle & Bickerdike, 2015). The test is for proteins. This test is done using Biuret's test. This test relies on the color change of test samples after biuret's solution is added. If the color change results in a purple color, then protein is present. This purple color is derived from a chemical reaction between amino acids in protein and the copper ions in the biuret solution (Mshayisa & Basitere, 2021). **Table 1** summarizes color changes during food testing.

METHODOLOGY

Study Area

This study was conducted in the four conveniently selected secondary schools Morogoro Municipality. The municipality is in the eastern part of Tanzania, 196 kilometres west of Dar es Salaam, the country's largest commercial city, and 260 kilometres east of Dodoma, the country's capital city. The municipality has a total of 34 government secondary school and 26 privately owned ones.

Research Design

This study is basically descriptive research. This is because it intended to provide descriptions of the knowledge level of form four biology students in selected on the food test practicals. Descriptive statistics were also used to analyze overall general knowledge, and students' performance by specific practical areas in an attempt to determine whether performance differs with the subscale of practical skill.

Population and Sample Size

The population for this study was the form four biology at Morogoro Municipality, Tanzania. However, only four secondary schools were conveniently selected to provide of students for the sample of the study. The choice of form four was from the fat that these students are in their final year of their ordinary secondary education. The assumption here is that they are finalizing the contents of the curriculum. So, the findings will allow the researcher to have a fair judgment on whether the curriculum is implemented, and students are acquiring competences prescribed. All form students in these four schools who were willing were involved in the study. This implies that no sampling technique was employed to obtain the appropriate sample size. As indicated in **Table 2**, the sample size was 252 students of which 137 (54%) were male students and 115 (46%) of the subjects were female.

Data Collection Instrument

In assessing the knowledge level of Biology students in food test practicals, a food test practical test was constructed and used for data collection. The test measures five subscales of carrying out food test (knowledge on the aim of the practicals, materials needed, procedure, theoretical knowledge, and interpretation of results). Each subscale was

Table 2. Schools and number of students that participated in the study (2022 research survey data)

School	Sex	n	Number of students
Kihonda	Male	38	76
	Female	38	
Uwanja wa Ndege	Male	46	87
	Female	41	
Kauzeni	Male	20	36
	Female	16	
Mgulasi	Male	33	53
	Female	20	
Total		137 (54%)	252
		115 (46%)	

Table 3. Test scores grading system (URT, 2022)

Range of scores	Corresponding percentage	Grade	Description of food test practical ability
0-6	0-19	F	Very unsatisfactory
7-10	20-29	E	Unsatisfactory
11-13	30-39	D	Below average
14-17	40-49	C	Average
18-20	50-59	B	Satisfactory
21-26	60-74	B+	Very satisfactory
27-35	75-100	A	Excellent

measured by seven items making the tool to have a total of 35 items. In answering, most of the questions demand students just to briefly describe, state and give reasons. The test fits with the context of Tanzania and the competence-based curriculum being implemented.

Procedures and Administration

Students were informed of the aim and importance of the test before to each administration. Under the supervision of biology teachers and a researcher, the exam was given to all students in each school at the same time, throughout the course of the regular school day. The test was again voluntary and lasted one hour. All participating pupils kept their identities confidential. Sex and the school's name were the only demographics that were gathered. The only use of student test results was for research; they were not returned to the students. Students were advised of their right to access their grades, nevertheless.

Each test's completed papers were collected, and teachers were not permitted to keep them or copy them. Each exam script was marked. For the purposes of scoring test scripts, each correct response received one mark, while any incorrect, omitted, or multiple-choice answers received zero points. The total number of accurate answers was determined, and the percentage of correct answers out of all possible answers (items) was computed.

Grading System of Students' Performance in the Food Test Practical

In grading biology students' performance on the food test practical exam, Tanzania's grading method for students at the ordinary level was used. The National Examination Council of Tanzania modified this scale in 2014, which divides student scores into seven categories. A grade is between 75% to 100% and denotes a very satisfactory or excellent performance, while a grade of B+, which goes from 60% to 74%, denotes a reasonable or good performance. According to the scale, a student will receive a grade B if their score falls between 50% and 59%, which denotes "good or above average," and a grade C (average) if their score falls between 40% and 49%. Grade D, which is given for a performance rating of between 30 and 39%, stands for "below average" or "unsatisfactory." The grades E and F, which stand for poor and very poor, are given to pupils who receive scores between 20% and 29% and 0% to 19%, respectively. Following marking, student scores were converted to percentages, then following the aforementioned criteria, they were divided into seven groups and presented in the manner depicted in **Table 3**.

Data Analysis Plan

Descriptive statistics were used to analyze overall practical test performance and performance by specific practical subscale. Students' score was analyzed using SPSS version 25.0. Descriptive analysis of frequencies, percentages, means (Ms), and standard deviations (SDs) was used to categorize, organize, and analyze student scores. Analysis of variance and independent samples t-test, on the other hand, were used to statistically determine whether there was the difference in the scores of students based on their sex and type of school.

