Constructively Aligned Teaching Sequence (CATS): A Tool For Teaching Organismal Biology In STEM Senior High School Education

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Abstract. This paper presents the developed and evaluated innovation, the Constructively Aligned Teaching Sequence (CATS). This teaching sequence is a K to 12 compliant that may be used in teaching the topic on human organ systems to Senior High School students. The CATS' prototype was constructed and tested in authentic school context. The development was done using the design principles embodied in the model of educational reconstruction proposed by Duit et.al. (2005). The evaluation was conducted by looking into the students learning outcomes and teachers’ evaluation. The research instruments included students’ pre-assessment/post-assessment drawing, pretest/posttest, questionnaire, and recorded unstructured interviews. Quantitative and qualitative data corroborates that use of CATS contributed to the attainment of the students’ learning outcomes. In conclusion, future prototypes may be developed to address more strongly students’ alternative conceptions through the applied design principles or add new design principles. Findings showed that CATS may be redesigned to further strengthen the correct conceptions, enhance limited conceptions and remediate conceptions in conflict with the accepted biological concepts. Furthermore, this study provides an avenue for further research on its improvement such as construction, usage, handling, and storage of the student outputs.

1. Introduction

Philippine education is currently going through a major reform to align its educational system with the larger majority of educational institutions of the world. Consequently, is the implementation of K to 12 Enhanced Basic Education Program in which K to 12 Science Curriculum is a part of. In the current reform, science education is set to attune to the 21st-century education. In light of this implementation, studies in the country
revealed several challenges including the availability of curriculum materials. CATS was thought of in recognition of the challenge at the same time in response to the call for curriculum compliant with appropriate methodologies and innovative approaches. This study intends to answer some of the challenges that couple the implementation of the revised curriculum in science education in the Philippines particularly in the use of more effective curriculum material. Likewise, the developed teaching sequence will try to address teachers’ teaching difficulties as well as students’ initial conceptions on the topic. Results of this study will contribute to the country’s emerging literature on K to 12 science curriculum and students’ conceptions on organ systems. In the early implementation of this new curriculum, materials that are K to 12 ready are scarce if not, unavailable. This material was developed to provide Science teachers the needed instructional material in teaching the topic to comply with the new curriculum’s content and performance standards. Consequently, advance the field of science education.

2. Literature Review

Literature shows several studies conducted in various countries which imply that designing and evaluating teaching sequences can be one of the natural ways in conducting research on science classroom education [1-3]. According to [4-6], design studies can be seen as approaches to conducting research that is concerned in developing and testing teaching/learning methods, instructional materials and/or software tools. A study by [7-8] revealed that students possess alternative conceptions before instruction about a variety of science topics. Specifically, of K to 12 Biology 2, the study of Özsevgçe (2007) listed topics that were studied extensively in biology [9-11]. This includes cells, respiration, photosynthesis, and genetics. The same study also mentioned that recent studies show students having problems in understanding key topics of biology such as internal organs, organ systems, and processes of their own bodies [12-13].

3. Methodology

The study consisted of the following phases namely preliminary phase, development, implementation, and evaluation phases.

3.1. Preliminary Phase

The students were asked to draw on a clean piece of paper a human body and what they think their bodies are made up of. The collection of data was done in a formal condition where the participants were not free to look into others’ work even with the information that it was not a quiz. The completed drawings were examined and analyzed. The drawings of the organs were analyzed according to their presence and connections of the organs and other observable data but not on its aesthetic value. The fear of cultural differences and biases were removed in this study for as pointed out in the literature that drawings are special value for international comparative studies. An unstructured interview was conducted to students whose drawings showed distinctiveness. The pretest and pre-assessment were done to look into the students’ initial conceptions on organ systems. For the teachers’ approaches and difficulties in teaching the topic, the Teachers’
Approaches and Difficulties in Teaching the Organ Systems (TADTOS) questionnaire were administered to the ten teacher participants. TADTOS was divided into 3 parts namely teacher’s information, Approach to Teaching Inventory-Revised or ATI-R and the enumerated specific topics of the organ systems.

