Journal of STEAM Education
Journal of Science, Technology, Engineering, Mathematics and Art Education
2021, Jan. (Issue: 1, Volume: 4)

DEMYSTIFYING THE 'DENSE' PROBLEM OF DENSITY USING 5E LEARNING CYCLE

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Article History

Received: 30 May. 2020

Received in revised form:

6 Nov. 2020

Accepted: 11 Nov. 2020

Published: 12 Jan. 2021

ABSTRACT

The purpose of this action research was in two folds. First, it was to find out the efficacy of the 5E Learning Cycle in improving pupils' understanding of density. And second, to find out whether there will be a significant difference in males and female pupils' understanding of density after the application of the 5E Learning Cycle. All 36 Basic Six pupils of a Basic School in the Assin North Municipality in the Central Region of Ghana were purposively selected to participate in the study. Since the design used was action research, the data collection procedure occurred in three stages: Pre-intervention stage, intervention stage and post-intervention stage. The results of the study showed that the mean score for the post-intervention test was almost twice the mean score of the pre-intervention test. While the girls' mean score showed a 111.26% increase, the percentage increase in mean scores for the boys was 98.68%. However, there was no significant difference between the performance of the boys and girls in the post-intervention test. This study confirmed that by taking pupils through the Engagement, Exploration, Explanation, Elaboration and Evaluation phases of the 5E Learning Cycle, learners will gain an improved understanding of density.

Keywords: 5E learning cycle, Density, basic school, science teaching and learning, inquiry

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Donkoh, S., Osei, J. & Kofi-Annan, M. (2021). Demystifying the 'dense' problem of density using 5E learning cycle. *Journal of STEAM Education, 4(*1), 31-42.

INTRODUCTION

For several decades, potent techniques that encourage learners to construct knowledge for themselves rather than teachers directly revealing information to learners have been advocated by science educationists. These advocacies have resulted in a plethora of theories and techniques for teaching science, especially to children. The conventional teaching technique in which the teacher passes information to passive learners has been seen as an inappropriate technique that dims the creative instinct of learners (Palmer, 2019). Attempts at replacing this conventional approach to teaching have produced a variety of teaching approaches developed through extensive research. These teaching approaches are developed based on learning theories such as behavioral, cognitivist, constructivist, social constructivist and developmental theories (Altan, Lane, & Dottin, 2019). The advantages of using these innovative approaches effectively have been extensively documented and can be summarized as *effective use of innovative approaches in teaching and learning lead to an improvement in retention of learners and learners' understanding concepts* (Qazi, Ashar & Ahmad, 2019; Jensen, Neeley, Hatch, & Piorczynski, 2017).

The teacher's role in the science classroom is progressively changing. In the recent past, basic school science teachers considered science as a body of facts that are best learned through direct instruction and memorization. The learners were therefore only considered as receptors of the facts. The teachers' duty in the science classroom was to transmit science facts to passive learners. However, the quest for encouraging learners to meaningfully construct and use knowledge in novel situations is changing how science teachers teach science, especially to young learners (Lehesvuori, Ramnarain, &Viiri, 2018). As a result, inquiry-based-rational is becoming pronounced in the science classroom. The application of inquiry-based teaching approaches is a key strategy for effectively delivering science lessons in basic schools.
Learners are in the science classroom to do science, science is not to be done to them (The National Research Council [NRC], 1996). The inquiry approach to teaching is about 'doing' science. The NRC (1996) defined inquiry as a:

> … multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. (p. 23).

Inquiry is largely about engaging learners to let them learn the scientific way of knowing the natural world and develop their capacity to conduct scientific inquiries on their own. Lehesvuori, Ramnarain, and Viiri (2018) have rightly observed that the application of inquiry-based approaches to teaching science causes a shift from teacher-centered approaches that leads to learners memorizing text in textbooks to learner-centered approaches in which learners are engaged in hands-on activities. One inquiry-based strategy that has been found by researchers to be very helpful to young learners is the learning cycle inquiry approach.

