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REVIEW

Conceptual Model of Biology Learning with Citizen Science Project: Learning Syntax Developed from a Systematic Literature Review

Modelo Conceptual de Aprendizaje de Biología con Proyecto de Ciencia Ciudadana: Sintaxis de Aprendizaje Desarrollada a partir de una Revisión Sistemática de la Literatura

Asih Luklu Susiati[1,2], Arsad Bahri[2], Andi Asmawati Azis[2], Hardianto Hardianto[3]

[1]Universitas Famika, Biomedical Science Study Program. Makassar, Indonesia.
[2]Universitas Negeri Makassar, Department of Biology. Makassar, Indonesia.
[3]Universitas Negeri Malang, Department of Biology. Malang, Indonesia.

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Corresponding author: Andi Asmawati Azis

ABSTRACT

Introduction: Citizen Science Projects (CSP) have emerged as a powerful approach in scientific research, involving the community in data collection and problem-solving. This study examines the application of CSP in biology education, focusing on how CSP can be integrated into learning processes to enhance scientific literacy, community collaboration, and the application of biological concepts.
Method: a systematic literature review (SLR) was conducted to analyze 33 research articles related to CSP in biology education. The review aimed to define CSP-based biology learning and identify the conceptual model of CSP syntax in the educational context. The data was gathered from peer-reviewed articles published between 2014 and 2024, primarily sourced from the Scopus database.
Results: the review identified key definitions of CSP, emphasizing community collaboration, the application of biological concepts, and the development of 21st-century skills as the core components of CSP-based biology learning. A conceptual model for CSP syntax in biology education was developed, consisting of five key stages: concept mapping, project design, presenting, execution, and gallery walk. These stages were found to support both student learning and community engagement.
Conclusions: CSP-based biology learning fosters collaboration between students and the community, enhances the application of biological concepts, and equips students with vital 21st-century skills. The study concludes that CSP offers significant potential for improving biology education by integrating real-world problems into the learning process, thereby advancing scientific literacy and contributing to societal development.

Keywords: Citizen Science Project; Biology Teaching; Systematic Literature Review.

RESUMEN

Introducción: los Proyectos de Ciencia Ciudadana (CSP) han emergido como un enfoque poderoso en la investigación científica, involucrando a la comunidad en la recolección de datos y la resolución de problemas. Este estudio examina la aplicación de los CSP en la educación en biología, centrándose en cómo los CSP pueden integrarse en los procesos de aprendizaje para mejorar la alfabetización científica, la colaboración comunitaria y la aplicación de conceptos biológicos.
Método: se realizó una revisión sistemática de la literatura (SLR) para analizar 33 artículos de investigación relacionados con los CSP en la educación en biología. La revisión tuvo como objetivo definir el aprendizaje basado en CSP en biología e identificar el modelo conceptual de la sintaxis del CSP en el contexto educativo.

Los datos fueron recolectados de artículos revisados por pares publicados entre 2014 y 2024, principalmente obtenidos de la base de datos Scopus.
Resultados: la revisión identificó definiciones clave de los CSP, destacando la colaboración comunitaria, la aplicación de conceptos biológicos y el desarrollo de habilidades del siglo XXI como los componentes principales del aprendizaje en biología basado en CSP. Se desarrolló un modelo conceptual para la sintaxis del CSP en la educación en biología, compuesto por cinco etapas clave: mapeo conceptual, diseño de proyectos, presentación, ejecución y paseo por la galería. Se encontró que estas etapas apoyan tanto el aprendizaje estudiantil como la participación comunitaria.
Conclusiones: el aprendizaje en biología basado en CSP fomenta la colaboración entre los estudiantes y la comunidad, mejora la aplicación de los conceptos biológicos y dota a los estudiantes de habilidades vitales del siglo XXI. El estudio concluye que los CSP ofrecen un gran potencial para mejorar la educación en biología integrando problemas del mundo real en el proceso de aprendizaje, promoviendo así la alfabetización científica y contribuyendo al desarrollo social.

Palabras clave: Proyecto de Ciencia Ciudadana; Enseñanza de Biología; Revisión Sistemática de la Literatura.

INTRODUCTION

Citizen Science Project (CSP) is a collaborative process in which members of the general public actively participate in scientific research, contributing to data collection, analysis, and dissemination of results.[1] CSP has been rapidly developing and is increasingly influential in research, particularly on scientific themes, including biology involving large numbers of people in research, which results in more comprehensive data collection and better conclusions.[2] Data from CSP activities can produce new scientific knowledge, offering alternative ways to solve local environmental problems.[3] These projects may also lead to new findings that could redefine CSP itself. While many environmental problems are rooted in biology, other disciplines like physics and chemistry may also be involved in addressing them.