RESULTS AND DISCUSSION

General Performance of Selected Students in Food Test Practicals

The first objective of this study was to assess the general knowledge level on food test practicals of selected biology students by using a researcher constructed practical test. The test was administered to a group of 252 students. The study involved 137 (54%) male students and 115 (46%) female students. To evaluate the Ms, SDs, percentages, and frequency distributions of the scores, descriptive statistics were performed. Descriptive statistics indicates that students' average score was 12 (34.3%) with an SD of 8.1. The highest

Table 4. Descriptive statistics of student scores in the food test instrument (n=252)

Range of scores	Corresponding percentage	Grade	n	Percentage of students	Description of the knowledge level
0-6	0-19	F	29	11.5%	Very unsatisfactory
7-10	20-29	E	51	20.1%	Unsatisfactory
11-13	30-39	D	54	21.4%	Below average
14-17	40-49	C	58	23.1%	Average
18-20	50-59	B	26	10.3%	Satisfactory
21-26	60-74	B+	20	7.9%	Very satisfactory
27-35	75-100	A	14	5.6%	Excellent

Note. Source: 2022 field data

Table 5. Descriptive statistic of the test and its component subscales (n=252)

Specific food test subscale	Total items	Lowest mark	Highest mark	Mean mark	SD	Percent correct
Deducing the aim of the food test experiment	7	0	6	4.05	0.88	57.8
Knowledge of materials needed for the experiment	7	0	6	3.49	1.43	49.8
Knowledge procedure	7	0	6	3.71	0.96	53.0
Ability in setting hypothesis	7	0	5	2.34	0.75	33.4
Ability in interpreting results	7	0	6	3.27	0.96	46.7

Note. Source: 2022 research survey

score was 30 (85.7%) and the lowest 0 (0.0%) out of 35 possible. 58 (23.1%) students out of 252 scored 16 (45.7%) out of 35 and this was the mode score. About 29 students (11.5%) of all students who participated in the test failed to score a single mark as shown in **Table 4**. More statistics descriptive to the general performance in food test is given in **Table 4**. According to **Table 4**, majority of selected biology students scored below average on the food test. Some 20 (7.9%) students out of 252 in the sample had satisfactory knowledge of food test as they scored between 21 to 26 items as shown in **Table 4**. 14 students had excellent performance.

Only 14 (5.6%) out of 252 students received an A, according to **Table 4**. Both of these kids, who received exceptional grades, achieved a score of 27 out of 35, or 77%. Skewness of scores, a measure of how far a score distribution deviates from symmetry around the mean, was also calculated, and a result of 0.039 was found. Positive 0.039 skewness shows that there were significantly smaller values than the mean (von Hippel, 2011). Additionally, it shows that the majority of test-takers received below-average results. On the other hand, the overall mean score was 12.0 (34.1%), which indicates that on average, chosen students answered 11 to 13 of the 35 questions in the test correctly.

According to the grading system of Tanzania adopted in this study, 34.1% represents a "D" class, which means unsatisfactory ability on food test. This means that on overall, selected biology students have poor knowledge level on food test practicals. For example, 179 (71%) of students in the sample were not able to state the procedure for the Benedict's test for reducing sugars, while 170 (67.4%) failed to mention expected observations for the Benedict's test for reducing sugars. In addition, 166 (65.8%) students in the sample failed to explain why we need to heat the solution and why does starch produce a negative result with Benedict's solution unless acid is added.

Given the importance put in the subjects' learning of practical skills in their syllabus, the performance of the students in this test is considered to be unsatisfactory. There are a number of potential explanations for the students' "mediocre" performance, including the possibility that many were unfamiliar with the activities and methods of assessment utilized in this study. According to Athuman (2017), students' success on practicals was reliant on their familiarity with and participation in domain-specific practice exercises that honed the skills in earlier tasks. In a related line, Sahranavard and Hassan (2018) argued that students' performance on practicals depends on how well-versed they are in the contexts they are required to work on. This is also supported by the observation that performance of tasks requiring these lab practical abilities is substantially content-dependent (Athuman, 2019). Biology instructors must take advantage of opportunities to emphasize practicals during in-class activities.

Performance by Specific Subscale of the Practical Work

Another objective of this study was to examine the performance of selected form four biology students on the five specific subscales of practicals namely

1. ability in deducing the aim of the food test experiment,
2. knowledge on materials needed for the experiment,
3. knowledge specific practical procedure,
4. ability in setting assumptions and hypothesis, and
5. ability in interpreting results.