3.2. Development Phase

With the availability of the abovementioned data, the Constructive Aligned Teaching Sequence was designed. The students’ initial conceptions, teachers’ difficulty, the content and performance standards of K to 12 Biology 2 curriculum were brought together to serve as the inputs for CATS. Taking these into consideration, the teaching sequence was designed applying the principles of constructive alignment. The design of the teaching-learning CATS was grounded on the principles of Biggs’ Theory of Constructive Alignment. It is a systemic theory regards the total teaching context as a whole. It provides a model for a teaching system where the parts may be looked into and how these aspects of teaching may react under modification. The main parts of the system to be considered are the students, teachers and of cognitive processes. It was stated in the study that a course is constructively aligned when: a) the learning objectives (ILOs) are stated clearly, b) the learning objectives are explicitly communicated to students, c) the exam’s assessments (ATs) match the learning objectives, and d) the teaching forms (TLAs) match the learning objectives. The SOLO Taxonomy (Structure of the Observed Learning Outcome) formed the model for the competences in writing the ILOs.

3.3. Implementation Phase

In this particular study, the designed CATS was carried out by the researcher to the students of the randomly selected Biological Science class with 47 students. The validated CATS was used in teaching the topic on organ systems. The teaching of lessons in the teaching sequence was videotaped set up in the classroom. Videotaping of lessons is a straightforward method used to capture teacher-student interactions during implementation.

3.4. Development Phase

Posttest and post-assessment by drawing method were administered at the end of the unit. The posttest and post-assessment were compared to the pretest and pre-assessment scores to reveal data on the achievement of the students. The biology teachers as teacher-respondents were given a questionnaire to assess the CATS on its dimension namely presentation of content, curricular alignment and practicality of implementation as measures of the developed CATS.
4. Developing teaching sequence

The design principles included the following: undergoing clarification and analysis of science content, designing learning environments and investigation into students’ perspectives. In this study, a survey on the teachers’ perspective in teaching the topic was conducted in addition to the three design principles. The development of this teacher material was based on the Content and Performance Standard for Senior High School Biology 2 Curriculum, Students’ Initial Conceptions on Organ Systems’ Structure and Function as well as the Teachers’ Difficulty in teaching the said topic. Consequently, the developed teaching material was entitled Constructively Aligned Teaching Sequence or CATS which denotes that its teaching-learning activities and assessment tasks were aligned to its performance standards.

4.1. Analysis of science content

The first principle included the clarification and alignment of the topic to the Content and Performance Standard for Senior High School Biology 2 Curriculum of K to 12. In terms of the content standard, CATS covered the Animal Organ Systems and their Functions which is only a part of the content Organismal Biology. In line with the content and performance standards, the teaching-learning activities and assessment tasks were designed to address the students’ initial conceptions and teachers’ difficulty in teaching the said topics.

4.2. Designing of learning environments

The development of this teaching sequence designed on Constructive Alignment Theory, as a theory of teaching and material development. Theory of Constructive Alignment is a theoretical underpinning of OBTL. Constructive alignment requires alignment between the three key areas of the curriculum namely, the intended learning outcomes (ILOs) or performance standards, teaching-learning activities (TLAs), and assessment tasks (ATs).

4.3. Investigation into students’ perspectives

According to the constructivist framework, understanding students’ prior knowledge is a significant step that determines the outcome of learning. Results of the preliminary data to the construction of this teaching sequence showed that students see themselves made up of common organs however they had a little understanding of the interconnections and interrelationships of these organs. All of the respondents were aware that their body is composed of organs but missed to see their structures as a functioning whole. Their understanding on the interconnections and the interrelations of the functions of these organs and the organ systems as well as the spelling, shape,
and location of certain organs has to be looked into with emphasis on the teaching process. The findings of the students’ initial conceptions were reflected in the CATS as Common Student Concept with its corresponding Scientific Concept. The students’ initial conceptions that emerged from their responses and the teachers’ teaching difficulties formed as input in the development of the teaching sequence.

