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The Role of Innovative Teaching and Learning Methods Towards the Classification of Living Things: A Review

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Abstract

Biology continues to present difficulties in teaching and learning. Among other biology domains classification of living things is considered to be one of the challenging subjects as different studies indicated students' misconceptions in the test to classify both plants and animals. Inadequate teaching methods were the core source of these challenges which were also found to lead to poor performance in schools. This review paper shows the role of active teaching methods to improve learning science subjects. The article gives an insight into how adopting innovative teaching methods can help educators implement appropriate teaching strategies recommended in reforms of science education, such as the Inquiry Based Learning (IBL) using the 5Es (Engage, Explore, Explain, Elaborate and evaluate) instructional model. Findings of this review indicate that the instructional methods give opportunities to relieve misconceptions for learners. It is appreciated to allow students learning by doing, hence perform well in assessments and evaluation due to acquired skills and competences. This is the reason why the 5Es instructional model was recommended among other active learning instructions as a remedy that can enhance teaching and learning of biology, especially the content of classification of living things, based upon its advantages in science education.

Keywords active learning; biology education; living thing;, instructional model, misconceptions

Introduction

Biology is one of science subjects that offers skills and knowledge that contribute to the human wellbeing, motivate for the protection of other living organisms and the environment as well (Ibrahim, 2015). Classification of living things is a basic topic to understand biological concepts. It involves collecting organisms and grouping them based on common features and endeavors to understand living organisms and their interactions with the environment, contributing to biodiversity conservation (Kılıç, 2016). Further, the classification of living things contributes to the fields of natural resources management, plant and animal ecology (Jacquemart, Lhoir, Binard, & Descamp, 2016; Keogh, 2014). Furthermore, classification provides bases in learning and understanding biological concepts related to living things' anatomy, physiology (Sami, 2018), and evolution

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(Keogh, 2014).

The classification of living things was introduced by Carolus Linnaeus in the Systema Naturae, around eighteenth century. Linnaeus introduced a hierarchy scientific method, from the biggest hierarchy, namely the kingdom, class, order, genus and species (Sreedevi, Meshram, & Shashank, 2015; Ruggiero et al., 2015). Nowadays that science becomes more dynamic, higher levels in taxonomy were introduced. They include the domain, the phylum, where overall organisms are classified into three domains, specifically Archae, Bacteria and Eukarya (Buster, 2014). Some other levels such as sub-phylum, sub-order, sub-family, sub-genus and sub-species were also incorporated. The main purpose of classification of living things was, and it is nowadays to describe living organisms and give its specific binomial scientific name.

Based on the importance of the classification of living things, biology teachers need to bring students to understand classification principles (Keogh, 2014). For instance, the identification and classification of some plant species may motivate learners to learn other science subjects such as pharmacy. In this perspective, when some species of pharmaceutical importance are not well known, this may lead to the extinction of these species in the future (Jacquemart, Lhoir, Binard, & Descamp, 2016). Further, the classification of living organisms can raise awereness about relationships among species, reflecting evolution and paving the ways for the understanding scientific natural world (Keogh, 2014). Furthermore, classification can motivate leaners to understand the importance of animal diversity such as pollinators and biological indicators of the environmental change.

Despite the importance of classification of the living things, studies in biology education indicated that learners at the secondary school level continue to face difficulties in learning biology (Etobro & Fabinu, 2017; Çimer, 2012). Other researches revealed that the inadequate teaching methods, students' attitude, nature of topics, students' learning and studying habits, and the lack of teaching resources are among the factors that cause the above mentioned challenges (Etobro & Fabinu, 2017; Çimer, 2012; Wafula & Odhiambo, 2016). Besides, the teacher-centred method is another factor that amplifies problems for secondary school students in learning the classification of living things (Wafula & Odhiambo, 2016) .

These are the reasons why attention should be made to teaching and learning biology, particularly classification of living things to provide an understanding of biological diversity, and hence raise attitudes and knowledge of learners for sustainable conservation of natural resources (Sreedevi, Meshram, & Shashank, 2015; Maskour, Alami, Zaki, & Agorran, 2019). The present review paper investigates the problems and challenges encountered in teaching and learning classification of living things from primary to the university levels. It describes some teaching strategies that have been used in classification of living things and shows gaps. Further, it proposes a teaching strategy that can help as a remedy referring to innovative teaching methods, that can contribute to develop competences in learners and provide meaningful learning in the classification of living things.

Specifically, the study shows the role of innovative teaching methods focussing on 5Es instructional model to improve teaching and learning systematic of living things susceptible to provide meaningful learning. The article gives an insight on how adopting innovative teaching methods can assist educators to implement appropriate teaching strategies recommended in reforms of science education, for instance the Inquiry Based Learning/5Es instructional model.

