REVISTA DE INNOVACIÓN Y BUENAS PRÁCTICAS DOCENTES

The Malacotheca as a methodological innovation in the teaching of Prehistory

La Malacoteca como innovación metodológica en la enseñanza de la Prehistoria

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Submitted: 21/03/2026; Revised: 12/05/2026; Accepted: 01/06/2026

How to cite this article:
Cantillo Duarte, J. J., Vijande Vila, E., Ruiz Gómez, A., Guilloto Bollullos, L., Muñoz Muñoz, A., Luque Porras, P., López Quiñones, M., López Berdugo, M. C., Martínez Torres, M. P., Muñoz García, I., Suplet Montado, M. N., Aguilar de la Cruz, P., & Becerra Martín, S. (2026). La malacoteca como innovación metodológica en la enseñanza de la Prehistoria. *Revista de Innovación y Buenas Prácticas Docentes, 15*(1), 65–81. https://doi.org/10.21071/ripadoc.v15i1.19158

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Abstract:

In this paper, we present the teaching experience derived from the creation of a *malacotheque* (shell collection) with educational and research purposes, developed as part of an innovation and teaching enhancement project approved by the University of Cádiz. The establishment of this reference collection has made it possible to strengthen various learning pathways among students at different academic levels (undergraduate and postgraduate), focusing on the so-called *blue economy*, one of the main strategic axes underpinning the university's academic development. The use of this resource in the classroom has improved the skills acquired by the pupils, as confirmed by the results of an anonymous survey.

Keywords: Shell collection, teaching experience, hands-on learning, Prehistory.

Resumen:

En el presente artículo aportamos la experiencia docente que ha supuesto la creación de una malacoteca con fines formativos e investigativos, como resultado de un proyecto de innovación y mejora docente autorizado por la Universidad de Cádiz (España). La creación de esta colección de referencia ha permitido fortalecer distintas líneas de aprendizaje entre alumnado de diferentes etapas (Grado y Máster), enfocados hacia la denominada economía azul, uno de los principales ejes sobre los que dicha universidad está vertebrando su proyección académica. La aplicación de este recurso en el aula ha mejorado las competencias adquiridas por el alumnado, refrendado por los resultados de una encuesta anónima.

Palabras clave: Malacoteca, experiencia docente, aprendizaje práctico, Prehistoria.

1. INTRODUCTION

Over recent years, the University of Cádiz (Spain) has assumed a prominent role in initiatives devoted to maritime and marine research. Its leadership within the institutions that comprise the European University of the Seas and the International Campus of Excellence of the Sea (CeiMar) has positioned the institution as an international benchmark in the so-called blue economy.

Motivated by this strategic axis of development, the Department of Prehistory at the University of Cádiz has promoted a range of research lines addressing, among other topics, the issue of crossing the Strait of Gibraltar during prehistory (Ramos, 2012), the phenomenon of megalithism and its relationship with coastal settlement patterns (Vijande et al., 2025), and the exploitation of marine resources by prehistoric societies from the Palaeolithic to the Bronze Age (Cantillo, 2017; Ramos et al., 2024). The incorporation and integration of these themes into university teaching constitutes one of the principal challenges faced by part of the teaching team. However, the lack of teaching materials capable of complementing theoretical instruction has represented a significant obstacle when addressing these approaches, to the detriment of students' academic training itself.

With this premise in mind, a project for teaching innovation and improvement was submitted to the 2024/2025 Innova Call for Teaching Innovation and Improvement Projects at the University of Cádiz under the title "A Malacological Collection as a Teaching Tool for Laboratory Practice in Prehistory". The project's main objective was to contribute towards overcoming this difficulty in order to improve the quality of training provided to undergraduate and postgraduate students. At the same time, from a perspective oriented towards object-based learning (Egea et al., 2018; Llonch, 2017), the project was grounded in a practical and experiential learning model aimed at reinforcing the acquisition of specific competences in Prehistory through direct observation, the handling of remains, and comparative analysis. In this regard, the malacological collection was conceived not merely as a support resource, but as an active tool for teaching innovation designed to connect theoretical content with laboratory practice and to encourage more autonomous and applied forms of learning. The project was approved (code sol-202400284367-tra) and developed by members of the research group Thalassa. Megalithism and Coastal Societies of Recent Prehistory in Southern Iberia (PAI HUM 1127) and the Marine Research Institute of the University of Cádiz (INMAR).