The learning cycle approach emerged from the Science Curriculum Improvement Study (SCIS) conducted in the 1950s. The SCIS proposed 'Learning Cycle' (Atkin and Karplus, 1962) was grounded in theories of learning and teaching at the time. The cycle included exploring concepts through experimentation, inventing conceptual understanding from data from experiment and classroom discussions and applying concepts (NRC, 2007). Dass (2015) described learning cycle as a pedagogical approach in which teachers organize lessons in a way that reveals the purpose and worth of lesson content at the initial stages of the lesson with 'real-life contexts, involves students actively in the learning process, provides opportunities for connecting lesson content to real-life applications, and gets students to "experience" science the way real scientists do and problem-solving the way real engineers do'(p. 5).

The application of the Learning Cycle approach differs from the traditional approach. The traditional method of teaching emphasizes the progression of skills and techniques, the delivery of ready-made information and knowledge of the outcome of an investigation before the investigation is completed. As described by Serbessa (2006) it is a transmission method that relies on 'didactic, expository and teacher-centered approaches' (p. 130). The learning cycles hinges on cognitivist psychology and constructivist theory. It emphasizes the explanation and investigation of the phenomenon, use of evidence to back-conclusion and experimental design. In the learning cycle approach to teaching, the teacher becomes a mentor and a guide who principally helps learners access, organize, interpret and transfer knowledge to solve problems. At the same time, students gain expertise in learning (Serbessa, 2006; Taşlıdere, 2015). Sarı, Hassan, Güven, and Şen (2017) pointed out, that the learning cycles generally result in better retention and understanding of concept, higher achievement, improved reasoning skills, superior process skills and attitudes towards science.

In this study, the 5E Learning Cycle was used as an intervention to help basic school pupils understand density. Density is a confusing topic in Science because it is abstract (Hashweh, 2016). According to Hitt (2010), pupils find 'density "too deep" to understand and "too theoretical" to have any meaning for their lives' (p. 25). Even though pupils to some extent have an understanding of mass and volume, pupils do not develop a conceptual understanding of density (Dole, Hilton, Hilton, & Goos, 2013). This is true for the pupils who participated in this study. The purpose of the study was to find out the efficacy of the 5E Learning Cycle in improving pupils' understanding of density. It was also to find out whether there will be a significant difference in males and female pupils' understanding of density after the application of the 5E Learning Cycle.

5E Learning Cycle

As the name suggests, the 5E Learning Cycle is a five-stage learning cycle. The cycle consists of the engagement, exploration, explanation, elaboration and evaluation phases. These phases do not proceed in a unidirectional manner. There can be mini cycles among two or three phases. For example, there can be several explorations and explanations before proceeding to elaboration. Another feature is that the evaluation phase includes assessment as, for and of learning. This implies that evaluation does not necessarily end the cycle. It occurs throughout the implementation of the 5E Learning Cycle. Figure 1 is an illustration of the 5E Learning Cycle.

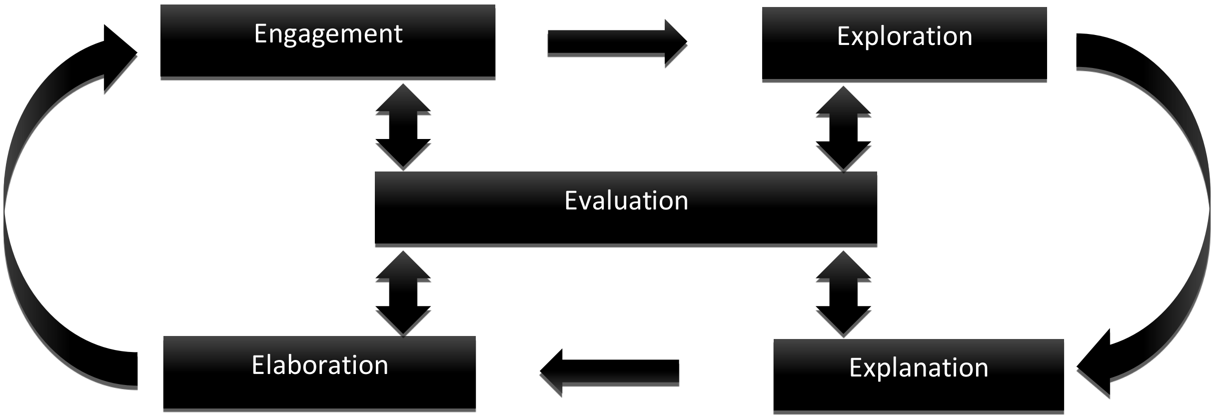

Figure 1. An illustration of 5E Learning Cycle

The engagement Phase is the introductory stage of the lesson. As pointed out by Dass (2015), the engagement phase aims at engaging learners' minds in the learning process so that they begin thinking about the topic and generate curiosity and interest in the lesson. In this phase, the learners' prior knowledge and/or possible misconceptions are identified and dealt with at the exploration stage.

