Infographics: Effects on Student Coding Skills and Conceptual Understanding in Biology

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Abstract
This study was conducted to test whether Infographics can improve student coding skills and conceptual understanding in Biology. Infographics was used in an intact heterogeneous Grade 7 class of 30 students (experimental group) and was compared to the conventional way of teaching the control group (30 students) in a private school in Calamba City. The two groups had the same activities (collaborative work, experiments and modelling) apart from the Infographics for the experimental group. The researcher-made Conceptual Understanding and Coding Skills Tests (pretests and posttests) which were validated by experts in the field (Biology Education and Educational Technology) and were pilot tested in two (2) private schools (Laguna and Parañaque City). The 50-item original test was reduced to 30 after item analysis. Its Cronbach's alpha of 0.878 indicated a high level of reliability. Independent samples t-test showed significant improvement in the posttest of the experimental group as compared to the control group which implicated the good effect of Infographics on student coding skills and conceptual understanding in Biology.

Keywords: Infographics, Coding Skills and Conceptual Understanding

Introduction

The role of educators is to facilitate learning and understanding, not just retention of information (rote learning), and develop in the students the ability to perform tasks and apply knowledge in a concrete/specific situation. The teacher is the key individual who has the immense accountability in developing student capabilities by setting and establishing the learning environment. This is the reason why teachers must be very cautious in choosing appropriate and proven effective teaching strategies that could facilitate student learning. These must never be neglected for they are crucial in creating specific learning experiences to bring about criterion performances that would cause change in behavior where knowledge is applied in real life contexts (Akeji et al., as cited in Atomatofa, 2013).

Visual representations are one of the most effective tools in the communication of science concepts (Ametler & Pinto as cited in Cook, 2011). Teaching science would be very difficult without the visuals for some topics that are too small (enzymes etc.), too large (solar system etc.), too slow (continental drift), too fast (chemical reactions) to see with the unaided eye, display data or organize complex information and represent processes that are difficult to describe (photosynthesis) (Cook, 2012). Visual representations help students in developing their schema (Saunders, Wise & Golden, 1995) which is the general knowledge of objects and events from past experiences (Cohen, as cited in Nishida, 1999). It is by stimulating the schema that students are able to link prior knowledge with new concepts and information being presented (Ausubel as cited in Daniel, 2005).

The basic process in teaching/learning is that the teacher who is the origination-point has a concept or idea that the student who is the receipt-point has to absorb and understand. In order for that to happen, the teacher has to use codes or symbols to get the message across. The teacher can be considered successful in transferring the concept when the student has made it his/her (as he/she understands) own the information/concept completely, able to interpret pictures/symbols, translate textual information in the same way which is also known as the coding skills (the author's operational definition of visual literacy), and does not just depend on the teacher's words or presentation. The ability to analyze, evaluate, manipulate information and put them to use provides evidence that the student has achieved conceptual understanding. To make such learning possible, it is important that the teachers are easily understood by the students.

The human mind works by representation and computation of things and events around him/her which provide the basis for all mental functioning (Mohammed, as cited in Friedenberg & Silverman, 2006). Reynolds and Baker (1987) found that instructional materials prepared digitally (computerized) had increased student attention and learning; and as attention increased, learning also increased. In this generation with fast-paced technology, teachers can take advantage of the opportunity to use technological/digital instructional tools to teach students better. Infographics are instructional tools that can be presented in digital forms that are visually appealing, and could motivate students to engage and learn. Infographics can also help illustrate new information (texts and concepts) and complex data visually in a more graspable way.

This study aims to know the effects of infographics on student coding skills and conceptual understanding in Biology.

Methodology

Research Design

The pretest-posttest quasi-experimental design was employed in the study. Both the experimental and control groups were given the Coding Skills and Conceptual Understanding pretest-posttest to determine whether Infographics had an influence on the improvement of learning in Biology.

Sample

Sixty (60) students, with ages 12 to 13 years old, from two (2) intact heterogeneous Grade 7 classes in a private school in Calamba City were involved in the study. The selection of the experimental group (infographics) and the control group (conventional approach) was done through a toss coin.

The Use of Infographics

The instruction for the experimental group was done in the morning daily from 7:00 to 8:00 A.M., and an hour for infographic practice/exercise in their computer class in the afternoon (made in collaboration with the computer teacher).