A malacological collection is a reference collection of molluscs from different environments (marine, freshwater, and terrestrial). From a biological perspective, the phylum Mollusca is divided into eight classes, of which only four were relevant to the present project, all of marine origin: bivalves, gastropods, cephalopods, and scaphopods, which constituted the principal focus of collection activities throughout much of prehistory. The creation of this type of collection is based on a dual objective: firstly, to support university teaching and, secondly, to provide a basis for comparative analyses in research projects in which archaeomalacological remains are documented. Several national institutions possess this type of supporting material, among which the

malacological collection of the International Institute for Prehistoric Research of Cantabria (IIIPC) is particularly noteworthy. This collection, comprising more than 100 different species and 2,000 specimens available to researchers, is employed as a reference in numerous projects aimed at identifying both the collection preferences and gathering areas of prehistoric human groups, as well as reconstructing the climatic conditions of different periods.

Special mention should also be made of the collection housed in the Department of Prehistory, Ancient History and Archaeology at the University of Salamanca, which contains 105 mollusc species, 20 crustacean species, and 18 fish species, among others. Alongside these university collections, those safeguarded by museum institutions, such as the National Museum of Natural Sciences, are particularly significant. In this case, the museum houses one of the largest and most important mollusc collections in the world, with nearly two million specimens (Araujo, 2021), supported by more than two centuries of tradition, since the collection was initiated in 1771 under the patronage of King Charles III following the donation made by Pedro Franco Dávila (Bragado et al., 2017).

Finally, due to its close connection with our teaching project, particular attention should be drawn to the enhancement and promotion currently being undertaken by the Museum of Cádiz of the outstanding collection of marine molluscs donated by the geologist Juan Gavala y Laborde. This process of documentation, identification, and cataloguing is currently the subject of study by malacologists from the Gaditana Society of Natural History (Ríos and Amarillo, 2024).

2. OBJECTIVE

The malacological collection presented at the University of Cádiz is conceived as a systematic educational intervention. It has been installed in the Archaeology and Prehistory teaching laboratory of the Faculty of Arts and Humanities. Its principal aim is to become a reference collection, and it has been established with the intention of expanding progressively through successive fieldwork campaigns and/or donations.

The collection is primarily based on the compilation of species that, throughout history, have played a significant role due to their multiple uses (as food resources, working tools, containers, ornaments, sound-producing instruments, in dye production, ceramic manufacture, and so forth), and which have been identified as such within an increasingly extensive body of scholarship produced by researchers specialising in the field of Archaeomalacology, one of the principal branches of Archaeozoology.

Therefore, beyond purely biological or ethological interests, the purpose of this collection is to provide comparative samples for the identification of mollusc remains recovered from archaeological contexts within the framework of university-level teaching in Prehistory. The ultimate objective is to evaluate how the use of tangible and comparative material enhances the acquisition of competences within the classroom.

