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A constructivist approach to teaching scientific content to university students

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Abstract. The constructivist approach to acquiring new knowledge has very much been appreciated by foreign language practitioners for optimal learning. The E-Model, developed by Atkins & Karplus (1962) as a research-based approach implies that the learners construct new knowledge on their own (Lynch, 2017). The present paper then suggests the implementation of the instructional E-Model in teaching scientific content to Master students through a Self-Directed Approach. The study is exploratory and experimental in its scope and aims at unleashing university students' desire to construct new knowledge through a reflective model composed of a set of stages: engagement, exploration, explanation, elaboration, and evaluation. Participant observation was used as a tool to obtain qualitative data. The findings demonstrated that the E-Model was effective as a constructivist teaching approach for a great majority of the students, and this was reflected through their skills in presenting and manipulating new information. In addition to their cognitive development, the students' self-confidence and self-esteem were very much enhanced.

Keywords. E-Model, constructivism, Self-Directed Learning

Introduction

Effective learning is a challenging objective for the teacher and the learner. Both of them are in search of self-satisfaction and positive achievement. Therefore, teachers are often seeking an adequate methodology that facilitates reaching the learning outcomes. As a result, foreign language classes have seen a variety of methodologies that correlate with social advancements, ranging from simply memorising vocabulary and lexical items to effective communication. To attain such an objective, contemporary research suggests generating learners' new knowledge from their existing one (Piaget, 1972; Vygotsky, 1978 ; Brunner ,1990).This requires a learner-tailored methodology where the learner takes charge of his own learning through the identification of personal needs, weaknesses, and wants. The first aspect of learner-centered teaching that can optimise learning is its focus on involving students in as much first-hand learning as possible (Doyle, 2008 p7). In fact, a later goal in learning a foreign language has been to use a method that fits each learner based on what they already know and where they came from. Hence, the implementation of an appropriate teaching methodology, a constructivist model.

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Instructional E-Model as a Self - Directed Approach

In the twenty-first century, education has witnessed a variety of teaching methodologies, which are learner-centered in scope. The communicative approach in language teaching emphasises fluency over accuracy. Then, the competency approach in foreign language learning helped learners solve real-life issues. In fact, learning in the twenty-first century necessitates students being deeper and self-directed learners who can take ownership of their learning, transfer knowledge, and possess a plethora of twenty-first-century competencies in the cognitive, intrapersonal, and interpersonal domains (Van Zyl & Mentz 2019 p102). Self-Directed Learning, henceforth (SDL), is an approach where learners take their own responsibility in learning (Bosch et al., 2019). SDL emphasises learners' self-management of their cognitive skills and emotional ones. Self-directed learning is a challenging goal for both educators and students, as it requires the role-players to change, take risks, and develop a plan in order to be a success (Bosch,2019 p 35).Although SDL stresses individual commitment in achieving goals, the approach encourages cooperative learning with peers and assistance from the teacher (Bosch et al., 2019).

The E-Model is a self-directed approach to learning with five instructional stages based on the constructivist theory of learning, which advocates that new knowledge is generated by building on existing knowledge.The E instructional model guides the learner through a series of steps that help him figure out how to use the new information. At the very beginning, during the **engagement** phase, the teacher diagnoses the learners' existing knowledge and prepares them for the acquisition of a new one (Lynch,2017). To successfully complete this stage and move on to the next one, it is important that the students be motivated and ready to acquire new knowledge. If it is not the case, the students will not be engaged in undertaking any tasks for learning. Once the engagement phase is accomplished, the students move to the next step ; exploration. During this stage, the students investigate and trigger to look for new ideas and knowledge necessary to expand and develop the existing knowledge they have about a given subject. They [students] should be able to identify and use appropriate resources to help them acquire the necessary knowledge during this phase, whether these resources are teachers, peers, books, or online resources (Van Zyl & Mentz, 2019 P70). The third stage of the model is **explanation**, during which the learner tries to understand what is beyond his intellectual capacities. With the assistance of the teacher, the learning difficulties are minimised. In this context, Bosch et al. (1997) cite Garrison (1997), who believes that this form of control implies working with other people within the context and not necessarily independent learning. Collaborations between educator and student in managing the learning situation are included (Van Zyl & Mentz, 2019 p. 12). The fourth step of the model is the **elaboration** phase, where the learner demonstrates his capacities for manipulating the new knowledge. The final stage of the model is evaluation. During this phase, the teacher and learner evaluate the teaching and learning process. It is the stage where the learning outcomes are unveiled to examine the deficiencies and learning difficulties .

According to Bybee et al., the sustained use of an effective, research-based instructional model can help students learn fundamental concepts in science and other domains. If we accept that premise, then an instructional model must be effective, supported by relevant research, and implemented consistently and widely to have the desired effect on teaching and learning (2006 P1).