Problems and Challenges in Teaching and Learning of Classification of Living Things

Teaching and learning classification of living things are characterized by students' poor performance, and they are mainly dominated by the traditional teaching methods (Maskour, Alami, Zaki, & Agorran, 2019: Wafula & Odhiambo, 2016; Yangin & Sidekli, 2014). Used teaching methods cause difficulties to students to understand classification principles, and hence classifying living organisms (Anderson, Ellis,& Jones, 2014; Trowbridge & Mintzes,1988). As a result, students present ideas about living organisms and natural phenomena that are not scientifically proven (Trowbridge & Mintzes,1988; Venville.G,2003). For example, bats can be classified as birds, while they are mammals, millepedes can be classified in reptiles while they are arthropods.

Misconceptions were also found in other studies (Kurt, 2013; Sami, 2018; Trowbridge & Mintzes, 1988). For example, some students classified fungi in plants, and some consider plants as non-living organisms because they do not move like animals (Stavy & Wax, 1989). Other studies on performance showed that poor performance in classifying living things is mainly rooted in the misconceptions about plants, animals and microorganisms (Janssen & Crauwels, 2011; Yangin and Sidekli, 2014; Wafula & Odhiambo, 2016). Reviewed literature revealed that inadequate teaching methods, media and informal information, intuitive conceptions were the sources of misconceptions (Yangin & Sidekli, 2014; Sami, 2018), which lead to poor understanding of classifications concepts, and hence poor performance.

Difficulties encountered by students in learning classification of living things are mainly related to the traditional teaching methods which do not give room to students to explore the environment, link characteristics of organisms with the area of study, and make a generalisation based on morphological characteristics of identified specimens (Kılıç, 2016; Trowbridge and Mintzes,1988; Venville,2003). Studies indicated that teachers have challenges in teaching the content of classification of living things, and specifically fail to connect the content with pedagogy (Yangin and, Sidekli, 2014; Kurt 2013; Putri, Hidayat, & Purwianingsih, 2020). Other studies on pre-service teachers indicated that they still present misconceptions from secondary schools about classification, and if not corrected in advance, they can be transferred to students while they will be in service (Yangin & Sidekli, 2014 ;Kılıç, 2016).

Some biology concepts, including classification of living things continue to challenge students to learn and lead to the memorization of some terms without understanding the meaning and importance (Zulfah& Putriyani, 2021; Selvi & Çoşan 2018). Problems related to the language are among factors that hinder proper learning of classification of living things. Students show lower level of communication skills due to teaching techniques that do not give opportunity to communicate and interact each other and with teachers (Zulfa &Rosyidah, 2020; Putri, Hidayat, & Purwianingsih, 2020). Moreover, non-scientific culture-based conceptions were found among other factors that contribute to poor understanding of the concepts studied in the classification of living things (Stavy& Wax, 1989).

Some Instructional Methods Used in The Classification of Living Things

Different studies were conducted with new teaching strategies to evaluate their effectiveness towards teaching and learning classification of living things. For instance, a rule-based method named expert system was

used and was found easier than the use of dichotomous keys (Desiani, Arhami, Firdaus, & Maiyanti, 2018). A rule - method is appreciated to deal with reasoning softwares that relates facts to the given problem, make inference, draw conclusions and provide a solution. The software consists of reasoning engine, and memory database of scientific knowledge and user interface (Masood & Soo, 2001). Regarding the classification of living organisms, the rule -based refers to the taxonomy knowledge which inspires the software system. The knowledge guides the reasoning system to identify new organisms based on characteristics that make a group of organisms from the biggest to the lowest group, whereby similarities increase (Desiani et al., 2018). Since the system contains more facts about classifying living organisms, it makes taxonomy easier and helps students to identify organisms.

Another instructional method used in the classification of living things is audio-visual resources. It consists of an integrated application that stimulates many senses to convey a piece information. It involves images, audio, and video which complement to deliver the message and facilitate interactions (Tang & Intai, 2017). In the context of the educational system, it is indicated that students can grasp knowledge easily when more senses are engaged and enhance the retention capacity (Idris, Shamsuddin, Arome, & Amiru 2018). The approach creates a room that foster reasoning ability and creativity; hence, learners understand well the concept of classification of living things and increase the ability to recall (Idris, Shamsuddin, Arome, &Amiru 2018). The audio-visual resources provided more graphics, images that helped learners relate living organisms' characteristics while classifying them.