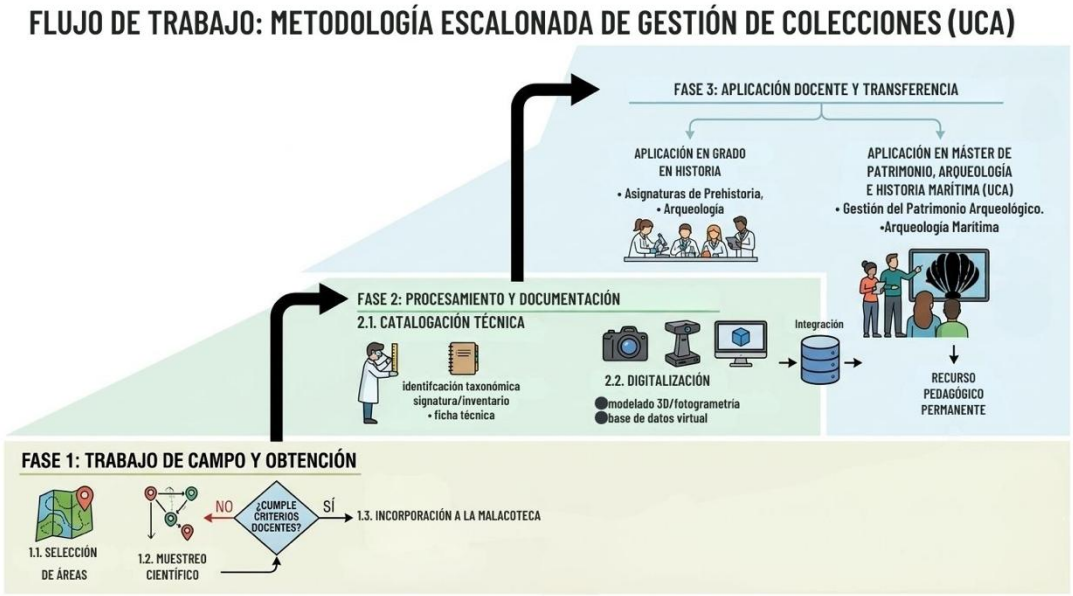
3. METHOD

In order to create the collection, it was necessary to implement a staged methodology which, beginning from an initial foundation, progressively addressed the selection, collection, preservation, and cataloguing of specimens, before ultimately being employed in several modules taught within both the History Degree and the Master's Degree in Heritage, Archaeology and Maritime History at the University of Cádiz (Spain).

Accordingly, three phases were developed. The first two involved greater participation by the teaching staff (creation of the malacological collection and specimen processing), while the final implementation phase placed students at the centre of the learning process as the principal participants (Figure 1).

Figure 1

Staged methodology implemented in the creation of the malacological collection for pedagogical purposes.



Note. Image created using NotebookLM.

3.1. Design of the Resource: The Malacological Collection

3.1.1. Collection of Species

During November 2024 and throughout spring 2025, members of the project carried out the collection of molluscs in a range of pre-established natural habitats, including, among others, Playa El Palmar (Figure 2), Cala Roche, and the pier area of the Faculty of Marine Sciences at the University of Cádiz, located on the Río San Pedro estuary.

This strategy ensured the representativeness and diversity of the malacological fauna of the Cádiz coastline, which was essential for the initial development of the collection.

Figure 2

Sampling at Playa El Palmar (Vejer de la Frontera, Cádiz) and detail of the discovery of a Dentalium, together with other malacological remains.

3.1.2. Cataloguing

Subsequently, each specimen was dry-cleaned, preserved, and documented through the creation of an individual catalogue record. This record included detailed information on the species (taxon), habitat, distribution area, place of collection, and known or attributed uses in prehistory (historical observations), together with specific bibliographic references to archaeological contexts in which it had been recorded.

Within this cataloguing phase, in which undergraduate students who are also collaborators within the Prehistory unit participated, it was necessary to incorporate taxonomic, ecological, and geographical data. For this purpose, several key reference works were consulted (Gofas et al., 2012; Hayward et al., 1998; Hayward & Ryland, 1996; Lindner, 1983; Poppe & Goto, 1993a, 1993b; Sabelli, 1980). Nomenclature followed the CLEMAM checklist (Check List of European Marine Molluscs, https://www.bodc.ac.uk/resources/inventories/edmed/report/4628/) and the World Register of Marine Species (https://www.marinespecies.org/).

