THE IMPACT OF CONSTRUCTIVE ALIGNED TEACHING SEQUENCE (CATS) ON STUDENTS' LEARNING OUTCOMES AND TEACHERS' EVALUATION: A PEDAGOGICAL FRAMEWORK FOR SCIENCE PRESERVICE TEACHERS

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ABSTRACT: *With the global focus on achieving Sustainable Development Goal 4 (SDG 4), Quality Education, relevant science education, and pedagogical approaches become essential for better learning outcomes. This study investigates the impact of Constructive Aligned Teaching Sequence (CATS) on students' learning outcomes and teachers' evaluation with a specific focus on science preservice teachers in the Philippines. Aligned with SDG 4's principles of inclusive and equitable quality education, this study addresses the pressing need to advance science education in the country. The study anchors on the educational design studies using various research instruments, including researcher-made pretests/post-tests, questionnaires, checklists, videotaped lessons, and recorded interviews. The study involves a class of 47 university students taking Bachelor of Science in Education majoring in science and 10 Science instructors from a prominent normal school in the country. Data analysis involves quantitative methods, such as relative frequency distribution, percentage method, nonparametric tests, t-tests, and qualitative approaches, including thematic analysis of student drawings, interviews, and observations. The study reveals that CATS positively influences students' learning outcomes, aligning well with SDG 4's objectives in promoting quality education. Moreover, the research recommends adapting CATS to address students' conceptions, strengthening their comprehension of scientific concepts. CATS is also an innovative teaching material, offering the potential for further research on its construction, usage, handling, and storage of organ system model outputs. By providing a tailored pedagogical framework for science preservice teachers, this study contributes to advancing science education in the Philippines and the broader global efforts to achieve SDG 4.*

Keywords: Constructive Aligned Teaching Sequence (CATS), Students' Learning Outcomes, Teachers' Evaluation, Pedagogical Framework, Science Preservice Teachers

1.INTRODUCTION

Science education reform is a dynamic process that evolves in response to changing trends and societal challenges. The goal of achieving quality education, as emphasized by the United Nations Sustainable Development Goal 4 (SDG 4), is particularly relevant in the context of science preservice teachers' training [1, 2]. Providing quality education in science is crucial to fostering a generation of scientifically literate individuals capable of addressing global challenges and contributing to sustainable development. Given the scope of these global initiatives, the involvement of science educators is imperative to broaden the perspectives of science education to address sustainable development, empowerment, and social transformation, thereby ensuring an informed, ecologically, environmentally literate, thoughtful, and empathetic citizenry [2].

Historical reviews, such as the work of Byber and DeBoer [3], highlight how international science education goals have evolved over different periods, adapting to the changing landscape of education. In recent times, science education reforms have shifted towards developing scientific literacy among students. Scientific literacy for change-making emphasizes empowering learners to take a knowledge-based stance and act toward change [4, 5]. This emphasis aligns with SDG 4, which aims to ensure inclusive and equitable quality education for all, promoting lifelong learning opportunities for sustainable development.

Like many other countries, the Philippines recognizes the importance of aligning its educational system with international trends and demands. To keep pace with rapid advancements in science and society's evolving needs, as highlighted in the UNESCO Bangkok report in 2022, the Philippine government implemented the K to 12 curriculums. This curriculum reform aims to produce scientifically, technologically, and environmentally literate individuals with the necessary 21st-century skills to actively and competitively participate in local and global communities. For preservice teachers specializing in science, embracing the goals of SDG 4 and the K to 12 curriculum requires adopting innovative and practical approaches to science education. By equipping preservice teachers with the knowledge, skills, and pedagogical strategies needed to deliver quality science education, the Philippines can lay the foundation for achieving sustainable development through scientific literacy [6, 7]. However, implementing the K to 12 program and preparing preservice science teachers to meet the goals of SDG 4 poses several challenges. Schools must be well-prepared to incorporate the K to 12 curriculums effectively, and teachers must be equipped to adjust and innovate their teaching practices [7]. Additionally, ensuring access to updated teaching materials, resources, and professional development opportunities for preservice teachers is essential to enhancing the quality of science education [6].

This study embarks on a vital mission to confront the challenges faced in science education, particularly in preparing science preservice teachers. It endeavors to design, implement, and evaluate a research-based teaching sequence rooted in the principles of the Theory of Constructive Alignment as the theoretical underpinning of Outcome-based Teaching Learning (OBTL) [8, 9, 10], a version of Outcomes-based Education (OBE) intended to improve the quality of learning at the classroom level [10, 11, 12, 13]. The pedagogical framework is tailored to equip science preservice teachers with the necessary tools for delivering quality science education. This research-driven teaching sequence employs constructive alignment, a proven OBTL approach that fosters students' deep learning and scientific literacy [7, 13, 14]. By empowering science preservice teachers with

effective pedagogical strategies and upholding the principles of SDG 4, which aims to ensure inclusive and equitable quality education for all, this study seeks to elevate the standards of science education and shape the future generation's understanding of the world, better enabling them to tackle global challenges.