The students followed the guidelines below in doing the Infographic exercises and assignments (http://www.learndurkin.com/assets/graphicsstudent-infosheets.pdf):

1. Read the lesson from the textbook carefully. Then locate, analyze and sift relevant/ important data and decide how you are going to group information considering the complexity of the topic and the receiver of the message.
2. Sketch out your idea on paper. Organize your idea first before you start choosing graphics from the computer. Once the organized data and graphics are ready, you may begin to layout the design.
3. Decide how to best visualize the meaning of the information. Determine the kinds of graphics that will best represent each information.
4. Write a caption that clearly summarizes the content of the infographics.
5. Carefully select a color scheme for the Infographics. Make use of as many colors that you have in the color wheel.
6. Carefully select the font and font size (big enough) that do not distract the reader from the message.
7. Bring individual elements into a cohesive layout. Any graphics used must have enough resolution and size. The layout must have good spatial organization, structure of elements, and informative value.
8. Do refining processes by gaining feedback from group mates.
9. Make sure that your Infographics depicts your message. Ask a classmate or group mate to tell you the message that he/she gets from your Infographics. Do some adjustments from feedbacks.
10. Always cite your sources of pictures, images and others.

Table 1 compares how the use of Infographics and the conventional approach are implemented in the experimental and control classes.

Table 1

Comparison of Infographics and Conventional Approach

Infographics Group (60 minutes)	Conventional Group (60 minutes)
Motivation (10 minutes) • Asking questions • Citing situations or stories referring to **Infographics**	Motivation (10 minutes) • Asking questions • Citing situations (stories)
Pre-Activity (10 minutes) • Games • **Infographic Presentation** • Discussion	Pre-Activity (10 minutes) • Games • Discussion
Activity Proper (20 minutes) • Collaborative Activity (Reporting, PowerPoint presentation and Group Discussion/Activities) • **SOI Modeling**	Activity Proper(20 minutes) • Collaborative Activity (Reporting, PowerPoint presentation and Group Discussion/Activities)
Processing with **Infographics** and Classroom Discussion (20 minutes)	Processing through Classroom Discussion (20 minutes)

The teacher used the Infographics in discussing the lessons in the experimental group. The teacher-made Infographics was assigned to the students before a lesson was introduced to give them enough time for group analysis, evaluation, and reflection of their understanding by discussing and sharing insights in preparation for the creation of their own. This activity was part of the SOI exercise (Selecting, Organizing and Integrating) in choosing the relevant information (ideas, concepts, events etc.) for summarizing the lessons before laying out the Infographics design.

The SOI Design of Infographics (Mayer, 2010) includes the following:

a.) selecting relevant words for processing in verbal working memory
b.) selecting relevant images for processing in visual working memory
c.) organizing selected words into a verbal model
d.) organizing selected images into a pictorial model
e.) integrating the verbal and pictorial representations with each other, and with prior knowledge.

Research Instrument

In the study, the Coding Skills and Conceptual Understanding Test were developed by the researcher to measure the students' coding skills and prior/deeper understanding in Biology.

The Coding Skills Test (CST)

This is a five item test with 10 points given for each as a score. It contains posters for the students to interpret and textual information to be interpreted through drawings. The researcher prepared rubric was used to grade the students by the teacher/researcher and invited science teachers as interraters.

The Conceptual Understanding Test (CUT

This is a 30-item multiple choice type of test trimmed down and modified after doing the item analysis. The Grade 7 science second quarter topics such as Biological Levels of Organization, Characteristics of Life, Basic Unit of Life, Prokaryotes vs Eukaryotes, Cell Structures and Functions, Plants vs Animal Cells and Ecosystem were covered. Originally, 50 items were prepared based from several resources (TIMSS Like Items in Science and Math 2002 and DOST-SEI eTraining Manual for Teachers), were validated by subject matter experts and pilot tested to Grades 8 and 9 students of the sample school and another private school. The test had a reliability coefficient of 0.878 (Cronbach's alpha) which was considered very high (close to 1).

Results

Pretest Scores of Experimental and Control Group

Table 2. presents the results of both groups in the Coding and Conceptual Understanding Pretest.