For the organisation and cataloguing of the molluscs (Figure 3), zip-lock plastic bags, small lidded containers, and plastic storage cases available in the laboratory were used. This enabled the project to be carried out without requiring additional budget allocation beyond the institutional resources provided by the university. The molluscs were arranged randomly by species. Each specimen was assigned its corresponding bag, together with a small label indicating its scientific name and an inventory number linked to more detailed information.

This work made it possible to establish a structured, organised, didactic, accessible, and functional reference material for purposes related both to teaching and to future research lines developed by students in training and established researchers.

Figure 3

Sorting and cataloguing phase of species in the Archaeology and Prehistory Laboratory of the University of Cádiz, with the participation of undergraduate students.

3.1.3. Digitisation

Finally, each specimen was photographed using a Nikon D6400 digital camera, following a consistent protocol: dorsal and ventral views in the case of bivalves, and frontal and dorsal apertural views in the case of gastropods (Martinell & Domenech, 2021). Each image included an appropriate scale in order to provide an accurate estimation of the size of the different remains. The images were subsequently processed using Adobe Photoshop CS6.

This photographic database is particularly valuable for several reasons. Firstly, it is useful for the preparation of illustrative plates for future publications by members of the research group. Secondly, it reduces the need for constant direct handling of the samples, thereby minimising potential degradation, especially in species with fragile structures. Finally, it enables remote access without the need for physical loan requests, thus facilitating consultation.

All descriptive and photographic information was integrated into a Microsoft Access database, in which a series of descriptive fields were organised into three sections. The first section contains basic information about the species, including its scientific designation and the various common names used in the area where it was collected, together with a sequential inventory number. The second section includes taxonomic data, focused on a biological description with particular attention to the place of collection and habitat, allowing the recording of geographical distribution and environmental factors. The third section is designed, on the one hand, to include an image of the specimen to assist identification and, on the other, to provide a historical observations field describing the different uses of the species throughout history, based on published studies and case analyses. The record concludes with bibliographic references (Figure 4).

Figure 4

Example of a catalogue record created for the malacological collection

3.2. Design of the Teaching Intervention

The intervention was carried out on a sample comprising 60 undergraduate students enrolled in the Degree in History and 8 postgraduate students enrolled in the Master's Degree in Heritage, Archaeology and Maritime History at the University of Cádiz. These groups were selected because they represent two different levels of competence and because, in the respective teaching guides for the modules Universal Prehistory II and Archaeozoology: Basic Techniques, both include content related to the exploitation of marine resources in different stages of prehistory. Accordingly, the study design was based on a basic training group and an advanced training group.

Sessions were conducted in the Archaeology and Prehistory Teaching Laboratory. Following a theoretical component, students addressed the topics from a predominantly practical perspective. To this end, they undertook tasks involving observation, taxonomic identification, and quantitative analysis in groups of approximately 10–12 students in the case of undergraduates, which enabled the implementation of content under conditions conducive to effective learning outcomes.

Once the classes had been completed, and in order to assess the impact of the implementation of this new teaching resource in university education, a survey was designed using Google Forms, consisting of eight items. This questionnaire was administered to students from both modules. The aim of the survey was to evaluate the effectiveness of this type of teaching resource and students' perceptions of the pedagogical value of the malacological collection, as well as to measure the level of satisfaction generated by the use of tangible materials.

To this end, the questionnaire addressed questions such as: How would you assess your prior level of knowledge in archaeomalacology before undertaking the practical sessions with the malacological collection? To what extent have the practical sessions helped you to better understand the theoretical content of the module? Do you consider that direct work with the samples (observation, classification, and analysis) has

enhanced your practical learning? Was the methodology used for identifying and cataloguing malacological species clear and useful? How would you rate the usefulness of the malacological collection as a teaching resource compared with other laboratory practices? To what extent has this experience helped you develop methodological skills applicable to archaeological research (classification, quantification, biometric analysis)? Would you recommend maintaining and integrating the malacological collection as a permanent teaching resource in Prehistory and Archaeology modules? Finally, students were invited to provide comments or suggestions for improving future practical sessions. The data were processed using descriptive statistical analysis (frequencies and percentages) and content analysis for open-ended responses.