The exploratory stage directly follows engagement and is designed to get learners to actively explore so that questions can be answered and solutions to problems can be designed and tested. This phase may involve designing and conducting experiments, participating in laboratory activities, gathering data from print sources and so on. This phase generally provides learners with concrete learning experiences. Learner-centered activities are used to enable learners to explore. It is the stage where the main inquiry-based activities are implemented. The activities incorporated here encourages learners to work in a cooperative learning environment without direct instruction from the teacher to enable the learners to develop skills and concepts. The activities are designed such that the learners are actively involved in the lesson 'mind-on' and 'hands-on' before the formal explanation of terms, definitions and concepts.

The explanation phase is a teacher-directed 'minds-on' phase. The key feature of this phase is that the teacher uses a teacher-directed interactive environment to help the students describe their understanding of the concepts being learned and how the concepts-connects to real life. The teacher first allows the learners to express their ideas and explanations. Following this, the teacher introduces the technical information and directly clear learners' misconceptions (Bybee, 2009).

The fourth stage of the cycle focuses mainly on the application of knowledge in novel situations. The application may be through answering 'new' questions, solving 'new' problems, or by using the concepts learned to address 'new' issues. At this phase, students are encouraged to apply knowledge gained at the explanation stage to reinforce the 'new' knowledge. This is done to help learners develop a deeper understanding of the concepts (Duran & Duran, 2004).

The evaluation in the learning cycle inquiry approach is different from the traditional approach. Though it completes the cycle, it occurs at every stage of the cycle. Both formal and informal assessments are appropriate at the evaluation phase. It is an on-going process in which teachers make observations of their students as they apply new concepts and skills. The learners have the opportunity to conduct peer or self-assessment.

METHOD

The research design used in conducting the study was action research. Action research is a systematic inquiry pre-dominantly conducted by educationists interested in the teaching and learning process who seek information on how teaching and learning occur, so that they can offer innovative ways of teaching or improve teaching and learning (Mertler, 2006). The study was designed to improve Basic Six pupils' understanding of density. In the study, the 5E Learning Cyclewas used as an intervention to demystify density. All 36 Basic six pupils of a Basic School in the Assin North Municipality in the Central Region of Ghana were purposively selected to participate in the study. The pupils were selected to participate in the study based on their performance in the pre-intervention test conducted to find out how pervasive the problem was. A sample is the fraction of the population from whom data is collected. This fraction of the population may be considered as representatives of the population or they may be considered as non-representatives of the population depending on how the fraction of the population was selected. (Som, 1995). The sample consisted of 14 girls and 22 boys. Since the design used was action research, data collection occurred at three stages: Pre-intervention stage, intervention stage and post-intervention stage. At the pre-intervention and Post-intervention stages, the pupils were tested. The test consisted of 10 questions which tested pupils' knowledge in calculating densities, explaining why objects float and sink and predicting which objects will sink or float in water. The intervention lasted for two weeks. A summary of the activities conducted during the intervention period has been presented below.

Engage

The pupils were.

1. put into heterogeneous groups of 4-5 pupils.
2. provided the following materials: 500ml measuring cylinder, water trough half-filled with water, cork, piece of stick, bottle top, 50 pesewas coins, marble and worksheet.
3. asked to make predictions whether the following objects will sink or float in water: Cork, piece of stick, bottle top, 50 pesewas coins and marble.
4. asked to record their predictions on their worksheet.

Explore

The pupils were asked to.

1. put each of the five items into the water in the trough and record their observation (sink or float).
2. measure the mass of each of the five objects using a balance.
3. measure the volume of each of the objects with the aid of measuring cylinder, using the displacement method.

The mass and volume of the various objects were recorded in a table as shown in Table 1.