Table 2.1

Means and Standard Deviations of Coding Skills Pretest

Group	N	Mean	SD	SE
Control	30	7.5	6.7	1.22
Experimental	30	18.8	11.6	2.12

Note: CST Perfect Score = 50

Mean Difference in the CS Pretest of the Experimental and Control Groups

Mean	SD	SE	t	df	Sig (2-tailed)
-11. 27	12.88	2.35	- 4.79	29	0.00

Note: CST Perfect Score = 50

Table 2.2 ANCOVA for CST Posttest

F-Ratio = 18.109
p value = 0.00

The results of ANCOVA show that the experimental group performed better than the control group in the posttest. This indicates that the treatment had a positive effect on the coding skills of the students in the experimental group, although the control group also slightly increased in their posttest scores. Students in the experimental group who have shown enthusiasm and improved work in their seatworks, group work and assignments have higher scores than those who were not. Since the students came from different elementary schools and were in their first year in high school, all are considered with low prior knowledge about the topics. The results agree with the findings of Mayer and Gallini (1990) that those who have low prior knowledge about a topic or a subject would have greater benefit than those who have higher prior knowledge. In doing the infographic exercises and assignments, the students were able to practice using or doing the SOI, which according to Waldrip (2006) would help learners link verbal and visual codes in developing knowledge of science concepts and processes. In his study, students who were able to represent their knowledge have higher performance, concept understanding, spatial visualization and proportional reasoning (Matulac-Belarga, 2007). The students in the experimental class were given the time to read and analyze a given reading exercise and assignment; and to reflect on the teacher's infographics. From this activity, the student could create his/her own infographics after selecting what he/she thought was necessary or important for his/her own recall and learning. Also from Mayer's (2007) findings, those who were able to create their own graphic organizers, infographics in this study, were able to learn best.

Table 3 Presents the Results of both Groups in the Conceptual Understanding Pretest.

Table 3.1a

Means and Standard Deviations in the Conceptual Understanding Pretest

Group	N	Mean	SD	SE
Control	30	13.1	4.49	0.82
Experimental	30	14.6	2.72	0.50

Note: CUT Perfect Score = 30

In order to compare the initial conceptual understanding of the two groups, the pretest mean scores were subjected to independent samples *t*-test. As shown in the table, the experimental group obtained a slightly higher mean score (M = 14.6, SD = 2.72) in the pretest than the control group (M = 13.1, SD = 4.49). The experimental group got a mean score which can be rounded off to the passing mark (15) and obtained a small value for standard deviation (2.72). Table 3 indicates the mean difference of the two groups.

Table 3.1b

t-test for Equality of Means in the CU Pretest Scores

Mean Difference	SD	SE	t	df	(Sig. 2-tailed)
-1.50	5.37	0.98	- 1.54	29	0.137

The mean difference in the CU pretest scores is not significant at t-computed = – 1.54 against t-table = 2.05; and 0.137 significance which is greater than 0.05. The results indicate that the two groups were comparable in terms of conceptual understanding at the beginning of the treatment. Table 4 compares the means and standard deviations of both groups in the Conceptual Understanding Posttest.

Table 3.2a

Means and Standard Deviations of Conceptual Understanding Posttest

Group	N	Mean	SD	SE
Control	30	13.4	5.41	0.99
Experimental	30	18.2	3.04	0.56

Note: CUT Perfect Score = 30

The mean score of the experimental group (M = 18.2, SD = 3.04) was higher than that of the control group (M = 13.4, SD = 5.41), and was a little higher than the passing score, while that of the control group was still below the passing score and increased only by 0.3. The standard errors for both groups were just close to 1 (small margin of error). Table 5 highlights the significance of the two groups' mean difference.

Table 3.2b.

t-test for Equality of Means on the Conceptual Understanding Posttest Scores

Mean Difference	SD	SE	t	df	Sig (1-tailed)
4.8	6.7	1.2	- 4.8	29	< 0.05

The mean difference in the CUT posttest scores with t-computed = - 4.8 against t-table = 2.05; and p value less than 0.05, is significant. The results indicate that the experimental group performed better than the control group after the treatment. The use of infographics as instructional material in Biology led to significant difference in the posttest scores in favor of the students in the experimental group.

Conclusions and Discussion

Based on the results of the study, the use of Infographics in teaching Biology is more effective in improving student coding skills and conceptual understanding than the use of the conventional approach. The researcher's theory is that Infographics helped in decongesting the lessons and removing irrelevant information that made the concepts easy to organize and link with prior knowledge. The SOI exercises trained the students in making an outline or summary of a lesson and helped them in tapping/enhancing their coding skills. In reading and outlining, the students were actively processing the information they were receiving and not just memorizing them. In this process, they selected which of the information were necessary and those that were irrelevant or could be discarded.

