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by Julie Hongki

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Analysis of grade VII students' learning outcomes for animals classification and sets by using the STEM approach

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Abstract. With the global economic system emerging in the 21st century, learning in the fields of science, technology, engineering, and mathematics (STEM) has gained a very important role in increasing the role of a country in the global economy. Therefore, learning in all four fields is focused on the emergence of innovative solutions to a complex contextual problem facing the world today. The purpose of this study was to describe the learning outcomes achieved by students for animal classification in science and set in mathematics after students experienced the learning process with the STEM approach. The Gravemeijer and Cobb design research model used in this study. The research subjects in this study were 34 students of class VII D of SMPN 1 Yogyakarta. The instrument used in this study was a test. In the learning process, to help students understand how the process of classifying animals in science, and how to make sets, determine membership requirements from a set, and write down membership from a set, students were invited to make observations about animal characteristics and animal placement in the Gembiraloka zoo. 65.63% of students could define the meaning of a set, make a set along with the terms of membership, and write down the membership of a set.

1. Introduction

Based on Minister of Education and Culture Regulation No. 14 of 2018 concerning penerimaan peserta didik baru (PPDB) TK, SD, SMP and SMA / SMK or other forms are equivalent in the form of zoning [1]. This type of PPDB aims to ensure that PPDB runs in an objective, transparent, accountable, non-discriminatory, and equitable manner in order to encourage increased access to education services. In the 2018/2019, Yogyakarta applies a zoning system for PPDB purely based on the student's domicile or the closest distance to the student's residence address based on C1 or family card (KK). As a result, the value of admission of students is very diverse, and most of the entry value becomes low which results in classroom learning requires appropriate learning strategies, so that learning objectives can be achieved.



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SMP Negeri 1 Yogyakarta is one of the schools that experienced the impact of PPDB zoning. This school consists of 24 classes, namely classes VII, VIII, and class IX each in 8 classes. Class VII D is one of the classes with poor input, students in this class have low learning motivation, individualists and lack the attitude of cooperation or collaboration.

Mathematics is seen as difficult material by most students. This results in students being less interested in learning. When learning in class, teachers still use conventional methods, namely lecture and learning methods are still teacher-centered. The challenge of learning in the future, a teacher must make learning innovations, so that learning becomes interesting, fun, and more meaningful. By observing this facts, it is necessary to improve the learning process in the classroom, including by implementing a learning approach that can foster an attitude of cooperation between students.

The rapid development of technology and communication in the era of globalization characterizes modern society in the 21st century as rational, open, forward-thinking, creative, independent, respecting time and innovating. In the world of education, a teacher is expected to be able to present learning that is able to foster collaboration skills, problem solving, critical thinking, creativity, communication. STEM learning has an important role in a country's global economic growth. According to Ref [2], STEM is an acronym for science, technology, engineering, and mathematics. The term STEM was launched by the US National Science Foundation in the 1990s as a theme of the education reform movement in the four disciplines to grow the STEM field workforce, as well as develop STEM-literate citizens, and enhance US global competitiveness in science and technology innovation. Science is one component of STEM that examines natural phenomena and requires observation or observation. According to the National STEM Education Center, STEM education does not only mean strengthening the praxis of education in STEM fields separately, but developing an educational approach that integrates science, non-engineering, engineering, and mathematics, focusing on the educational process of solving real problems in daily life and professional life. According to [3], in the context of primary and secondary education, STEM education aims to develop STEM literate students who have:

- a. knowledge, attitude, and skills to identify questions and problems in their life situations, explain natural phenomena, design, and draw conclusions based on evidence regarding STEM related issues;
- b. understand the characteristics of STEM disciplinary features as forms of knowledge, investigation and design initiated by humans;
- c. awareness of how STEM disciplines shape the material, intellectual and cultural environment,
- d. want to be involved in the study of STEM-related issues (eg energy efficiency, environmental quality, limited natural resources) as constructive, caring, and reflective citizens using scientific, technological, engineering and mathematical ideas. The definition of STEM education is an interdisciplinary approach to learning, in which students use science, technology, engineering, and mathematics in real contexts that connect between schools, the world of work, and the global world, so as to develop STEM literacy that enables students to compete in the economic era new knowledge-based [4].