Central to this research is the recognition of science education's pivotal role in molding the minds of upcoming generations [2]. As preservice teachers enter the field of education, their impact on student learning and development becomes instrumental in nurturing scientific literacy and critical thinking [7]. By providing preservice teachers with the means to deliver effective and engaging science lessons, this study aims to cultivate a generation of scientifically literate individuals capable of making informed decisions and contributing to sustainable development, as outlined in SDG 4. Equipping science preservice teachers with innovative and evidence-based pedagogical tools will pave the way for students' transformative and enriching learning experiences. The success of this initiative will resonate beyond the confines of the classroom, leaving a lasting impact on society by cultivating a scientifically literate and engaged citizenry.

This paper will focus on assessing the effect of the researcher-developed Constructively Aligned Teaching Sequence (CATS) on human organ systems on student learning outcomes, including their final conceptions and learning gains. Additionally, it will explore university teachers' evaluation of CATS, examining its efficacy in content presentation, curricular alignment, and practicality of implementation. Through a comprehensive and meticulous analysis, this paper provides valuable insights into the effectiveness of CATS and its potential to address the challenges faced in science education, ultimately contributing to the advancement of SDG 4 and the pursuit of quality education for all.

2. MATERIAL AND METHODS

This study adopted the design-based research approach [15], employing qualitative and quantitative methods for developing, designing, and evaluating an aligned teaching sequence on organ systems that draw inputs from teacher's and university students' concepts. The study aimed to develop, design, and evaluate a teaching sequence focused on organ systems by adopting qualitative and quantitative methods. The research was conducted in one of the prominent normal schools in the country.

A randomly selected class of 47 participants, predominantly female students pursuing a Bachelor of Secondary Education during the second semester of SY 2021-2022, represented the student population. Their age ranged from 16 to 22 years, with an average age of 17. On the other hand, ten teachers, six females and four males, were purposively selected based on their expertise and experience in teaching human organ systems. Over half of the teachers held a master's degree or had completed units in a master's or doctorate program, and their teaching experience ranged from two years to more than 20 years.

The research methods involved qualitative data collection during the design and evaluation phases. Questionnaires and interviews were used to gain insights into the challenges faced in teaching organ systems and the students' initial conceptions. This information guided the development of the teaching content and activities.

During the evaluation phase, qualitative methods were used to determine whether the teaching sequence was implemented as intended and whether students achieved the desired learning outcomes. Additionally, quantitative data was extracted from the questionnaires administered to the university students. The pretest-posttest design allowed for an examination of the students ' final conceptions of organ systems, and the qualitative data served to complement and validate the quantitative findings.

The evaluation phase involved administering a post-test and post-assessment using the drawing method [4, 16, 17, 18] after the unit on organ systems. By comparing the post-test and post-assessment scores with the pretest and pre-assessment scores, data on the students' final conceptions and learning gains were obtained [16, 17, 18]. Moreover, teachers' evaluations of CATS, focusing on content presentation, curricular alignment, and practicality of implementation, were carefully assessed [19]. This comprehensive data collection procedure aimed to examine the impact of the CATS on students' learning outcomes and provided valuable insights into teachers' experiences and approaches in teaching organ systems. By following a coherent and systematic approach to data collection, this study aimed to contribute significantly to the field of science education and to promote quality education in alignment with SDG 4.

3. RESULTS

The research findings of this study shed light on the effectiveness of the Constructive Aligned Teaching Sequence (CATS) [20] in improving students' learning outcomes related to their understanding of human organ systems. The effect of the developed teaching sequence was looked into through the Students' Learning Outcomes (SLO) and Teachers' Evaluation of CATS (TEC).

Student Learning Outcomes (SLO). The SLO was determined through the pre-and post-assessment drawings and learning gains through the pretest and post-test scores. Examining the pre- and post-assessment results laid side by side, as shown in Figure 1, shows apparent differences in the organ systems presented entirely.

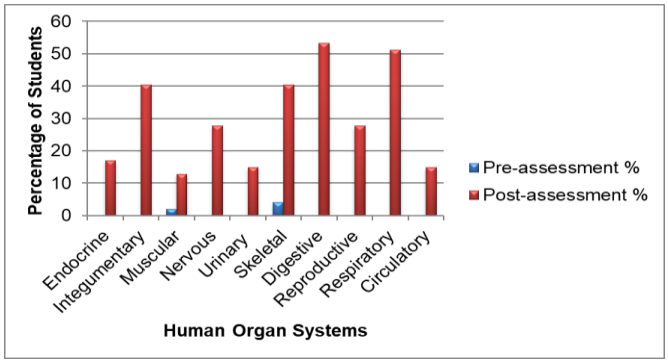

Figure 1, The percentage of students whose drawings showed complete human organ systems during pre- and post-assessments.