4.4. Survey on teachers’ perspectives

The teachers’ perspective was considered wherein their difficulty in teaching the topic was coupled with the students’ conceptions. Data of the preliminary phase also showed that teachers teaching the subject were predominantly Information transfer/teacher-focused scale (ITTF). Hence, ITTF teachers tend to conceptualize teaching as “transmitting content” compared to the CSSF teachers who conceptualize teaching as “concept exploration” and in the process develop students’ awareness about their own reasoning abilities. Moreover, these teachers did not find the teaching of the structures or the functional processes of the organ systems easy nor difficult. But most, if not, all of their stated comments agreed for the need for hands-on activities that will facilitate students’ better and correct understanding of the structures and functional processes of the organ systems. CATS was designed that may encourage ITTF teachers to more student-centered in the process. The findings of teachers’ difficulty in teaching the topics were incorporated in the teaching-learning activities in terms of the strategies.

5. Description of CATS

CATS is offered as one of the great choices that uphold K to 12 curricula. The central theme in the development of this teaching sequence is the constructive alignment in teaching-learning the organ systems in order to attain the desired performance standard in the SHS Biology course. One significant feature of this CATS is the application of a teaching system where teaching-learning activities and the assessment tasks are aligned to the performance standard. In the same way, the identified scientific concepts are based on its specified Content Standards. Another important feature is the use of model making activities requiring the active involvement of every student at the same time providing opportunities for learners to use multiple resources for learning. Teaching the organ systems through model making helps teacher tackle all the organ systems within the allotted time, a solution to the chronic challenge of too much science to teach in too little time. Aside from the constructivist student activities, it also features ICT – based materials through the suggested web links and other technology-mediated activities. The proposed activities foster creativity, problem-solving among other skills in students which the new curriculum upholds. In totality, CATS is K to 12 compliant. Finally, the integration of research results on students’ conceptions on organ systems as well as teachers’ approaches to teaching the said topic also plays a vital role in the development of this innovation. It is in these premises that this teaching material
trails the learner-centered curriculum model and inquiry-based curriculum design. Inquiry-based approaches to science education focus on student-constructed learning as opposed to a teacher–transmitted information. Inquiry-based as learning process or strategy aims to enhance learning based on (1) increased student involvement, (2) multiple ways of knowing, and (3) sequential phases of cognition. Among the various inquiry-based approaches, the students will be exposed to the 5 Es- model (Engage, Explore, Explain, Elaborate and Evaluate) teaching and learning model as the framework for the TLAs of this teaching sequence. Its constructivist learning activities emphasized the 5Es Approach and model making.

6. Evaluation of CATS

The success of the developed CATS was derived from the students’ learning outcomes and the evaluation of the biology teachers on the implemented teaching sequence. Posttest and post-assessment by drawing method were administered at the end of the unit lesson. The pretest and posttest were compared using a t-test for independent samples at \( \alpha=.05 \) level of significance to reveal learning gains of the students. The result suggested that there was enough evidence to conclude that the significant increase in the test mean scores among students after the lesson was likely due to the use of CATS. The pre-assessment and post-assessment data were used to describe the conception of the students through drawing method before and after the use of CATS. As the data were subjected to a normality test, the results showed that the data were not normally distributed hence the use of a nonparametric test was utilized. A Wilcoxon Signed-ranks test indicated that the conception of students on the organ systems after the use of CATS (Mdn=6.0) was significantly higher than the conception of students of the organ system before the use of CATS (Mdn=2.00), \( Z=6.015, p<.001, r=.88 \). The CATS evaluation revealed that the innovation achieved a promising results in all its dimensions namely presentation of content, curricular alignment and practicality of implementation as measures of the developed CATS.

7. Conclusion

CATS, as supported by constructivism theory of learning and theory of constructive alignment, provide opportunities to these group of students in the improvement of their conceptions on human organ systems as manifested in their final conceptions, achievement, and positive feedback. This could be as a result of the design principles applied in the development of CATS specifically clarification and analysis of science content to be within the standards of the Senior High School K to 12 curricula, investigation into students’ conceptions and teachers’ perspectives and design of learning environments through an aligned teaching system. Moreover, CATS exposes students to learning activities enabling them to acquire life skills relevant in their daily decision making. Further analysis of the results provided key elements for a better understanding of the students’ conceptions on organ systems and engage teachers in actions that can better promote its goals. It also provided important features that may be applied in designing and developing teaching-learning
sequences in teaching other biological concepts. Finally, it can be implied that the intervention prototype may be explicitly designed to create a learning environment that promotes teaching-learning activities appropriate in achieving the desired learning outcomes.

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