CSP-based learning is highly relevant to biology courses, aiming to improve biodiversity literacy and research skills among future biology teachers. This learning process is often designed using a blended learning model.[4] CSP-based learning also enhances scientific skills such as data collection, the application of theory to practice, collaboration, and supports the achievement of SDG 4: Quality Education.[5]

Previous studies have shown that CSP-based learning has significant potential to connect scientific concepts with real-world issues.[6] CSP can enhance students' motivation, interest, knowledge, scientific abilities, and communication skills.[7] Another SLR by Bonney[8] demonstrated that CSP can increase public understanding of science, raise awareness about scientific research, and its benefits for the environment. CSP can lead to increased knowledge, behavioral changes, and attitudinal shifts, but community participation is essential for achieving maximum educational outcomes.[2] CSP also have transformative potential for developing individual skills.[8] CSP participants contribute to science and environmental education through a variety of learning theories, including experiential, sociocultural, social learning, open-choice learning, constructivism, and environment-based learning.[9] Approximately 91 % of the 2,346 CSP involved citizens solely as data interpreters. According to the European Schoolnet 2023 report, around 24 % of teachers in Europe actively use CSP in science learning, and most cite a lack of training and resources as the main barriers.[10] This gap between potential and practice demonstrates the need for a systematic approach to the integration of CSP in the learning process.

A comprehensive review of the literature on CSP in higher education, particularly in biology, has yet to be conducted in the form of an SLR. This review provides a detailed definition and explanation of CSP, rooted in general CSP frameworks, and explores how CSP can be integrated into biology education. It also outlines steps for CSP-based learning. This SLR is expected to advance research in biology education at the higher education level. This article focuses on original research related to CSP in the context of biology and its integration into learning. The purpose of this study is to define and create a conceptual model of CSP-based learning syntax.

METHOD

Research Framework

This research is an SLR, using a careful and methodical approach to find, select, and evaluate research that is relevant to the specified question (figure 1).[11]