Since the brain can only store limited information, Infographics also helped in chunking or grouping the information (terms, ideas and concepts) that would go together. The researcher believes that Infographics facilitated recall and retention by reducing and avoiding cognitive overload. Infographics also helped in setting the learning environment and conditioned the minds of the student for learning. Infographics made the students more engaged and excited, especially that they were aware that in any part of the discussion the teacher would show the Infographics with different designs. They were also expectant of the SOI activity where they could try to design their own Infographics. Infographics also helped in drawing out students' prior knowledge in Biology, and linking them to topics being discussed. The results of this study promote the use of Infographics in improving student conceptual understanding especially in teaching subjects with complex topics such as Biology. This does not just decongest the teacher's lessons but also allow the students to engage actively in constructing their learning, by critically analyzing, exploring, critiquing and reflecting on the lessons being learned.

These findings can help the educators in selecting the textbooks already out in the market, that they are going to use as their resources in teaching. It also suggests that textbooks and other instructional materials in many subjects should be designed according to these findings which are supported by related studies such as: the use of graphic and text format that provide separate systems or stores (Paivio,1971), SOI Model highlights of important and relevant texts and not much words must be used (Mayer, 1999), international or contextual symbols or images which every learner understands (Worthington, 2005), the visual design principle (Williams as cited in Yeh

& Lohr, 2010) which is an effective framework for teaching the skills, the cognitive processes that go beyond remembering (Topiel, 2013), the use of colors which most learners prefer and simple visuals (Matt & Carter, 1999; Kleinmann & Dwyer, 1999), and the use of static vs animated visuals (Chanlin, 1998) that facilitate learning where learners can have a meaningful understanding of the information presented and thus construct their knowledge. And lastly, the use of an assessment tool appropriate for the class composition and their learning needs.

Recommendations

Based on the findings of the study, teachers should design appropriate infographics for visual learners to facilitate recall and retention and thus improve coding skills that lead to conceptual understanding. It is highly recommended for educators and teachers to capitalize on this alternative instructional material to prevent students from getting bored.

School administrators must support the teachers in the implementation of infographics in the teaching of Biology and other subjects by providing trainings and workshops. Curriculum developers may incorporate infographics in the development of instructional materials to reinforce learning and produce scientifically and visually literate individuals.

This study lasted for four weeks only. For future studies, researchers can lengthen the time for the intervention so that the students can further learn the better way to use the SOI model. The sample size can also be increased to strengthen the results, for in statistics the larger the sample size the more reliable the figures and conclusions will be. This can be done for one grading period without saturating the students. Future researchers can look into the effects of infographics on other learning outcomes such as scientific literacy, metacognitive skills, intrinsic motivation and others. They can also take into consideration students who are low imagers or with low aptitude, to determine the extent to which infographics can help them improve in their performance.

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Appendix A

Figure 1. The Coding Skills (CST) and Conceptual Understanding Test (CUT)

A. The CST

Group the following words into categories:

lettuce	sandwich	strawberry
tomatoes	ice cream	fried tilapia
cassava cake	cucumber salad	milk shake
roast chicken	grapes	tuna omelette
steamed lapu lapu	ensaymada	carrot cake
papaya	pork barbeque	embutido
corn on cob	sauteed string beans	baked mussel
pandesal	hotdog	melon
Cheese	camote que	vegetable salad

B. The CUT

I. Directions: Encircle the letter of the correct answer.

1. In what forms of chemical energy are CO_2, H_2O,and sunlight being converted
during photosynthesis?
   A. O_2 and H_2O
   B. Glucose and ATP
   C. O_2 and ATP
   D. light energy and H_2O

2. Why is furrowing not possible for plant cells during cell division?

   A. because the cell wall is rigid
   B. ribosomes are responsible for protein synthesis
   C. because mitochondria in plants are the powerhouse
   D. because the chloroplast is the site for photosynthesis