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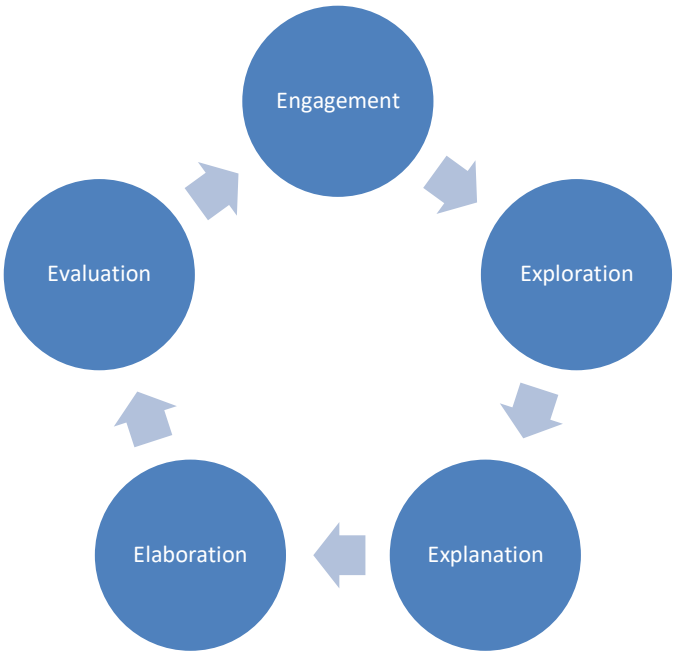
Figure 1 : Intructional E- Model



They [students] should reflect on their learning during the learning process; they should be able to assess whether they have achieved their learning goals; and they should persevere with learning and overcome obstacles until their goals are met (Van Zyl & Mentz, 2019 P70).

Inquiry -Based Learning

The inquiry-based approach to teaching is student-centered where the learner takes responsibility for looking for information through the guidance of the teacher. The approach triggers the learners' curiosity using different strategies in order to satisfy their inquisitiveness and gain satisfaction. Inquiry-based instruction not only helps foster curiosity and develop critical thinking, but it encourages independent thinking as well. It also leads learners to examine everything around them, address hypotheses, and evaluate their results. Moreover, inquiry-based instruction helps learners develop their intrapersonal competencies through the identification of their strengths and weaknesses and the use of adequate strategies for effective learning. Based on the constructivist view of learning, inquiry-based learning is an active process where the learner investigates, looks for, and reflects on specific information. The process starts from asking questions to looking for evidence and then evaluating conclusions during different stages of active reflection where the learner constructs new knowledge.

Throughout the process, the learner employs various strategies, tools, and sources to gather information and answer the initial question(s) in order to generate new knowledge at the end. It is noteworthy to mention that the learner may use inadequate strategies and sources. Yet, this is part of learning, and failure or wrong strategy use is part of effective learning.

Autonomy; a Reflective Practice

Contemporary approaches to teaching emphasise learners' autonomy in learning. Different approaches have seen light and proven their efficacy in improving autonomous learning. This latter implies being aware of the learning objectives, needs, and outcomes. Because of this, learners take it upon themselves to use the right methods and strategies for learning. That is, they are conscious of what an and how they learn (Richards, 2002). Moreover, the learner's autonomy enhances critical thinking skills and reflection. Through inquiry and

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investigation to provide evidence and answer preliminary questions, the learner goes through a process of inquiry and reflection, which at the end may provide satisfactory answers (at least to the learner). Self-directed learning emphasises knowledge construction through discussion and dialogue (Boyer et al. 2014) and de-emphasises teaching as a process in which an educator is the main source of information (Bosch et al. 2019 P2). Indeed, being able to research and use adequate research tools can only foster the learner's cognitive abilities. Yet , educators should be cognisant of the fact that a student who is self-directed in one situation might need more orientation, support, and guidance in other learning situations (Bosch et al., 2019. p8).

Methodolgy

The present paper suggests the implementation of the E-instructional model in teaching content subjects to 40 master students in didactics and applied linguistics. The subject is taught to Master 1 and 2 students. The two-semester course of three hours a week gives the students the opportunity to learn about major issues related to cognitive science and their impact on learning and teaching. Therefore, the students are introduced to major concepts related to cognitive science during their first year of study. Then, they are introduced to new ones during their second year. Because of the specificities of the course, being scientific , very technical , abstract, and mostly delivered to a specific population who is scientifically-oriented, the content of the course has been simplified so that the students, coming in their great majority from literary streams, would acquire the basic concepts related to cognitive science.

The content subject relates to cognitive science, a newly integrated content for students who come, in their great majority, from literary streams and do not necessarily master scientific knowledge. Thus, the main objective in teaching cognitive science to master students of applied linguistics and foreign languages is to try to examine the impact of cognitive science issues on the classroom context. Accordingly, the content of the course turns around major concepts, such as the role of memory in learning, attention in learning, learning difficulties like aphasia, dyslexia, etc. It is noteworthy to mention that the implementation of the E-Model ; engage,explore ,explain, elaborate, and finally evaluate, provides the students with an opportunity to develop their own understanding of the content to be mastered and may be beneficial to them as future teachers.