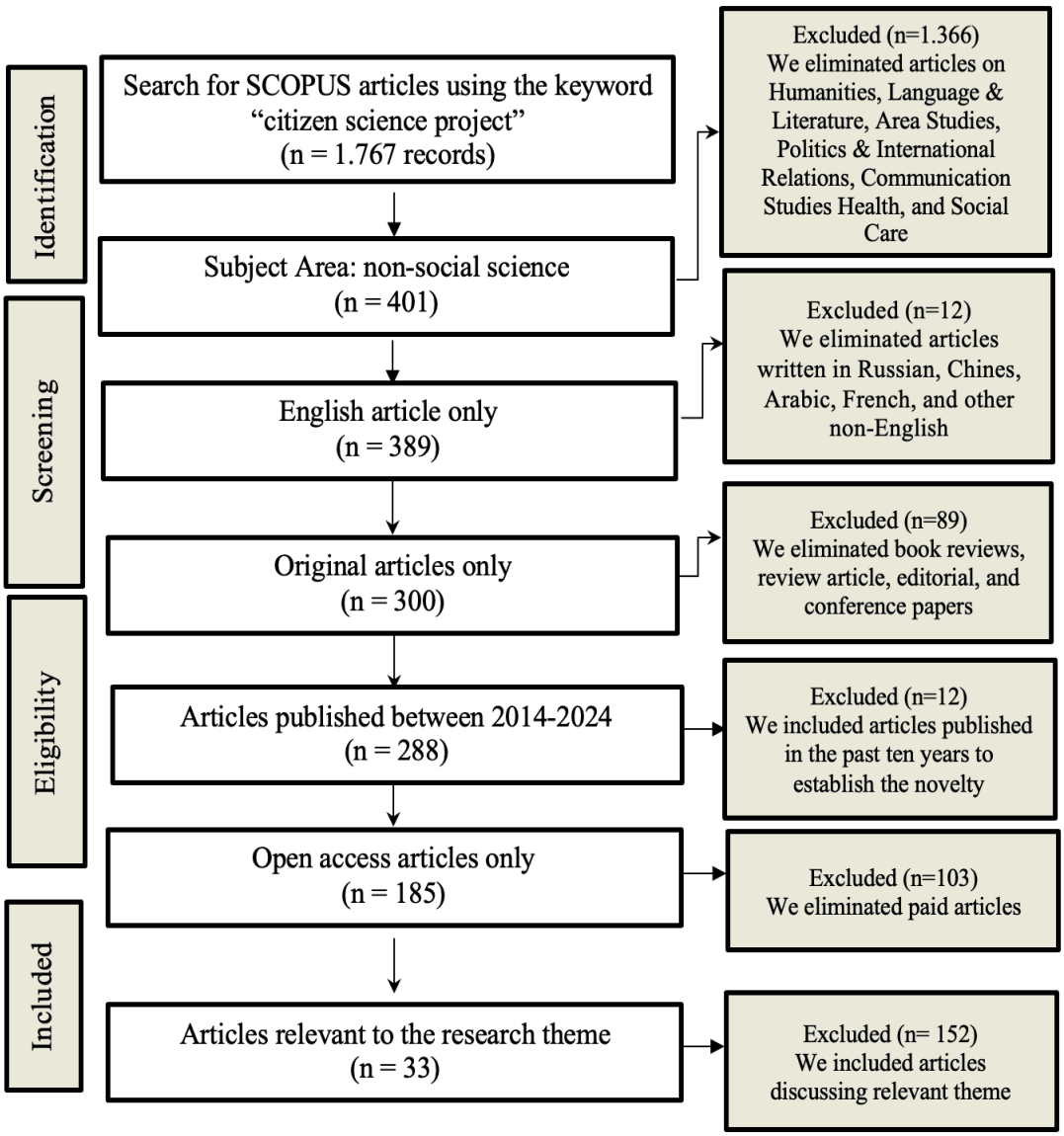

Figure 1. PRISMA diagram

Research Question

RQ1: How is the definition of Citizen Science Project in biology learning?

RQ2: How is the conceptual model of the Citizen Science Project syntax in biology learning?

Search Article & Inclusion Criteria

The keyword "*citizen science project*" is used to search for articles in the Scopus database. We found 1,767 articles that contain the keyword "citizen science project" using the search criteria. We include articles that include social science, English, original articles, published in 2014-2024, open access articles, and articles relevant to the topic under study. The PRISMA model used refers to research [12] that uses the PRISMA model in its SLR. The following points are the basis for including articles in this SLR. Figure 1 illustrates the methodology employed in this study for article inclusion and exclusion. Hence, of the 185 articles that were filtered using the criteria mentioned above, 33 original articles related to this research topic were examined.

RESULT

RQ1: How is the definition of CSP in biology learning?

The results of the analysis of 33 articles were obtained various definitions of CSP are the basis for the formulation of the concept of CSP in biology learning, so that three main keywords are found in building the concept of CSP in biology learning, namely "Community Collaboration", "Application of Biological Concepts", and "21st-Century Skills"

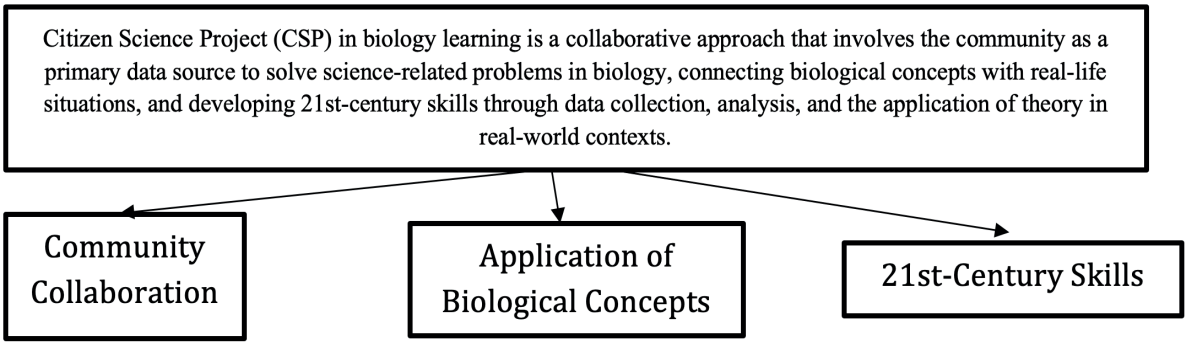

Figure 2. The process of defining CSP-based biology learning

RQ2: How is the conceptual model of the CSP syntax in biology learning?

Based on 33 articles that have been synthesized, we also try to formulate a CSP-based biology learning syntax based on learning theory, which has been carried out by previous researchers. Table 1 presents the CSP-based Biology learning stages based on the SLR results.