STEM-based learning can be made a solution to provide opportunities for students to foster an attitude of cooperation and integrate several subjects. In this study we integrated the set material on Mathematics subjects and the Classification of Living Things on science subjects. This study aims to analyze the results of daily tests related to the concept of sets in Mathematics and animal classification material in science subjects taught by the STEM approach.

2. Method

This study was design research which use Gravemeijer and Cobb. Akker, Gravemeijer, McKeney, and Reeves [5] stated that design research can be characterized by: (1) Interventionist : the research led to an intervention in design in the real world; (2) Iterative : research includes a cyclic approach to design, evaluation, and revision; (3) process oriented: a research model that avoids the measurement of inputs and outputs, focuses on understanding and improving interventions ; (4) usability oriented: the benefits

of design are measured by seeing the practicality of design for the user in reality; (5) theory oriented : design (partly) is constructed based on existing theory, and testing of the design contributes to the development of theory.

This study is conducted at SMP Negeri 1 Yogyakarta¹² on 25 August 2018 to 7 September 2018. The research subjects are 34 students of VII D class. The instrument used in this study is a test or evaluation. The teaching and learning process has purpose to help students in understanding how the classification of animal in science, how to distinguish between set and not set, determine the requirements for a set element, and stating the element of set.

Observations were carried out by students in groups by documenting pictures of various kinds of animals at the Gembira Loka Zoo in Yogyakarta. Photographs of the animals are printed and cut, and taped and grouped based on certain characteristics, for example based on food types, mobile devices and others. From this data students fill in the instruments that have been prepared by the researcher in the form of a questionnaire related to the concept of set, element of set and how to present the set. Evaluation was carried out to determine the level of student understanding of the learning process. The data obtained were analyzed qualitatively by: 1) the results of the evaluation of each student grouped according to the items to be analyzed; 2) similar student answers are grouped; 3) each student's answers are calculated.

3. Results and discussion

This research began with conducting learning outside the classroom, where students visited the Gembira Loka zoo on Saturday, August 25, 2018 to find data in the form of photographs of various animals there. Photographs of the animals will be used to find the concept of the Set for mathematics and animal classification in science lessons. This research is limited to four indicators: 1) The concept of set so that students can understand the meaning of set, 2) provide examples of sets, 3) distinguish set and not set, 4) How to present the set.

After did the observation in the zoo, each group sent their documentation to the researcher via email. From the photos, various types of animals is selected then to be printed and used for classroom learning for the next meeting. The first meeting is conducted at 3 September 2018 with pretest about animals classification and set. Students fill out a list of questions prepared by the researcher. he researcher explained the activities that will be carried out in the next several meetings and the tools that must be brought by each group. The researcher also explained that there was a task that had to be done by each group which was to design a zoo enclosure using manila paper or cardboard. They were also asked to present the results of the cage design, video the results of the presentation, and upload the videos they had made. Each group competed to get the most likes from people who watched their videos.

The second meeting is conducted at 5 September 2018. In this teaching and learning process, students will discuss the classification of living things, specifically the classification of animals. Students formed group which consist of 4 to 5 students. Each group was given several photos of animals and Student Activity Sheets. They were asked to cut and paste the photos based on the characteristics of animals that they observed. There are students who group by body of motion, type of food, how to breed and others. Students also filled the Activity Sheets related to set concepts, set membership and how to present them. Researchers guided students who have difficulty. After completing the discussion, students are asked to present the results of their discussion, but because the learning time is over, the presentation will be held on the next meeting.

The third and last meeting is conducted at 7 September 2018. Students present the results of their discussions regarding animal classification and set concepts. After the presentation is complete, students are directed to draw conclusions about the animal classification, defining the meaning of sets, distinguishing sets and not sets, and determining how to write or present the set. At the end of the lesson, students are given an evaluation question about the set and animal classification.