The E-Model's implementation went through five stages, during which the students actively acquired new knowledge or refreshed existing ones. During a semester, when students had to learn key ideas in cognitive science, they were taught using the same method. At the beginning of the semester, the students were introduced to the content of the course in cognitive science and the syllabus was provided. The classes took place every week for three hours. During the first hour, the teacher introduced the topic, and during the second hour, the students intervened with the assistance of the teacher. Of course, the students were given the topic to be dealt with a week before in order to give the students time to search for information and present it on the D-day. Then, during each session, the students were assigned to look for extra knowledge related to the topic dealt with during the coming session and which was shared and discussed within the classroom.

After introducing the field of cognitive science and its objectives, the teacher introduced the next topic: the brain, lateralization, and the main functions of the brain. Then, the students were asked to identify one part of the brain and explain its function to the rest of the class as a task for the coming session . It is the exploration phase where the students actively take charge of their learning and look for the knowledge by themselves and then

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share it in class orally. Oral presentations did not last long but took about ten minutes for each student to present what he had learnt and share the information with his mates. In class, knowledge was discussed with peers and the teacher. In addition, technical words were written on the board and explained. During this step, called "explanation," the students worked together with the person showing them the part of the brain and how it works. With the help of the teacher when needed, the students asked questions and discussed the functions of the part of the brain that controls them. After presenting and explaining the new information, the students came up with more information that they might have missed before. During this phase,the elaboration phase , the students not only developed new knowledge but their self-confidence as well, since their feeling of supplying new information to others provided them with assurance and self-confidence. The last phase of the model, evaluation, provided both the teacher and the students an opportunity to assess themselves.

On the one hand, formative assessment was possible, allowing the teacher to intervene from time to time, correcting the students' mistakes. The students, on the other hand, could identify their weaknesses and those of their classmates. The same process was implemented during a semester with Master students, during which they took charge of their own learning. Accordingly, different topics were dealt with; causes of learning disabilities, attention deficit disorder (ADD), and dyslexia as common classroom issues and their impact on learners' achievement.

Results and Discussion of Findings

The E-Model was implemented in two ways: it not only allowed students to generate new knowledge about cognitive science, but it also helped them overcome their fear of public speaking. In fact, the use of strategies helped students gain an understanding of new concepts, motivating them to learn and guiding them towards the identification of their competencies, as well as their weaknesses. At first, the students were engaged in choosing a scientific concept and looking for its meaning and functions. The choice of the topic or concept was not compulsory, but the students were free to choose the concept they wanted to research. Indeed, **engagement** cannot be imposed. If it were, the students would not go further to the next stage of **exploration**. This latter, in fact, is accomplished in the presence of personal motives. During this phase, the students were able to investigate and collect the necessary knowledge that was discussed in classOf course, it was important that the students manipulate the right meaning of the concepts that were explained during the class. With the assistance of the teacher and the students, the acquisition of knowledge became a dynamic process where mistakes were corrected and new knowledge was shared. During the elaboration stage and with the guidance of the teacher, the students were able to use the acquired knowledge trying to relate it to learning issues. The final stage was the evaluation. During this stage, the teacher could assess the students' improvement. From merely collecting new information from specific sources to reflecting on that information, the students were able to present technical concepts . In addition, the students were given an opportunity to discover their intrapersonal skills (which are very often ignored). In fact, oral presentations and public speaking in front of the class could provide the students with the opportunity for the betterment of their speaking skills as well as their self-confidence. In fact, at the end of the course , the students' self-confidence was manifested through their mastery of scientific concepts related to cognitive science and their final research projects.

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Conclusion

The present paper was an attempt to help master students who are confronted with new content understand and acquire new scientific knowledge that necessitates reflection and monotoring. The study, exploratory in scope, was meant to unleash the students' motives to look for and generate new knowledge. The implementation of Self-Directed Learning through the instructional E-Model was effective for the great majority of the students who demonstrated a real interest in acquiring new content since it could help them overcome issues that they may encounter as future teachers.

Undoubtedly, the experience might have been hard for some students who are introverted in nature or those with language deficiencies in the target language. However, figuring out how to deal with these weaknesses was necessary for many of the students who showed some improvement as the model was put into place by the end of the course. Indeed, the implementation of the model allowed the students to acquire new scientific terms , such as the Wernicke's area, which is responsible for understanding speech, or the Broca's area for producing speech, working memory, to mention a few of the concepts.

Nevertheless, one has to mention that for a few students, the E-Model was not effective. This was clear because they did not take part and could not get past their cognitive weaknesses. This may be due to their learning style or to poor strategy use. Thus, more effort is to be directed towards such students through the teacher's assistance and guidance.

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