Table 1. Learning Syntax and Its Definition

Syntax	Descriptions
Concept mapping	Understand biological concepts and be able to organize them
Project design	Create clear protocols and work steps that will be carried out with the community
Presenting	Clearly present the design of the project to be carried out
Execution (the point of CSP)	Collaborating involves the community in the data collection process
Gallery walk	Delivering the results of activities in the form of expert groups in group collaboration

DISCUSSION

Definition of a CSP in biology learning

Community Collaboration

Community collaboration in CSP plays an important role in empowering local communities by directly involving communities in the process of data collection and problem-solving. Through CSP, community members actively participate in scientific research, collecting data that helps address biological and environmental problems in the real world.[7] The citizen science project trains students and the community in analyzing problems that are closely related to daily life in a real environment, which later results in a positive social impact.[13] The collaboration of researchers, students, and community members not only contributes to science but also develops a deeper understanding of issues affecting its environment, creating a shared commitment to improve the surrounding environment.[14]

Application of Biological Concepts

The application of biological concepts in CSP has a very important role in connecting theory with practice in the field. Through direct involvement in data collection and analysis of environmental problems, students can see in real life that the concepts of biology learned in the classroom can be applied to solve challenges in society.[15] The citizen science project provides solutions to problems that occur in the environment by applying concepts during the activity process.[16] This process provides an opportunity for students to test biological theories in real-life contexts, thus deepening their understanding of scientific principles working in the real world.[3] The application of biological concepts in this project allows them to better understand the relationship between science and problems faced in everyday life.

21st-century skills

21st-century skills encompass a range of skills that individuals desperately need in an ever-evolving world, such as critical thinking, collaboration, communication, and creativity. These skills are particularly relevant because the project not only teaches scientific concepts but also engages students and society in a process that demands the application of practical skills to solve real problems.[6] The citizen science project fosters positive

interaction and collaborative attitudes to produce solutions to existing problems with various science concepts acquired from the learning that has been carried out so far.[17] This skill is in high demand in the world of work, as many jobs can be completed by collaborating.[18] CSP also trains students to think critically and analytically, as students must analyze the data collected and relate it to relevant biological theories to find the best solution to the problem at hand.

The syntax of CSP-based biology learning

Concept Mapping

Concept mapping allows students to practice problem-solving skills as well as science literacy in the learning process.[18,19] Basic conceptual understanding can generalize concepts to solve real-world problems.[17] Biology is a complex science because it consists of groups of humans, animals, and plants, so bridging the gap of phenomena in society requires a good understanding of concepts.[20]

Project Design

CSP-based learning activities require a clear project framework to answer problems or phenomena within the scope of biology. The stages in a good CSP process will make it easier for the public to understand information.[21] The science and goals of CSP should be aligned during CSP activities, increasing their potential to empower communities for data collection as well as benefit themselves.[22]

Presenting

A good project activity design is based on understanding concepts and organizing concepts from the learning that has been passed.[14,23] Then it is poured into designing a project or framework that will be carried out with the community in the field.[13,24] The main key to CSP activities is to present what will be done in the field together with the community so that the goals of the project will be conveyed to the community.[25]

Execution

The core activity of CSP-based learning is execution, which involves directly involving the community in collecting data and then examining problems that exist in the real world.[26] especially issues related to Biology. This process is carried out based on methodological guidelines created during the design of the project.[27] The expected result of the execution stage is to find solutions or ideas to problems that are studied with the community.[28]

Gallery Walk

The data obtained came from the solutive community in the environment. An additional ability resulting from CSP is communication skills as a science dissemination activity.[16] As well students will form active learning and build interest in science learning.[29] The principle of the gallery walk is that each student can explain and master the problems and solutions resulting from the data studied with the community.[30]

CONCLUSIONS

The definition of CSP-based biology learning was developed from three keywords, namely "community collaboration", "application of biological concept", and "21st-century skills". The syntax of CSP-based biology learning is very important for students. CSP in biology learning is a learning approach that involves the community in collecting and analyzing data to solve real-life biology problems. It helps students connect biology concepts with everyday situations and build 21st-century skills such as critical thinking, communication, and collaboration. The syntax includes:

(1) Concept Mapping
(2) Project Design
(3) Presenting
(4) Execution
(5) Gallery Walk

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CONFLICT OF INTEREST

There is no conflict of interest.

AUTHORSHIP CONTRIBUTION

Conceptualization: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Data curation: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Formal analysis: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Research: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Methodology: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Project management: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Resources: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Software: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Supervision: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Validation: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Display: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Drafting - original draft: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.
Writing - proofreading and editing: Asih Luklu Susiati, Arsad Bahri, Andi Asmawati Azis, Hardianto Hardianto.