4. RESULTS

4.1. The Malacological Collection as a Product of Academic Activity and Curricular Integration

The malacological collection was created with the participation of student collaborators from the Prehistory area within the framework of the teaching innovation and improvement project described in this article. It has enabled undergraduate and Master's students to interact, through a "learning by doing" methodology, with an initial collection comprising 48 different marine species, of which 17 are bivalves, 25 gastropods, one cephalopod, two crustaceans, one cnidarian, one scaphopod, and one echinoderm. This initial taxonomic representation reflects not only species frequently present in prehistoric archaeological contexts in the Strait of Gibraltar area (Cantillo, 2017; Ramos et al., 2024), but also includes specimens of relevance for historical and archaeological contexts from more recent periods. It also constitutes a valuable resource for palaeoenvironmental reconstruction, as each record includes biological information relating to collection site, habitat, and the common names by which the species are known in the region (Figure 5).

The scientific value of this collection lies not only in the availability of a digital database, but also in the existence of a tangible and comparative collection accessible to future researchers whose work focuses on archaeomalacology. In this regard, several students are currently beginning their Final Degree Projects (TFGs), Master's Dissertations (TFMs), and doctoral theses, specialising in a field for which the malacological collection represents a highly significant training tool. It should be noted that all of this is the result of the consolidation of a research line that originated with the doctoral thesis of one of the authors (Cantillo, 2012) and which has now been incorporated into university teaching as a tool for improving knowledge of marine resource exploitation in prehistory.

Figure 5

Catalogue entry from the malacological collection

4.2. The Malacological Collection in the Classroom: Objective Evidence of Learning

The incorporation of the malacological collection into university teaching has produced significant results, both in pedagogical terms and in the acquisition of specific competences aligned with the teaching guides of the modules involved. Direct access to collections of molluscs has enhanced the practical dimension of classes by providing students with tangible material with which to work directly. Furthermore, it has facilitated a broader understanding of all the elements involved in an archaeomalacological study.

In the case of the module Universal Prehistory II, the malacological collection facilitated the transition from theoretical to practical content, allowing greater attention to be devoted to species and their potential uses during this period. This learning outcome was aligned with specific competences aimed at helping students to understand the relationship between Late Prehistoric human groups and the natural environment, particularly through the ability to analyse and interpret the archaeological record.

Similarly, in the module Archaeozoology: Basic Techniques, the collection enabled students to achieve a more comprehensive understanding of mollusc morphology, improved taxonomic identification through direct observation, and a closer engagement with the quantification of minimum numbers of individuals. Overall, it promoted better retention of concepts in comparison with more theoretical or lecture-based classes in which resources are accessible only through conventional slide presentations. All of these aspects were integrated into the specific competence designed to ensure that students acquire knowledge of Archaeozoology as part of a comprehensive archaeological and historical education, as well as the ability to identify, evaluate, and apply the different scientific disciplines used in archaeology.

One objective indicator of the effectiveness of this resource is its immediate integration into students' scientific production. To date, the malacological collection has

served as the experimental basis for two undergraduate dissertations (TFGs) and two Master's dissertations (TFMs) that have already been defended. In addition, three undergraduate dissertations and one doctoral thesis currently in progress are using this collection as a reference resource. Furthermore, it will provide the foundation and supporting material for future scientific publications.

Finally, the effectiveness of the malacological collection as a pedagogical resource has been confirmed through the analysis of evaluation surveys (Figure 6), completed voluntarily by a total of 15 students, of whom 12 were enrolled in the Degree in History and 3 in the Master's Degree in Heritage, Archaeology and Maritime History at the University of Cádiz. The data reveal that students' prior level of knowledge in archaeomalacology before instruction was considered moderate (40%), low (26.7%), or even very low (33.3%). Nevertheless, following contact with the malacological collection, the acquisition of specific competences related to the discipline was observed at levels situated between "considerably" and "substantially".