Sample Data Table for Recording Mass and Volume of Objects

#	Item	A	B	C
		Mass	Volume	Density (Mass/Volume)
1	Cork			
2	Stick			
3	50 pesewas Coin			
4	Marble			
5	Bottle top			

4. complete Column C by dividing the Mass by the Volume.

Explain

In a teacher-led discussion, pupils compare the prediction at the engagement phase to the result of their experiment. Then went ahead to explain why some objects float and others sink in water using the densities calculated and the density of water.

Exploration

Pupils were;

1. given a list of items and their densities and they were asked to indicate whether the objects will float or sink in water.
2. asked to pick objects in the environment and determine their densities.

Evaluation

1. Groups were asked to display the results of their activities in the exploration phase for peer assessment.
2. A set of questions were given to pupils to test their understanding of the determination of density, comparison of different densities and explanation on why some named objects sink in water while other named objects float in water.

RESULTS

The results of the pre-intervention test and the post-intervention test were analyzed using bar graphs, descriptive and inferential statistics. To find out the effect of the 5E Learning Cycle on gender, the results of the two tests were disaggregated with respect to gender. A comparison of the pre-intervention test and the post-intervention test results have been presented in Figure 2.

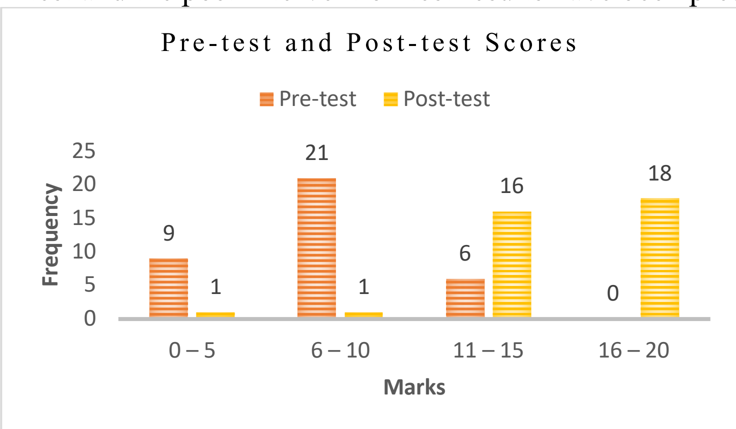

Figure 2. Pre-test and Post-test Scores

It can be seen from Figure 2 that there was a sharp contrast in the result of the two tests. While no pupil had a score above 15 in the pre-intervention test, 18 pupils scored above 15 in the post-intervention test. One pupil each scored from 0 – 5 and 6 – 10 in the post-intervention test. However, in the pre-intervention test, 30 pupils had scores in these two categories combined.

Generally, the performance of the pupils in the pre-intervention test was weak, relative to their performance in the post-intervention test. To investigate whether there were differences in the performance of boys and girls in the pre-intervention and post-intervention test the scores for the two tests were disaggregated. Figure 3 shows the result of the pre-intervention according to gender.

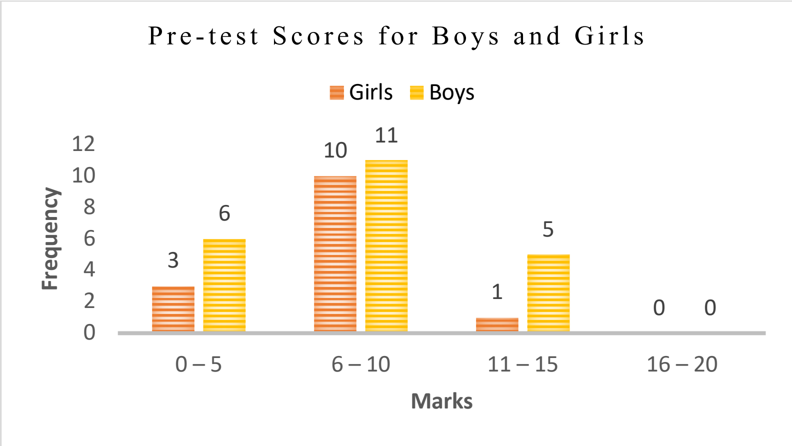

Figure 3. Comparison of Pre-test Scores for Boys and Girls

From Figure 3, the performance of boys and girls in the pre-intervention test was similar. No boy nor girl had a score above 15. The number of boys who scored from 6 – 10 was one more than the girls. The number of girls who scored 0-5 marks was one half of the number of boys who scored 0 – 5. Only one girl scored 11 – 15 while four more boys than the girls scored the same range of scores. Despite the difference observed in the score range 11 – 15, the majority of the boys and girls scored less than 10 out of 20. The post-test results of the boys and girls have been presented in Figure 4.