Results

The evaluation question about sets concept and how to present them of class VII D of SMPN 1 Yogyakarta school year 2018/2019 consists of 4 questions in the form of essay and attended by 32 students. The following is a table of the results of the evaluation and grouping of students' answers to each question:

Question No.	Indicators	Number of Students	Percentage
1	Defining the definition of set a. Defining the definition of set using two keywords b. Defining the definition of set using verbs c. Defining the definition of set using one keyword d. Defining the definition of set using verb and one keywords	21 6 4 1	65, 63 % 18, 75 % 12,5 % 3,125 %
2	Writing three examples of set including the reason a. Writing the example of set including the correct reason b. Not writing the conceptually correct example of set and not stating the reason c. Writing 3 ways of animal movement, reasons not appropriate d. Writing 3 members of the set, the reasons given are the characteristics of the animal e. Writing 3 examples of sets without reasons	14 13 3 1 1	43, 75 % 40, 63 % 9, 375 % 3, 125 % 3, 125 %
3	Writing one example of not set including the reason a. Writing an example of not set, with the right reasons b. Not writing examples not set according to the concept, the right reason c. Not writing examples not set according to concept, without reasons d. Not writing examples not set according to the concept, the right reason e. Writing the examples of sets without reasons	14 12 3 2 1	43, 75 % 37, 5 % 9, 375 % 6, 25 % 3, 125 %
4	States the set in 3 ways with examples a. Can express the set in 3 ways with an appropriate example b. Can express the set in 3 ways, not accompanied by examples c. Write down 3 characteristics of animals based on locomotor, food, and breeders d. Can express the set in one way with an appropriate example e. Can declare the set in 2 ways, examples are not appropriate f. Cannot declare a set in 3 ways	15 3 11 1 1 1	46, 875 % 9, 375 % 34, 375 % 3, 125 % 3, 125 % 1, 125 %

The explanation of each categorization is as follow:

A. Question Number 1

Question : What is the meaning of set?

In the set there are 2 keywords that must be met, namely:

1. Collection of objects
2. Have the same properties

Students' answer :

1. 1st classification

There are 21 students that defined set as follow:

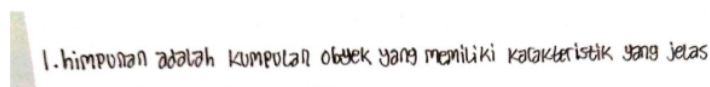


Figure 1. One of the student's answer

The twenty-one students define the set as a collection of objects that have clear characteristics. The definition made by students is correct, because the definition of a set there are 2 keys, namely a collection of objects and have the same property. So, twenty students can define the meaning of the set. As a result, 21 students can fulfill indicator of question number 1.

2. 2nd classification

There are 4 students that defined set as follow:



Figure 2. One of the student's answer

The four students define the set as grouping clear characteristics. The definition made by students is not right because the keywords "collection of objects" are not fulfilled but they write groupings which means a work or activity. Maybe they are tricked by the learning process where there are activities of students who group animals based on their characteristics. So the four students have not been able to fulfill the question number 1 indicator.

3. 3rd classification

There are 2 students that defined set as follow:

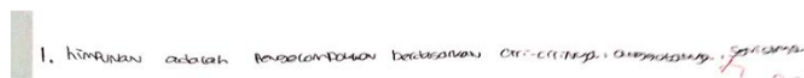


Figure 3. One of the student's answer

Both students define sets as grouping based on their characteristics, members, types. The definition made by students is not right because they use verbs, consequently the two students have not fulfilled the question number 1 indicator.

4. 4th classification

There are 3 students that defined set as follow:



Figure 4. One of the student's answer

The three students define the set is grouping by object. The definition made by students does not meet the indicator question number 1 because the keyword mentioned is only one, namely a collection of objects. Students have not been able to connect or draw conclusions from learning activities. Even

though the process of finding the definition of a set, students group animals that have the same characteristic. So that Sehingga three students did not meet the question number 1 indicator.

5. 5th classification

There is one student that defined set as follow:

1. Pembagian kelompok dengan karakteristik yang jelas

Figure 5. The student's answer

This student have been able to write one key from the definition of a set of characteristics that are clear, but do not understand that the set is a group or group, the cause is when they group photos of animals they see are activities that have been carried out, should the results of their activities be shaped a collection of animals with the same characteristics. So that this one student does not meet the question number 1 indicator.

6.6th classification

There is one student that defined set as follow:

1. Pengelompokan makhluk hidup dengan karakteristik yang jelas 24

Figure 6. The student's answer

Student only fulfills one key characteristic of set. Student understands the set as living things. In this student's view, only living things are the set. This error is possible because during visits at zoos, students only take pictures of animals. Thus these students have not fulfilled the question number 1 indicator.