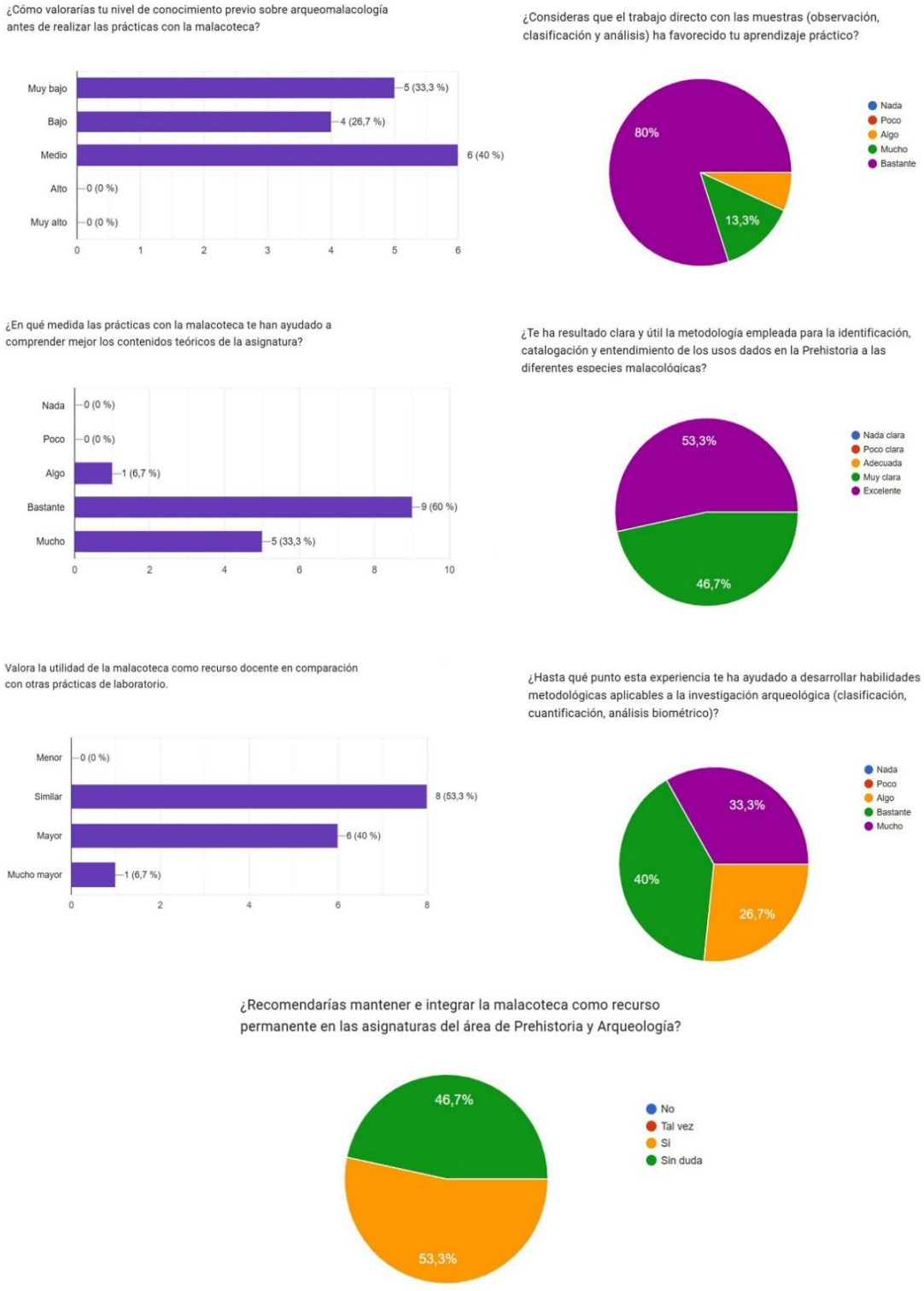
Particularly significant was the evaluation of the impact of direct work with the samples (observation, classification, and analysis). In this regard, 80% of respondents considered that it had substantially enhanced their practical learning. This assessment is supported by the methodological rigour employed in the identification and cataloguing of malacological species, as 53.3% considered the methodology to be excellent, while 46.7% regarded it as very clear.