Coding (Visual Representation) Rubric

	1	2	3	4
Chunking or Organization of Information	Chunking/Organization of Information is not logical and hard for the learner to understand	Chunking/Organization of information is a bit confusing but somehow show relation to other information that would make it understandable to the learners	Chunking/Organization of Information is understandable to the learners	Chunking/Organization of information is logical, sequential, logical and effectively conveys the meaning and purpose to the learners
Knowledge	Do not have an understanding of the content or the lesson. The content of the infographic is far from the core of the topic	have only a basic understanding of the content and do not show the summary of the lesson	demonstrate a firm grasp of the content and able to show the summary of the lesson	demonstrate an in-depth understanding of the content and provide a valid summary of the lesson
Graphics – Clarity (Images or Symbols Used)	Many graphics are too small or unclear	Graphics can be understood through the caption	Most graphics are clear and related to their captions	Graphics and captions are clear and are easily identified
Graphics-Relevance	Graphics do not directly relate to the topic	Some graphics relate to the topic	Most graphics are related to the topic and easier to understand	All graphics are related to the topic and easier to understand
Texts/Captions Used	Texts/captions are not directly connected to the graphics	Some texts/captions are not directly connected to the graphics	Most texts/captions are directly connected to the graphics	All texts/captions are not directly connected to the graphics
Visual Product (Infographics) - font, color, images and design	The infographic is not engaging or not well designed	The infographic may not be engaging but well designed	The infographic is somehow engaging but not well designed	The infographic is very engaging and well designed
Resource Page and Works Cited	The infographic does not cite resources	The infographic does not cite research and relies heavily on electronic resources	The infographic reflects/cites adequate research but relies heavily on electronic resources	The infographic reflects/cites adequate research and electronic resources