B. Question number 2

Question : Make at least 3 sets and give the reason why they are categorized as set!

In giving examples of sets, students must know when a collection will be a set. A collection will be a set if it can meet the concept of a set. The members of the association are clear or the members can be clearly defined.

Students' answer:

1. 1st classification

There are seven students that gave example of sets as follow:

2> 3 himpunan

- Kelompok hewan bergerak menggunakan kaki
* Karena karakteristiknya / ciri - cirinya adalah sama - sama memiliki kaki dan bergerak menggunakan kaki.
- Kelompok hewan bergerak menggunakan sirip
* Karena karakteristiknya / ciri - cirinya pasti mempunyai sirip dan bergeraknya menggunakan sirip. 25
- Kelompok hewan bergerak menggunakan sayap
* Karena Karakteristiknya / ciri - cirinya juga pasti memiliki sayap dan jika memiliki sayap pasti hewan tersebut terbang jika terbang pasti mempunyai energi - energi udara jadi sudah pasti karakteristiknya sudah jelas.

Figure 7. One of the student's answer

Examples of sets written by students are appropriate because they already contain the words set or group and have clear characteristics. In this example students give examples of sets based on the

animal's body part of movement and are able to provide the right reasons related to the set, so that the seven students meet the indicator question number.

2. 2nd classification

There are two students that gave example of sets as follow:

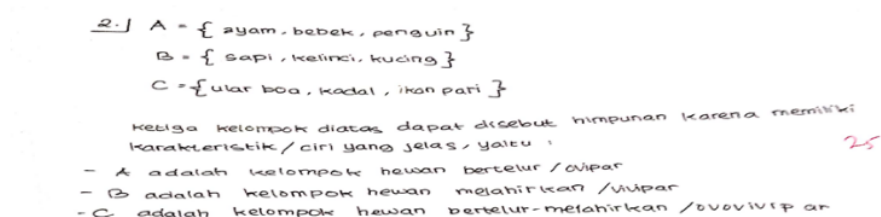


Figure 8. One of the student's answer

Both students provide examples of sets based on their breeding and by writing elements of the set directly according to set stating. The reason given is very precise, namely students are able to group the names of animals according to the appropriate breeding. Thus both students can provide examples of sets and their reasons.

3. 3rd classification

There are five students that gave example of sets as follow:

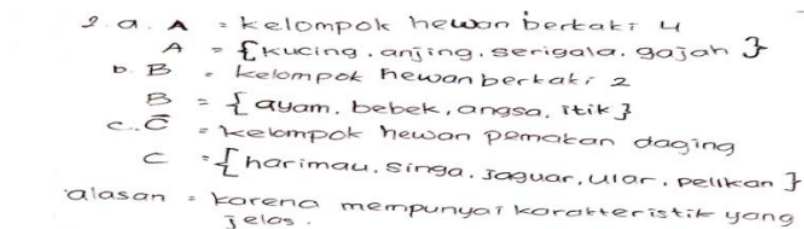


Figure 9. One of the student's answer

The five students gave examples of sets based on movement body part and food. They at the same time write down the members of the animal that are intended. Although the reason given is quite short "because it has a clear character" but the examples given have shown clear characteristics. So that these five students have fulfilled indicator question number 2.

4. 4th classification

There are eight students that gave example of sets as follow:

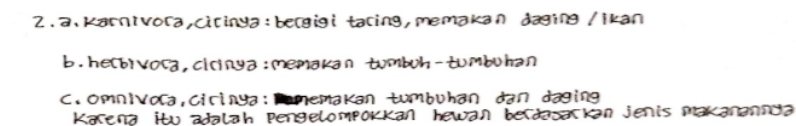


Figure 10. One of the student's answer

The eight students have not been able to give an example of the set exactly according to the definition of the set. Students do not write the set as a group, but write their characteristics based on the type of food. Thus the eight students have not fulfilled indicator question number 2

5. 5th classification

There are five students that gave example of sets as follow:

2. Buatlah minimal 3 himpunan dan berikan alasannya kenapa termasuk himpunan
 Alat gerak
 kaki yang menggunakan kaki : Beruang madu, Biawak, Gajah
 yang menggunakan sayap : Burung cendrawasih, Burung kakak tua, Burung merpati
 yang menggunakan badans ular

Figure 11. One of the student's answer

The example given by the five students has not represented the set because it does not contain keywords and students do not give reasons related to the example written, thus the five students have not fulfilled indicator question number 2

6. 6th classification

There are three students that gave example of sets as follow:

2. Cara bergerak dengan kaki : Kera, Jelas, berak, dan masuk
 dengan Sirip
 dengan Perut

Figure 12. One of the student's answer

The three students have not given the appropriate example of the set and the reasons listed are not related to the example given. Then the three students have not fulfilled indicator question number 2

7. 7th classification

There is one student that gave example of sets as follow:

2. a. Gajah adalah hewan yang besar karena memiliki tubuh yang besar, berat bisa mencapai 5 ton.
 b. Semut adalah hewan kecil karena semut sangat kecil, memiliki tubuh kecil
 c. kelinci itu kecil karena dia bertubuh mungil, kecil, pendek dan ringan

Figure 13. One of the student's answer

The student has not given a set example because he/she wrote the set members is not according to the rules that is not using curly braces. Student also write down the reason in the form of a description of the characteristics of animal not clear. Thus this student has not been able to fulfill indicator question number 2.

8. 8th classification

There is one student that gave example of sets as follow:

2. Himpunan Angkagenap, Himpunan Angka ganjil, Himpunan Bilangan bulat

Figure 14. One of the student's answer

Students can provide examples of sets correctly, but the reasons are not written down. But this student can provide examples of sets, and fulfill some indicators question number 2

C. Question number 3

Question: give an example not a set and give a reason

A collection will not be a collection if it does not have clear characteristics, its members cannot be clearly defined.

1. 1st classification

There are 14 students that gave answers as follow:

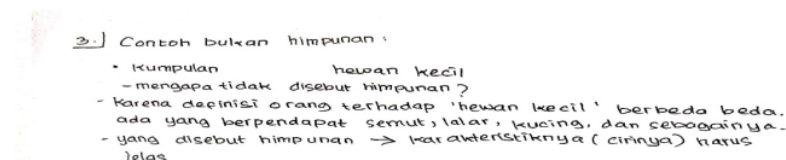


Figure 15. One of the student's answer

The fourteen students can provide examples that do not belong to the set and provide the right reasons. They can write the differences between sets and not sets according to the definition of the set. So that the fourteen students fulfill indicator question number 3.

2. 2nd classification

There are 12 students that gave answers as follow:

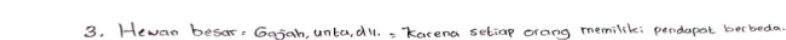


Figure 16. One of the student's answer

twelve students gave examples instead of sets without starting with the set, group / group. They do not write according to the correct rules. The student's answer can be a set example if adding a set symbol and giving curly brackets. For example: $A = \{\text{big animal}\}$. As a result, the twelve students have not fulfilled the indicator question number 3 even though the reasons are correct.

3. 3rd classification

There are 3 students that gave answers as follow:

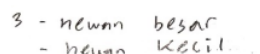


Figure 17. One of the student's answer

The answers given by the three students did not fulfill the requirements because they did not contain the word collection, did not use the set symbol and curly brackets. The three students also did not write down the reasons why the examples they wrote did not belong to the set. So that the three students did not meet the question number 3 indicator.

4. 4th classification

There are 2 students that gave answers as follow:

3. Kereta, mobil, dan motor, karena bukan makhluk hidup

Figure 18. One of the student's answer

Both students write examples and reasons wrong, students assume that the set is related to living things, so that something related to inanimate objects is not an example of a set. As a result, both students did not meet the question number 3 indicator.

5. 5th classification

There is one student that gave example of sets as follow:

7. Himpunan hewan kecil

Figure 19. Student's answer

This student can give an example not a set without any reason.

D. Question number 4

Problem: Write down 3 ways to state the set and give an example!