Th results of the post-assessment, conducted through a drawing method [4, 20], revealed a significant improvement in students' comprehension and representation of organ systems. The students' drawings were analyzed based on the completeness of the depicted organ systems [16, 20], and a considerable increase was observed in the number of students who accurately illustrated all ten organ systems after the implementation of CATS.

Table 1 below indicates the pre-assessment and post-assessment scores to describe the students' conception through the drawing method before and after using CATS. Normality test results showed that the data were not normally distributed. Hence, the nonparametric test was utilized. In the pre-assessment, the scores for the biological quality of the drawings ranged from 1 to 5, with a median of 2. This result indicated that the students could identify one or more internal organs but were placed randomly. After using CATS, the student's conception of the organ systems ranged from Levels 4 to 7 with a median of 6. The results indicated that, on average, the students could identify two or three organ systems sufficiently drawn with their composing organs in the right places. A Wilcoxon Signed-ranks test indicated that the conception of students of the organ systems after the use of CATS (Mdn = 6.00) was significantly higher than the conception of students of the organ systems before the use of CATS (Mdn = 2.00), $Z = 6.015$, $p < .001$, $r = .88$.

Table 1 results of Wilcoxon Signed-ranks Test on the Pre-Assessment and Post-Assessment Score
P< .001

Variables	N	Minimum	Maximum	Median	Z
Pre-Assessment Score		1.00	5.00	2.00	6.015
Post-Assessment Score	47	4.00	7.00	6.00	

The qualitative feedback obtained from the students provided additional support for the efficacy of CATS in enhancing their understanding of human organ systems [2019]. Students emphasized the importance of the model-making activity and the coherent flow of the lessons, which facilitated their comprehension of the subject matter. CATS's approach [19, 20, 21, 22] also provided transparency in learning objectives and criteria, enabling students to be more self-aware and grasp the concepts better.

The research findings solidified that CATS positively influenced students' final conceptions of human organ systems. The comprehensive methodology, encompassing qualitative and quantitative methods, ensured a robust and thorough evaluation of the teaching sequence's effectiveness. Additionally, the study's design principles and outcomes aligned with previous research on constructive alignment and Outcome-Based Teaching and Learning (OBTL) approaches, further affirming the significance of these methods in curriculum development and science teaching.

Teachers' Evaluation on CATS (TEC). The Constructive Aligned Teaching Sequence (CATS) evaluation revealed promising results across its dimensions, including the Presentation of Content (POC), Curricular Alignment (CAL), and Practicality of Implementation (POI).

Regarding the POC, all teachers rated CATS highly (average mean of 2.65 out of 3), indicating that it effectively emphasized scientific inquiry, presented content interestingly and engagingly with appropriate use of scientific language, and connected science to society. Some teachers suggested improving the material's presentation, such as ensuring alignment with the K to 12 curriculum's competencies and skills and developing activities that promote scientific process development as recommended in the new curriculum.

Regarding CAL, CATS received a perfect rating of 3 (out of 3) from all teacher participants. This score indicated that the teaching material was well-aligned with the intended learning outcomes (ILOs), targeted learning activities (TLAs), and assessment tasks (ATs). The alignment ensured that the activities designed would effectively achieve the desired outcomes.

The POI was assessed based on three aspects: inquiry and activities as the basis of the learning experience, using a practical instructional approach, and the presentation and format of CATS. CATS was rated highly in all these aspects, receiving an average mean of 3 (out of 3) from all teachers. The material was perceived as focused on concrete experiences with scientific phenomena, allowing students to gather and defend their evidence in various ways. It also provided practical strategies for assessing student learning and encouraged collaborative and individual work.

However, some suggestions were provided for improving the presentation and format of CATS. Teachers recommended incorporating properly labeled illustrations to supplement the text, improving the layout, ensuring uniformity of materials used in making the model, clarifying assembly instructions for creating whole-body systems, and establishing a method for displaying or storing the student outputs.

The study highlights the importance of considering teachers' perspectives and experiences when developing and evaluating teaching interventions. The likelihood of successful adoption and implementation can be increased by ensuring that the teaching sequence is usable and relevant for teachers not involved in its development. Moreover, the successful experiences of other teachers and practical teaching materials and guidelines can positively impact teachers' practice. The evaluation of CATS demonstrated its effectiveness and potential for improving students' learning outcomes in various educational settings, making it a valuable addition to science teaching methods.