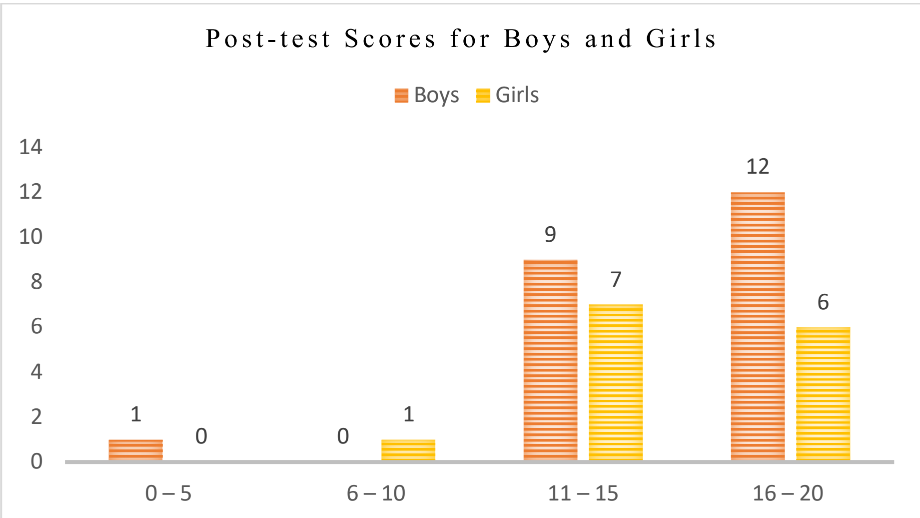

Figure 4. Post-test Scores for Boys and Girls

As shown in Figure 4, the performance of the boys and girls in the post-test was also similar. In the case of the post-test, the scores shifted to the right. A boy and a girl scored 0 – 5 and 6 – 10 respectively. Other than these two, all the scores were above 10. The difference between the boys and girls who scored 11 – 15 was 2. However, for 16 – 20, the number of girls was one half that of the boys. In the post-test, the majority of both boys and girls scored more than 10 marks.

The maximum, minimum and mean scores for boys and girls were computed to determine the group the 5E Learning Cycle favored. The scores for the Pre-intervention test and Post-intervention test have been presented descriptively in Table 1.

Table 1. A descriptive presentation of Pre-intervention Test and Post-intervention Test

Gender		**Pre-test**	**Post-test**
Girls	Mean	6.93	14.64
	N	14	14
	Std. Deviation	2.90	2.65
	Minimum	1	8
	Maximum	12	18
Boys	Mean	7.55	15.00
	N	22	22
	Std. Deviation	3.89	3.19
	Minimum	1	5
	Maximum	15	20
Total	Mean	7.31	14.86
	N	36	36
	Std. Deviation	3.50	2.96
	Minimum	1	5
	Maximum	15	20

The mean scores for the post-intervention test were almost twice the mean score of the pre-intervention test. While the girls' mean scores showed a 111.26%increase, the percentage increase for the mean scores for the boys was 98.68%. The changes in results can also be seen in the maximum and minimum scores of boys and girls for the post-intervention test and pre-intervention test. The minimum score for the girls increased from 1 to 8 while the boys' increased from one in the pre-intervention test to five in the post-intervention test. The mean scores for the girls in the pre-intervention test and post-intervention test were lower than that of the boys. To determine whether these differences were significant, a Mann-Whitney U test was done to compare the performance of the boys and girls in the pre-intervention test and post-intervention test. There was no significant difference between the performance of the boys ($Mdn=6.50$) and girls ($Mdn=7.50$) in the pre-intervention test U ($N_{girls}=14$, $N_{boys} = 22$) $=161$, $Z=0.245$, $p=0.81$. This result suggests that although there was a difference of 0.62 between the mean score for the boys and the mean score for the girls in the pre-intervention test, the boys and girls had the same understanding of density. Again, the result suggests that if there is a difference in performance between the boys' and girls' understanding then it is largely contributed by the implementation of the 5E Learning Cycle. There was no significant difference between the performance of the boys ($Mdn=15.00$) and girls ($Mdn=15.00$) in the post-intervention test U ($N_{girls}=14$, $N_{boys} = 22$)$=1381$, $Z=0.524$, $p=0.62$. This suggests that the application of the 5E Learning Cycle was appropriate for both boys and girls used in the study. In order words, the 5E Learning Cycle favored both boys' and girls' understanding of density.