In order to do further analysis, the five subscales of the complete practical test were broken down. **Table 5** presents the calculated mean scores and standard deviations for each subscale as well as the total sampled students. Correct response rates were highest for the subscale of determining the purpose of the practical, with a mean score of 3.7 (52.7%), and lowest for the ability for results interpretation, with a mean score of 1.8 (25.7%). The mean of a raw score of data interpretation subtest was low, indicating that the students found the questions measuring their ability to interpret results more difficult. For example, 166 (67.7%) of students in the sample fail to state the role of copper sulphate, sodium carbonate and of sodium citrate in Benedict's solution. **Table 5** is a summary of descriptive statistics for each subscale of the test.

As seen in **Table 5**, a sample of students demonstrates that participants did perform somewhat better on the subscale of

Table 6. Group Statistics t-test for test scores based on sex (2022 field data)

	Sex of respondent	n	M	SD	Standard error mean
Food test practical skills	Male	137	12.3143	2.10537	0.14684
	Female	115	12.4286	2.13622	0.31473

Table 7. Independent samples t-test for test scores based on sex (2022 field data)

		Levene's test		t-test for equality of means			MD	SE	95% CI	
		F	Sig.	T	df	Sig. (2-t)				
Food test practical skills	Equal variance	0.56	0.8	-0.4	61	0.233	-0.11	0.28	-0.681	.453

Note. MD: Mean difference; SE: Standard error; & CI: Confidence interval

determining the purpose of the food test, probably as a result of the fact that the majority of the questions requiring this skill provided explicit instructions on what the students should look for. However, a careful evaluation of the test scripts for the students showed that very few of them had the skill to comprehend tables and graphs.

Many students are unable to do the formal operations that are necessary for this ability, according to Piaget (Sahranavard & Hassan, 2018). The subjects did reasonably well when it came to interpreting data, which required them to extract information from graphs and tables, but they did less well when it came to generalizing, which involved drawing conclusions, extrapolating between and beyond data points, and finding supporting evidence. Performance of selected biology students by subscales is consistent with findings from Athuman (2019), in which students performed better on tasks assessing their knowledge of variables and formulation of hypotheses but less well on tasks assessing their knowledge of graphing and data interpretation.

The Influence of Sex on the Knowledge Level of Students on Food Test Practicals

The study also sought to investigate the influence of sex on the knowledge level of selected biology students of food test practicals. Independent t-tests were performed on students' test results based on their sex. Independent t-test was suitable for this kind of analysis because the test involved testing the mean scores of only two independent groups (males & females). The study involved 137 male and 115 female students. When the null hypothesis (Ho) was put through an independent samples t-test, there were no statistically significant variations between students' knowledge of food test practicals based on their sex. Null hypothesis (Ho) stated that there is no statistically significant difference between students' scores on a test of food test based on their sex.

A sex-based analysis of independent samples t-test with α=0.05 resulted in ρ of 0.233 and a t-value of 0.373, which meant that the null hypothesis was not successfully rejected. A t-test failed to show a statistically significant difference between the mean score of male students (M=2.3143, SD=2.10537) and that of female students (M=2.4286, SD=2.13622), as shown in **Table 6** and **Table 7**.

As a result, the null hypothesis (Ho), which states that there is no statistically significant association between a student's sex and their ability of food test, was accepted at the 0.05 α level. The findings from the independent samples t-test based on students' sex are summarized in **Table 6** and **Table 7**.

The findings presented above on a sample of students are consistent with those of Athuman (2017), who studied how male and female students combined content knowledge with science process skills. The researcher found that student sex did not significantly affect the variation in students' development in the science process skills. However, Okon and Archibong (2015) found that female students struggled more than male students with issues involving chemical problem-solving. These findings, however, differ from the recent study by Bailey et al. (2020) who found that female participants had a much higher ability for solving numeric issues than their male colleagues.

CONCLUSION AND RECOMMENDATIONS

As with the Tanzania's competence-based curriculum of 2005, practical skills have been acknowledged as a key component of science education. This study assessed the knowledge on food test practicals of form four students in selected secondary school in which is located in Morogoro Municipality. The study also studied the ability of students in namely

1. deducing the aim of the experiment,
2. materials needed for the experiment,
3. practical procedure,
4. setting assumptions and hypothesis, and
5. in interpreting results.

Based on the food test practical test scores, it was found that selected students have poor knowledge on food test practicals. The overall mean score was 12.0 (34.1%) means that on overage selected students have a "D" class which means poor knowledge level on food test. However, the chosen students performed somewhat better on items that assessed their ability for determining the purpose of food test experiments, with a mean score of 1.8 out of 7 items, and they performed worse on items that assessed their ability for interpreting data, with a mean score of 3.7 out of 7 items. It can be suggested every student in Tanzania should perform practical exercises, not just the few tested on national exams. On the other hand, teachers should employ a wide range of hands-on activities to build a deep understanding in their students. However, due to the nature of this study and the sample size used, it is difficult to generalize these results. To comprehend the phenomenon being studied and attempt generalization through replication of findings, another research involving larger samples across the country is required.

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