Further, an interactive multimedia dichotomous key was employed to study plant classification and compared with conventional methods of a dichotomous key. Findings indicated the improvement of learners' achievements (Jacquemart et al., 2016). Interactive multimedia is a computer program combined with different applications involving videos, sound, graphics and animation and allows the user to control. It plays a role in science learning, while making abstract concepts more tangible and promote understanding (Sukariasih, Erniwati, & Salim,2019). For example, in classification of plants, interactive multimedia was made of botanical terms and description of the plant characteristics with photos and charts to identify plant. Those botanical terms are challenging and easy to forget. The more students do the practice, the more they become familiar with the names of living organisms. The method motivates students to learn classification (Jacquemart et al., 2016) by using dichotomous keys.

Project-based learning is also another methodology in spite of traditional teaching methods. It was found to promotes students' performance in the classification of living things and improve attitude towards the subject (Wafula & Odhiambo, 2016). Project-based learning is a teaching instruction method by which learners are engaged to solve a problem which requires problem-solving skills, critical thinking skills and investigation spirit (Uziak, 2016). The method is practical oriented facilitating interactions between teacher and students and promotes cooperative learning. In this regard, learners understand the concept of classification and get actively involved in learning. Consequently, their academic achievements were improved, and they developed a positive attitude towards the subject.

Limitations of the current instructional methods used in the classification of living things

The instructional methods currently used in the classification of living things are mainly computer-based. Even though ICT tools are preferred in the current modern world learning processes, they have some limitations. Learners are not given the opportunity to learn by doing as they are limited to the manipulation of the machine (Cakir, 2008). In this regard, the development of scientific skills such as observation, information about the collection area, sampling techniques, prediction of outcomes based on observed features, testing hypothesis and communication of results are not fully developed in leaners. While science education recommends the learning environment that engages learners in scientific practices through learning transferring and building new knowledge (Taştan, et al., 2018), the use of ICT does not provide these opportunities for students, and limits the development of skills.

Further, some key steps of the lesson are hard to be verified through the use of ICT. For example, the Principe of motivation that engages learners to explore learning materials is hard to be done through ICT tools. Further, cooperative learning is limited as every student is working on his/her own. The aspect of assessment which actually plays an important role in providing tremendous information that guides teachers to evaluate how learning takes place, showed that it is hard for leaners who did the classification of living things with computer-assisted (Tosuncuoglu,2018). This signifies that classification of living things needs the inquiry learning that fully engage leaners in leaning by enhancing the understanding of the content, leading to high achievement.

The Inquiry Based Learning and 5Es Instructional Model

Inquiry-based learning (IBL) is a form of active learning approach whereby students learn from questions or problems, basing on existing experiences or knowledge (Friedel et al., 2008). With the IBL, students actively find solutions to the problems presented through questions, propose possible ways of solutions, and communicate results (Abd-El-Khalick et al., 2004). It is rotted in constructivism, a theory where learners construct new ideas and integrate them with their prior knowledge. The IBL has four different levels of inquiry, level 0 being the poorest and level 3 being the highest level (UR-CE, 2020). During inquiry level 0, all materials guiding students are provided and they verify the procedures leading to solutions that is already known. Level 1 teachers provide problems and provide the way to solve them. In level 2 teachers steer students to problem solving. Lastly in level 3, students figure out problems with no teachers' intervention. Teachers are encouraged to use higher levels (actually level 1 to 3) of inquiry that engage leaners in full learning by doing, and hence allow them to think critically.

Under the IBL, the 5Es instructional model is one of the learning cycle that help to design an inquiry teaching method. The model includes five specific stages: engage, explore, explain, elaborate and evaluate (Campbell, 2000), that are coherent and linked each other. The 5Es instructional model was designed to stimulate observation, questioning and thinking of leaners. It is based on current understanding of learning processes and has been widely used and tested (Duran &Duran, 2004). In relation with each stage, teacher and leaner activities are specific (Table 1).

Appreciations of the IBL and 5Es instructional model

Trends in science education studies indicated a need to change teaching strategies that were observed through the persistent poor performance of learners in science subjects towards the active teaching methods, the IBL in this case **(**Ajaja and Urhievwejire, 2012). Further, the IBL presents more advantages compared to other current instructional methods used in the classification of living things. The advantages consist of the engagement of leaners in the leaning process through problem and cooperative leaning (Driel et al., 2001). By embracing the use of the IBL in teaching and learning science, academic achievement will be improved (Udu, 2018) based on the ability, skills and competences of students in doing things gained through the IBL process (Abd-El-Khalick et al., 2004).