DISCUSSION

The application of the 5E Learning Cycle in teaching density greatly improved pupils' understanding of density. This positive impact on pupils' understanding of density cut across gender. The use of the 5E Learning Cycle is one of the potent ways of designing purposeful and meaningful lessons in Science. As an approach that hinges on inquiry, the 5E Learning Cycle allows pupils to link results of experiments to activities to their preconceptions about a topic. As Putra, Nur Kholifah, Subali, & Rusilowati (2018) put it, the 'use of the learning cycle provides opportunities for students to express their previous knowledge and the opportunity to refute, debate their ideas', (p. 173) resulting in developing a higher level of thinking. Applying the 5E Learning Cycle helped pupils to learn and retain information meaningfully. The use of the 5E Learning Cycle also developed pupils' scientific reasoning, problem-solving abilities and communication skills.

Analysis of the pre-intervention test and post-intervention test results showed that the 5E Learning Cycle was effective in helping pupils understand density. This result is consistent with the studies of Hitt (2005); Campbell (2006); Akbulut, Sahin and Cepni (2012); Almuntasheri, Gillies, and Wright (2016); Putra, Nur Kholifah, Subaliand Rusilowati (2018); Wendel, P., Spoltman, and Pochodylo (2019); and Diyana, Haryoto, and Sutopo. (2020). The use of the 5E Learning Cycle did not just improve pupils' understanding of density, it also motivated students to learn. An unusual suspense was created among the pupils. For each activity, they were eager to know what the outcome would be and so they did not mind so much that they were having extended lessons. This motivation to learn generated by the 5E Learning Cycle could be one of the positive effects the approach has on pupils. This motivation to learn may account for the increase in the mean scores of pupils in the pre-intervention test and the post-intervention test. This suggests that the pupils' understanding of density doubled after the application of the 5E Learning Cycle. It also suggests that the retention of the concepts learned was high.

The application of the 5E Learning Cyclewas suitable for both boys and girls. The positive effect of the 5E Learning Cycle on students' understanding of density was observed in both boys and girls. There was no significant difference between the performance of boys and girls in the pre-intervention test. This suggests that before the application of the 5E Learning Cycle the girls had a weak understanding of the density just as the boys. There was also no significant difference in the performance of boys and girls in the post-intervention test, although the girls showed greater gains in performance than the boys. The girls showed greater gains because the mean score for the girls was a little lower than that of the boys in the pre-intervention test. The gains in the mean scores in the girls' performance could be interpreted as that the 5E Learning Cycle has the potential of improving the performance of weaker learners. However, the t-test result did not support this claim. The t-test results indicated that the 5E Learning Cycle can promote boys' and girls' understanding of density.

CONCLUSION

The 5E Learning Cycle is an effective teaching approach for teaching density. Using the usual methods of teaching concepts learners find it difficult to understand may not yield positive results. The 5E Learning Cycle is one of the innovative approach's science teachers can consider when looking for a teaching approach that can improve learners' understanding of density. This study confirmed that by taking pupils through the Engagement, Exploration, Explanation, Elaboration and Evaluation phases of the 5E Learning Cycle, learners will gain an improved understanding of density. What is good about the application of the5E Learning Cycle in teaching density is that it motivates learners to learn meaningfully as they reflect on their preconceptions and compare them to the results of experiments they have conducted. The 5E Learning Cycle improves learners' conceptual understanding of density and the ability to conduct scientific inquiry related to density.

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