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Enhancing Educational Impact: The Use of Artificial Neural Network (ANN) Modeling for Object-Based Learning in Chinese University Museums

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Abstract

University museums play a pivotal role in assisting educational institutions in the teaching and research missions. But, what Chinese university museums presently face are issues of marginalization and lack of certain direction, which make these entities less effective in their tasks to improve teaching, research, and learning among students. Such restrictions act as a constraint to the educational role of Chinese university museums. Generally, this article attempts to explore the possibilities of object-based learning (OBL) in the university museums in increasing the learning experiences of students. Guided by the good practice that has been undertaken at University College London (UCL) the paper examines multi-level teaching collaboration project run by UCL Museum Group to undergraduate and postgraduate students. Using descriptive case studies, the article has indicated how OBL has successfully been implemented into the curriculum at UCL enabling deep and immersive learning among students. Through the analysis of the effective relation between university teaching and museums at UCL, this article presents important information in the research of subject teaching and conducting a research in university museums in China. With such, Chinese university museums will be able in equalizing their practice and thereby develop a better degree of educational role and provide a better contribution to the general learning activity of the student. In collection of data, this study relied on Artificial Neural Network (ANN) to approximate the significance of marginalization and absence of clear orientation on the effective integration of OBL into the curriculum and enhancement on educational

operations of university museums, as well as contribution to whole learning experience of UCL. Predictions given by the network demonstrated the direct relationship between the higher grade of marginalization and the absence of the clarity of orientation with these aspects. The suitable accuracy of the network was proved to be acceptable according to experimental results using linear regression. The article comes to a conclusion that deep integration of university museums and teaching like the case of OBL approach has a great potential in enhancing the learning process of students as a whole and creation of a generalized, unified approach to different academic fields.

Keywords: OBL, Artificial Neural Network, Learning Experience, Building Museums

1. Introduction

Museums aspire to become inclusive, bi-directionally based, and democratic and often take special steps to ensure diversity and sustainability [1-3]. Operating with ethical and professional standards, museums engage communities and offer a range of experiences to facilitate education, enjoyment, reflection, and the sharing of knowledge [3-4]. In addition to their core educational function, museums must prioritize effective communication and interaction with the public in order to fulfill their mission successfully. University museums, as a distinct branch of the museum field, are established within higher education institutions [4-5]. They serve the purpose of facilitating scientific research and teaching at universities while also playing a crucial role in promoting university culture and preserving national heritage. The primary functions of university museums encompass education, collection, and research [6-7]. However, current research in China primarily focuses on conceptual and theoretical aspects of university museums' educational and social functions, with limited analysis of "OBL" projects and a lack of exploration into the benefits of this approach in higher education. Consequently, this article [resents a case study of UCL to elucidate the practical application of "OBL" in the context of higher education [7-9].

By employing the expertise of professionals, the study showcases how museum collections can be effectively integrated into subject teaching, thereby maximizing the educational

functions of university museums through a diverse range of methods. Presently, many university museums in China have not fully utilized their extensive collection resources to effectively serve their educational purposes. These museums often rely on guided tours and explanations that provide one-way dissemination of information to visitors, thereby lacking systematic learning projects that revolve around "objects" [9-11]. OBL, however, embraces a student-centered approach that encourages active engagement with museum collections, fostering more enriching and immersive learning experiences. The analysis presented in this case study is expected to hold practical significance and provide inspiration for the advancement of scientific research and teaching support initiatives within Chinese university museums and art galleries [12-16]. OBL is a variety of teaching method that focuses on the application of physical materials as one of the key aspects of teaching process that surpasses the traditional forms of teaching. Through this first-hand interaction with objects, students get to explore them, analyze them, and interpret them which leads to taking learning to the next level in the process. The main concept here is to move on to active consumption to passive one and invite the students to engage with objects, pose questions, and build their own knowledge. The mode prepares people regarding critical thinking, observation, and interdisciplinary linkages [16-18]. OBL makes everything you learn and see to be real and identifiable through the use of actual objects, which can have an idea of a deeper sense of abstract things. Pieces of historical evidence, biological samples, and works of art refer to theoretical knowledge to begin related implementations in the world. Obviously, OBL also invites interdisciplinary learning as it eliminates divisions between various topics by inviting students to connect dots and create a comprehensive knowledge of complicated issues. The benefits of OBL come through its focus on interactive learning, critical thinking, and interdisciplinary learning, which improves one education and makes the learning process more in-depth and holistic [17-21].

While previous research has mainly concentrated on conceptual and theoretical aspects of university museums, there is a lack of analysis regarding the advantages and implementation of "OBL" in higher education settings [22-24]. The idea is to show how well museum

collections may be used in delivery of subject content through tapping into the expertise of the professionals and the abundance of collection resources at their disposal. The study aims to present practical value and stimulation of the scientific research and teaching assistance activity performed by Chinese university museums and art galleries through the case study analysis to offer information on the potential of the innovative methodology of the setting called OBL. A shallow artificial neural network (SANN) with a hidden layer was developed in this continuous research to investigate various test cases. These cases focused on the successful integration of OBL into UCL's curriculum (%), improvement in educational performance of university museums (%), and projected contribution to the overall learning experience (%). A broader scope of marginalization (%) and inability to have a clear orientation (%) input was used to train the neural network. In addition, the linear regression was used to measure the error of the network. This study presents the predicted outcomes generated by the SANN and assesses the estimation process.