There are three ways to express a set, namely:

- Stating or mentioning its members
- Mention all the terms / nature of membership
- With set-forming notation

1. 1st classification

There are 15 students that gave answers as follow:

4. a. Menyatakan anggotanya
 Contoh = $A = \{\text{kapir, gajah, unta, sapi}\}$
- b. Menyatakan dengan sifatnya.
 Contoh = A adalah himpunan hewan pemakan tumbuhan
- c. Dengan notasi pembentuk himpunan
 Contoh : $A = \{x \mid x \text{ adalah hewan pemakan tumbuhan}\}$

Figure 20. One of the student's answer

The 15 students stated the set in three ways, namely:

- listing the elements
- describing the elements
- set-builder notation

the fifteen students were correct in writing how to express the set, each accompanied by a suitable example. So that the fifteen students fulfill indicator question number 4.

2. 2nd classification

There are 3 students that gave answers as follow:

4. Menyebutkan anggotanya.
- 1) Menyebutkan anggotanya.
 - 2) Menyebutkan sifatnya.
 - 3) notasi pembentukan himpunan.

Figure 21. One of the student's answer

The 3 students stated the set in three ways, namely:

- listing the elements
- describing the elements
- set-builder notation

Students can state the set correctly, but students do not write examples of each method, consequently the two students only partially fulfill the question number 4 indicator

3. 3rd classification

There are 11 students that gave answers as follow:

4. urtuk menyatakan himpunan ada 3 cara. Berikan 1 contoh dan tuliskan
 cara tersebut

Macam :

alat gerakanya 2 kaki

makanannya : karnivora

alat berkembangbiak : vivipar

Figure 22. One of the student's answer

The eleven students have misperception in writing answers about how to express the set. They precisely write down one example of the animal, and write down the 3 properties possessed by the animal. Although the characteristics that are written are true but cannot represent how to express the correct set. So that the eleven students cannot fulfill the question number 4 indicator

4. 4th classification

There is 1 student that gave answers as follow:

4.1 A) Menyebutkan anggota
 Contoh : $A = \{ \text{ayam, bebek, penguin} \}$

B) Menyebutkan sifat
 Contoh : $\{ x/x \text{ adalah hewan berkaki empat} \}$

C) Notasi
 Contoh : ? (# forget)

Figure 23. Student's answer

This student can write how to express the set in 3 ways. For the first way (method A) students can write the example correctly, but for the second method (method B) that is to mention the nature, students give an example that is not right, this example should be for the third way (method C) that is with notation, so actually students have not given an example of the second way (method B). thus this student can fulfill some of the question number 4 indicators.

5. 5th classification

There is 1 student that gave answers as follow:

4. - Nama anggota : kaki

- sifat : $\{ x/x \text{ hewan yang memiliki dan telinga} \}$

- ~~definisi~~ notasi : pembentukan himpunan

Figure 24. Student's answer

This student writes 3 answers for how to express the set, but for the first way students write the names of the limbs of a living thing, namely "feet" students should write "mention elements". For the second way, students write "traits", the example given is "animals that have ears" and are written with set

notations, and for the third way students write notations = set of sets, both words are separated by equals, without example. The three ways written by these students are not appropriate. As a result, these students have not been able to fulfill indicator question number 4.

6. 6th classification

There is 1 student that gave answers as follow:

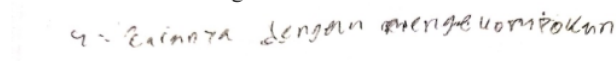


Figure 25. Student's answer

These students may be tricked by learning activities when they discover the concept of set, namely by grouping pictures of animals that they get from the zoo. These students are unable to understand question number 4, consequently students do not fulfill question number 4.

4. Conclusion

1. The STEM approach can assist students in finding set concepts, because students directly observe contextual examples
2. Need to habituate students to develop STEM literacy, so they can have skills, knowledge based on the experience they have gained from a learning activity
3. From the results above, we conclude that:
 - a. There are 21 out of 32 students or 65.63% of students who could define the meaning of the set.
 - b. There are 14 out of 32 students or 43.75% of students who can make examples of set accompanied by the right reasons.
 - c. There are 14 out of 32 students or 43.75% of students who can make examples of not set accompanied by the right reasons.
 - d. There are 15 out of 32 students or 46.875% of students who can state the set in 3 ways.

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