patterned from www.mrmasters.net

Figure 2. The Coding Skills Rubric

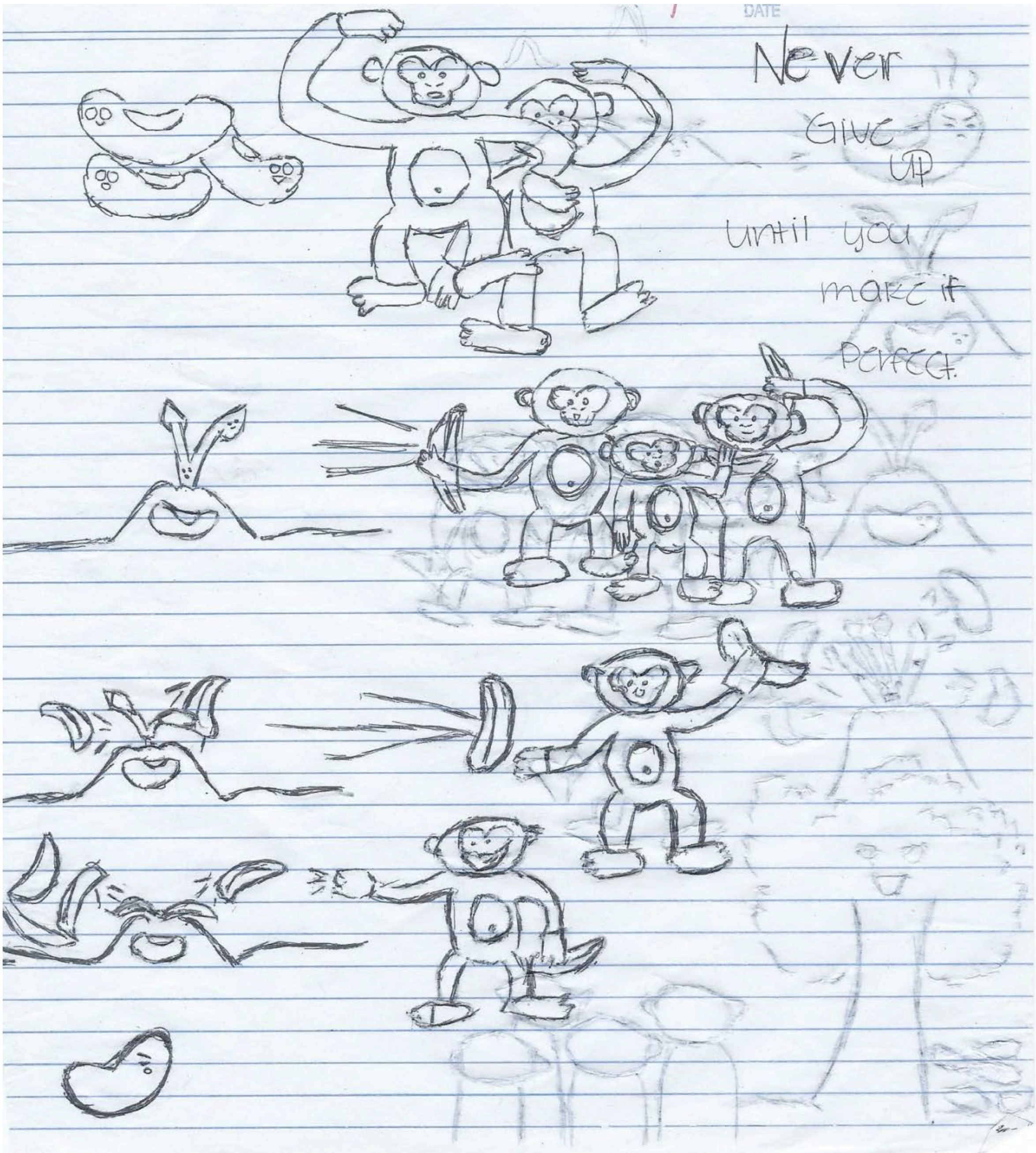

Figure 3. Initial attempt of a student to code a story (seed germination)

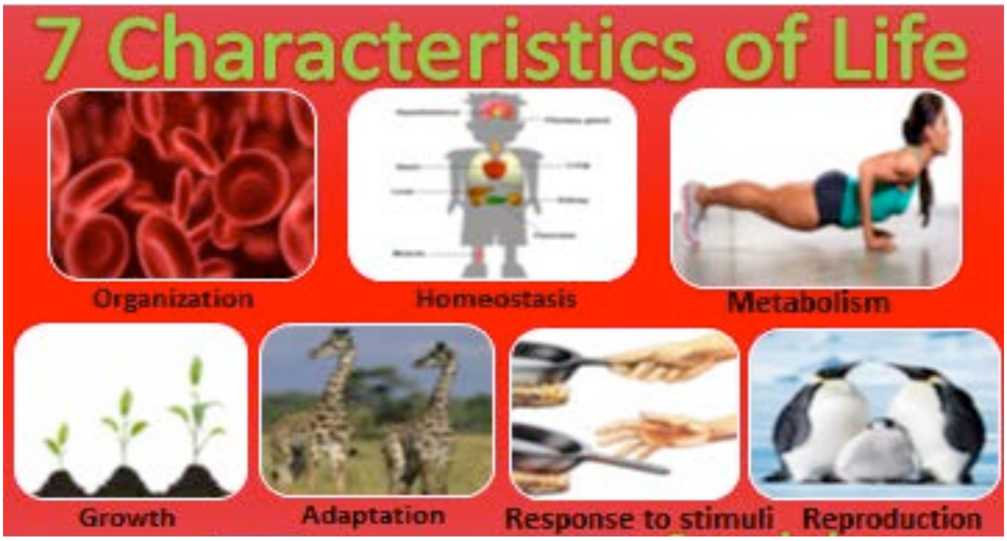

Figure 4. Infographics on characteristics of life

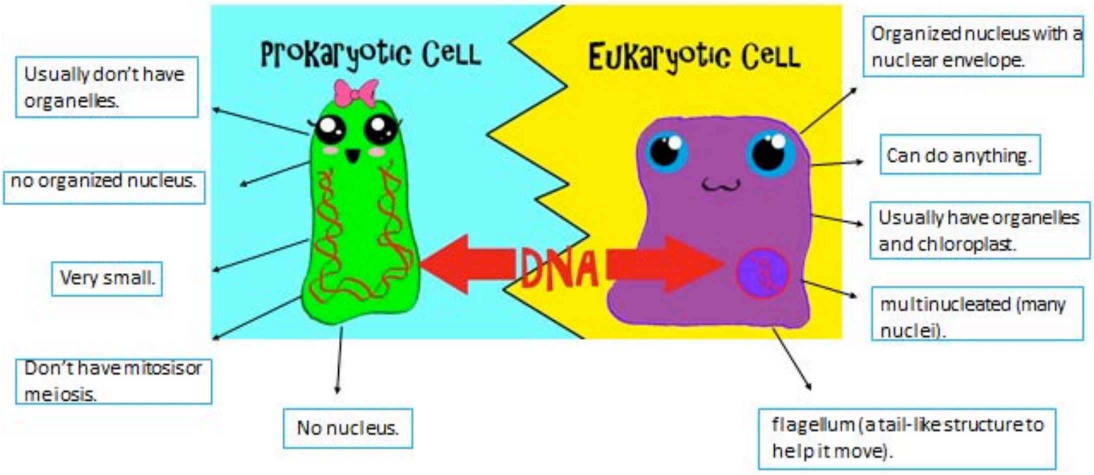

Figure 5. Comparison of prokaryotic and eukaryotic cells