In addition, when compared with other laboratory practices, the malacological collection continued to receive highly positive evaluations. The majority of respondents considered its usefulness to be similar (53.3%), whereas a significant proportion regarded it as greater (40%) or even much greater (6.7%).

With regard to the use of this resource for the development of methodological skills applicable to archaeological research (classification, quantification, biometric analysis, and related techniques), the results indicate that it had helped "considerably" for 40% of respondents, "substantially" for 33.3%, and "to some extent" for 26.7%, with no respondents indicating that it had helped "little" or "not at all". Finally, all students participating in the survey unanimously recommended maintaining and integrating the malacological collection as a permanent resource within modules in the areas of Prehistory and Archaeology. Responses ranged from those expressing complete certainty (46.7%) to those responding positively (53.3%), thereby consolidating the malacological collection as a highly valuable teaching resource capable of complementing theoretically based instruction. In terms of suggestions for improving future practical sessions with the malacological collection, comments included observations such as: "I found it very comprehensive, and archaeomalacology could serve as a model that may be extrapolated to other subjects such as Ancient History", "Provide more than one session", and "Expand the teaching innovation project in order to create a larger malacological collection". These responses are particularly encouraging and indicative of the positive reception of this new pedagogical resource.

Figure 6

Graphs showing the results of the survey on the malacological collection as a teaching resource



5. DISCUSSION

The malacological collection created within the framework of the teaching innovation project should not be regarded as an object in itself, but rather as a driver of

learning for students at different stages of their academic training, both at introductory (undergraduate) and advanced (Master's) levels. In both cases, it acts as a catalyst for methodological change in teaching by implementing object-based learning centred on tangible materials and by mitigating the limitations associated with more theoretical forms of instruction.

As demonstrated by the survey results, the perceived usefulness of the tangible resource is notably high (80%). In this regard, the value of materiality suggests that the physical perception of objects—in this case, malacological remains—facilitates a deeper understanding of course content than other forms of digital support. The collection also functions as an effective bridge between the stages of academic training and professional development, as evidenced by its use in the preparation of several academic research projects, including TFGs, TFMs, and doctoral theses. Consequently, the collection not only fulfils its role as a pedagogical resource, but also contributes to fostering students' scientific careers from their initial stages through to more advanced phases of research activity.

In addition, the implementation of the malacological collection has enabled the fulfilment of another of the project's objectives: to raise students' awareness of environmental conservation and the rational management of natural resources through the analysis of prehistoric ecosystems. This initiative, aligned with the Sustainable Development Goals (SDGs) of the 2030 Agenda, established parallels between contemporary challenges and practices documented in the archaeological record. During the sessions, episodes of intense anthropogenic pressure on certain mollusc species during prehistoric and protohistoric periods were examined. Particular emphasis was placed on the intensive overexploitation of limpets in the Cantabrian region during the Mesolithic (Gutiérrez Zugasti, 2009), as well as that of murex species in the eastern Mediterranean for the purple dye industry (Cantillo et al., 2014), whose impacts reduced specimen size and even threatened species survival (Jackson et al., 2001; Reese, 1980). The integration of this diachronic perspective fostered not only an understanding of the past, but also ecological awareness and the transfer of knowledge between archaeology and current sustainability challenges.

Finally, for the University of Cádiz itself, the project represents the beginning of a long-term initiative aimed at continuing to expand the collection through the incorporation of new species, thereby creating a unique reference resource for both teaching staff and students. It therefore constitutes an asset of considerable strategic value for the Faculty of Arts and Humanities, the Marine Research Institute of the University of Cádiz (INMAR), and the university as a whole, whose strategic development is strongly connected to the sea and its natural resources. For students, this collection should not be understood merely as a "repository or storage facility for mollusc shells", but rather as a resource that lecturers may use to invigorate the teaching–learning process through experiential knowledge. It will also be valuable for researchers, who may employ it as a comparative reference collection in archaeomalacological studies and as a means of promoting knowledge transfer, an increasingly important aspect within contemporary academic environments.