4. DISCUSSION

The results of the study on the Constructive Aligned Teaching Sequence (CATS) present compelling evidence of its effectiveness in improving students' learning outcomes related to their understanding of human organ systems [20, 21, 22, 23]. The study utilized a design research approach, incorporating qualitative and quantitative methods to evaluate the impact of CATS on students' comprehension of organ systems.

One of the study's key findings is the significant improvement in students' ability to represent and understand organ systems through the post-assessment by drawing

method, as reported in other studies [4, 16, 17, 18]. Before CATS implementation, only a minority of students could adequately depict complete organ systems. However, after CATS, there was a substantial increase in students who could sufficiently represent all ten organ systems. This trend demonstrates the positive influence of CATS on students' visual understanding and conceptualization of organ systems.

Furthermore, the biological quality of the students' drawings, adapted from the work of Reiss & Tunicliffe [16], also showed a remarkable enhancement after CATS. Most of the drawings fell within Levels 5 to 7, indicating that students could identify and depict two or more organ systems with their composing organs correctly placed. This improvement suggests that CATS helped students recognize individual organs and facilitated their understanding of the interconnections between organs and their functions within the body.

Comparing pre- and post-assessment scores further supported the effectiveness of CATS in enhancing students' learning gains related to organ system processes. CATS proved successful in helping students grasp the complex relationships and functioning of human organ systems. This finding underscores the significance of using CATS as a teaching approach to promote deeper comprehension and critical thinking in science education.

The qualitative feedback from the students provided additional insights into the impact of CATS on their learning experience. They highlighted the significance of the model-making activity and the precise flow of the lessons, which helped them better grasp the concepts. CATS provided transparency in learning objectives and criteria, fostering self-awareness and promoting a deeper understanding of the subject matter. These aspects are crucial in cultivating an engaged and motivated learning environment that encourages students to take ownership of their learning process [24].

Moreover, the teachers' evaluation of CATS revealed positive perceptions across its dimensions. Teachers perceived CATS to be well-aligned with the curriculum, emphasizing scientific inquiry, engaging presentation of content, and effective use of instructional approaches. The practicality of implementation was also considered favorably by teachers, with CATS being rated highly for its focus on inquiry and activities and its flexibility in accommodating diverse learning needs.

The comprehensive and robust methodology of this study, combining qualitative and quantitative methods, strengthens the validity of the research findings. The alignment of CATS with previous research on constructive alignment and Outcome-Based Teaching and Learning (OBTL) approaches further supports its significance in curriculum development and science teaching [11].

The results of this study provide compelling evidence that the Constructive Aligned Teaching Sequence (CATS) is an effective and valuable framework for enhancing students' learning outcomes in the understanding of human organ systems. CATS improved students' ability to visually represent and comprehend organ systems and facilitated their knowledge about organ interconnections and functioning [4,16, 17, 18, 20]. The positive feedback from both students and teachers affirms the practicality and relevance of CATS as a teaching framework. As educators continue to explore innovative approaches [24] to science education, CATS stands out as a promising and impactful tool for fostering more profound understanding and critical thinking in students.

5. CONCLUSION

In conclusion, the study on the effect of the Constructive Aligned Teaching Sequence (CATS) on students' learning outcomes and teachers' evaluation has provided valuable insights into the effectiveness of this innovative teaching approach. The results demonstrate that CATS positively impacts students' understanding and representation of human organ systems, significantly improving their learning gains and overall comprehension. Moreover, the teachers' evaluation of CATS revealed its effectiveness in presenting content, aligning with curricular objectives, and being practical for implementation in the classroom. These findings highlight the importance of equipping preservice teachers with effective teaching methods like CATS as they enter the field of education. The implications for preservice teachers are profound, as they underscore the significance of incorporating student-centered and inquiry-based approaches into their teaching practices. By embracing CATS and its principles of constructive alignment, preservice teachers can enhance their instructional strategies, promote active and engaged learning, and effectively cater to diverse student needs. Emphasizing using CATS in teacher training programs can empower preservice teachers to develop meaningful learning experiences for their future students, fostering critical thinking, scientific literacy, and a deeper understanding of complex concepts. The study advocates integrating CATS into preservice teacher training, emphasizing the importance of creating environments that prioritize active learning, collaboration, and hands-on experiences. As future educators, preservice teachers hold the key to shaping the next generation's scientific understanding and curiosity. By equipping them with effective teaching approaches like CATS, educational institutions can prepare preservice teachers to be innovative, skilled, and impactful educators who inspire a lifelong love for learning in their students [5]. Ultimately, this study can contribute to developing scientifically literate and empowered science preservice teachers to advance science education in the Philippines and support the broader global efforts to achieve SDG 4 - Quality Education [25].

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