Under the IBL, the 5Es instructional model stimulates learners to acquire different skills through observation, exploration and gathering the information through scientific analysis, predicting and testing hypothesis, communicating results from group discussion (Duran and Duran, 2004). Through the steps of the model, concepts become more digestible and promotes the understanding of concerned subject (Lina et al., 2020), because the model is rotted in constructivism theory, appreciated to actively engage students in learning process by constructing new ideas upon experiences, and assess the understanding of concepts taught (Bybee et al., 2006; Robert et al., 2019). The model facilitates the conceptual change, help teachers to address misconceptions during explain phase (Baydere et al., 2020; Ultay & Çalik, 2015).

Nowadays, the constructivist 5Es model is taken into consideration following its great benefit in knowledge transfer that equips learners with scientific competences that enable them to be more skilled in the domain (Pagsangkanae et al., 2019; Lin and Thuan, 2020). With 5Es teaching methods, students explicitly understand the nature of science (Pagsangkanae et al., 2019). The model was used in different studies to promote achievement, interest and confidence in science, retention in the learned concepts, and enhance problem-solving skills (Tek et al., 2018; Lina et al; 2020). Further, the 5Es instructional model promotes students' positive attitudes towards science subjects (Ibrahim, 2015). Moreover, it provides a learning environment where learners embrace science concepts that seem to be taught through science practices that promote reasoning skills (Robert et al., 2019).

Teachers proved the learning cycle to be more effective during teaching and learning science lesson. They confirmed that it helps to connect to the prior knowledge while engaging students to follow the new lessons, helps learners to hands-on while exploring facts and concepts and helps to assess if desired skills were gained by elaborating the learned concepts in a new context (Wilder and Shuttleworth, 2010). Further, the model organizes instructions in sequential phases that are essential in knowledge construction. In this line, one phase is linked, and contributes to the next one in a logical way (Bybee, 2006). Furthermore, the 5Es learning model assists teachers implementing learner-centered teaching methods, and develops activity-based instruction while delivering coherent lessons that favour the understanding of concepts by learners. Teachers improve teaching practices through the sequences of 5Es teaching strategy while integrating knowledge of content, pedagogy and technology into learning activities.

The review study revealed the advantages of 5Es learning cycle in teaching and learning different biology topics. For example, Wilder and Shuttleworth (2010) indicated that learning cell biology with 5Es model

promotes learners' interest in the subject, facilitate the knowledge transfer and self-directed learning. Further, Cardak et al., (2008) indicated that 5Es instructional model influences performance in the learning circulatory system and facilitate alternative conceptions that learners possess before instruction. The model was proven to boost academic achievement, retention and improve learners' attitudes in learning genetics (Ibrahim, 2015). However, nothing is known how the 5Es instructional model contributes to the teaching and learning of the classification of living things.

5Es instructional model as a remedy in teaching and learning classification of living things

With the 5Es instructional model in the classification of living things, we assume that students will get the opportunity to correct misconceptions through self-reflection, sharing ideas with peers during the group discussion (Bybee, 1997 as cited in Duran & Duran, 2004). Since the 5Es learning cycle gives room for exploration, students will be given the opportunity to explore living organisms from the natural habitat before sampling, discuss together, and then compare and contrast based on observable characteristics of sampled specimens. We further assume that knowledge and skills in the classification of living things shall be developed in the explain phase, where learners have peer assessments and express ideas and taking responsibility for self-learning (Trowbridge & Mintzes,1988).

Conclusion

Based on the findings of this review study, teaching and learning classification of living things presents challenges that involve misconceptions, problems related to communication that have led to poor performance mainly caused by inappropriate teaching strategies. Teaching approaches like Inquiry based learning designed by 5Es instructional model are recommended to be introduced at all school levels and continuous professional development for the in-service teachers. Further, teaching materials have to be supplied if we want to improve teaching towards the quality in Education. With the 5Es instructional model, teaching and learning classification of living things is enhanced, the reason why it can be extended to other biology topics and science subjects.

Recommendation and Educational Implication

We recommend the use of the 5Es instructional model for it is effective in teaching and learning biology (Ajaja & Urhievwejire, 2012). The effectiveness of the model is explained by the opportunities given to learners while guided by teachers to explore, get actively involved at each stage of learning, interact with peers and teachers which results in better understanding of concepts, being responsible for learning (Ajaja & Urhievwejire, 2012). Moreover, students are motivated in learning science subject and have confidence to express ideas through explain phase and the model promotes students' achievements, positive attitude towards science, and improve thinking skills (Duran & Duran, 2004). Particularly, we recommend a detailed study to indicate how the IBL using the 5Es instructional model effectively teaches and learns classification of living things. Attention should be made on how classification of living things is taught and learned at all education levels, since it presents the basis to understand other biology concepts. Teaching practices that facilitate the achievement of all required learning objectives and enhance learning should be applied. In doing so, learners will be equipped with right scientific concepts and skills which will enable them to learn other subjects and transfer knowledge acquired in daily life.

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