Despite the highly positive reception, the initial size of the collection (48 species) represents only a fraction of the malacological potential of the study area. In the future, the project should focus on expanding the representation of species that are less common in archaeological contexts, as well as formalising protocols in order to obtain more quantitative and methodologically rigorous indicators of learning outcomes.

6. CONCLUSIONS

The creation of the malacological collection as a teaching resource has represented a significant advance for the laboratory practices associated with the modules Universal Prehistory II (Degree in History) and Archaeozoology: Basic Techniques (Master's Degree in Heritage, Archaeology and Maritime History) at the University of Cádiz, through the incorporation of a more tangible component capable of complementing theoretical instruction.

In the case of the undergraduate programme, students were able to work directly with reference material that enabled them to become familiar with the morphology and nomenclature of different mollusc species, as well as to recognise modifications associated with their prehistoric exploitation, thereby facilitating a clearer understanding of the diversity of their uses (dietary, ornamental, functional, and others).

For the Master's programme in Heritage, Archaeology and Maritime History, the malacological collection provided significant added value in methodological training by supplying a reference collection for the application of classification, quantification, and biometric analysis techniques, support material for practical archaeozoological exercises, and a consultation resource for future Master's dissertations and doctoral theses. Its impact has resulted in an improvement in the quality of training through the availability of a stable, institutionally based resource at the University of Cádiz, increased student motivation through the incorporation of direct observational practices, and transversal transferability, given that it may also serve as a future resource for subjects related to Classical Archaeology, Maritime History, or the blue economy, strategic areas currently being strongly promoted by the university.

Finally, in terms of research projection, the project has been particularly stimulating for the teaching staff by enabling students approaching the completion of their studies to develop research lines focused on archaeomalacology. Working with these samples has fostered student interest, enriching not only their knowledge but also opening opportunities for the development of future undergraduate and Master's dissertations through the implementation of research lines centred on marine resources and reinforcing the strategic axes upon which the University of Cádiz structures its institutional growth. Within this context, two undergraduate dissertations and two Master's dissertations have already been defended, while three undergraduate dissertations and one doctoral thesis are currently being developed from an archaeomalacological perspective. Furthermore, this training has also benefited students from the University of Granada and the University of Magdalena under the supervision of one of the authors. All of this constitutes evidence of the interest generated by the creation of the malacological collection and demonstrates how teaching innovation

projects and examples of good pedagogical practice can generate synergies both in the educational experience and in academic projection towards specific research lines.

Looking towards the future, there are plans to continue expanding the collection, conceived as a living and dynamic project, while also strengthening the relationship between students and the malacological collection in order to further enhance teaching in future academic years. Nevertheless, it should be emphasised that the creation of this collection alone has already received highly positive evaluations, not only from students, as reflected in the survey responses, but also from the University of Cádiz itself, having been awarded the "Mention of Excellence" by resolution of the Vice-Rectorate for Teaching Staff at the request of the Committee for Teacher Training and Teaching Innovation.

7. ACKNOWLEDGEMENTS

This article forms part of the teaching innovation and improvement project "A Malacological Collection as a Teaching Tool for Laboratory Practice in Prehistory" (code sol-202400284367-tra), developed within the INNOVA Call, academic year 2024/2025, at the University of Cádiz.

We would like to thank all undergraduate students from the Degree in History and postgraduate students from the Master's Degree in Heritage, Archaeology and Maritime History at the University of Cádiz who participated voluntarily and anonymously in the surveys. Finally, we are also grateful to the anonymous reviewers for their enriching and constructive comments, which contributed to improving the original version of the manuscript.

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