2. Museums and Higher Education

The initial emergence of museums within university institutions can be attributed to the interplay between education and research. Discussions regarding the origins of university museums trace back to the 1680s, when the Ashmolean Museum of Art and Archaeology was established at the Oxford University. This institution is widely regarded as one of the earliest public museums and represents a recognizable precursor to modern museum institutions, assuming responsibilities for public education. Consequently, it laid the groundwork for the organizational framework of contemporary university museums [25-26]. The history of development of Chinese university museums, in contrast, is quite recent as opposed to European and American ones. The Nantong Museum, rooted in the academic setting of colleges and universities, has a history spanning more than a century. Its establishment not only ushered in a new era of modern museums in China but also filled a void in the realm of modern university museums within the country. The interconnectedness between museums and higher education is evident from these historical accounts. University museums, as

integral components of the museum system, play a significant role in advancing the museum enterprise [27-29].

3. Literature Review

Hardie (2016) shows the significance of incorporating engaging designs into OBL, underscoring their potential to enhance the learning and teaching process [30]. Deller (2022) discusses the risks and rewards associated with personal- OBL, highlighting the possibility of fostering deep personal connections and meaningful learning experiences [31]. Yilmaz et al. [32] show the experiences of Turkish elementary school students engaging with objects in museums to learn social studies, demonstrating how OBL can enhance student engagement and understanding [32]. Cheung et al. (2022) explore the realm of OBL in the field of pharmacy, showcasing the value of working with museum collections and artifacts [33]. The incorporation of technology on OBL is also discussed in the literature. When speaking about research-based education, Gallou and Abrahams (2018) address the opportunities that technology offers in this field because it allows presenting active learning experiences [34-35]. Kukhareva, et al. (2020) investigate the strata of interaction within OBL with the focus put on the use of technology that prompts individual and collaborative active inquiry [36]. In addition, the literature draws attention to the significance of OBL in various fields. Cobley (2022) reveals the importance of objects in the context of higher education and how they could be used to make the teaching and learning experiences more interesting [37]. Peden (2017) concentrates specifically on the object-based workshops that take place in archaeology and anthropology where the article authors demonstrate their effectiveness in interacting with students and encouraging them to engage in learning experiences [38]. Raynes and Heiser (2019) [39] get into the question of using primary sources in OBL to improve cartographic literacy. Winston-Silk (2019) offers a new methodology of OBL with the deaccessioning and reimagining objects [40]. Willcocks (2016) problematizes concrete experience in the field of art and design pedagogy, where museum collections and tactile sense were used to play a significant role in the construction of meaning [41]. Laird (2020)

writes about experiential and OBL in the natural environment, providing its potential health effects on the well-being [42]. More so, the literature does not discuss the advantages of OBL in informal learning environments. Paris et al. (2002) [43] reveal the role of objects in learning in an informal environment that emphasizes on experiential learning. An object biography and OBL approach to the study of a tomb in Jordan demonstrated by Jamieson et al. (2020) [44] indicates how important it is to work with the archaeological objects. Mentioned by Turin (2015), the mixed outcomes of object-based teaching in a digital setting shed light on the ambiguities and reflections on practicability of adopting a technology-enhanced OBL experience [45].

University museums play a vital role in supporting scientific research and education within universities, serving as a significant platform for promoting university culture and preserving national heritage. Consequently, education represents a fundamental function of university museums. In terms of institutional classification, the most prevalent types of university museums include museums, archives, botanical gardens, and herbaria. Furthermore, when considering the classification of collection types, the top-ranked categories encompass art and cultural history, natural history and natural sciences, science and technology, as well as history and archaeology. Regarding the exhibition content within university museums, it primarily encompasses themes such as history, art, character, nature, engineering construction, and traditional Chinese medicine. The collections housed within university museums span beyond traditional fields like natural history, also encompassing exemplary outcomes derived from teaching and scientific research conducted within affiliated universities.

Many researchers [17-18] which study the university museums serve as valuable resource centers within higher education institutions, aiding in the development of their affiliated cultural institutions by emphasizing their scientific and educational characteristics, specifically in teaching and scientific research. These museums are designed to fulfill the dual role of supporting higher education and museum education. But the educational role of university museums is not the same as it is in the case of the public museums and is characterized by specific features. They not only cater to the needs of students and teachers

but also establish close connections with higher education disciplines and integrate more effectively with subject teaching. Additionally, they seek to attract new audiences from the local community and beyond [7-11]. As a result, the primary focus of university museums is their educational function, acting as a distinctive bridge between knowledge dissemination and scientific comprehension. Many renowned universities worldwide consider the establishment of first-class university museums as a crucial task and mission. Besides fulfilling the role of academic research and offering teaching support to the parent institutions, these museums also take up the obligation of offering social services to the citizens.

In 2002 Hein [8] published a book called Learning in Museums and the synthesis of the theory of museum education contained in the book is based upon a long period of his practical work over ten years. The work of Hein starts with the analysis of the historical progress of the museums and underlines the importance of education within the museums. In epistemological and pedagogical perspective, he suggests constructivist approach to museum education that entails observation of audience through personal experiences and thinking adventures. Similarly, because of the uniqueness of museum education, the uniqueness of the museum education is demonstrated in the book by Hooper-Greenhill [14]. They reveal the unique qualitive character of the museum experience and interactive teaching which focuses on employing material culture. This method implies the active presentation of suggestive pictures, e.g. cultural objects, specimen and models and gives the audience opportunities to use sight and touch, observing at the same time and touching the collections. The strategy will help to escape the elementary character of learning in the classroom and the related greyness and boredom that many people can identify with, and help the participants to make bright and memorable impressions [14]. Similarly, learning on university museums provides a versatile experience since educational opportunities are available through different learning activities entailing an experience, interactive and enjoyable facility. University museums attempt to enable the creation of impactful learning experiences and assist the participants to build their own knowledge by incorporating discipline-specific pedagogy and teaching into museum collections. University museums will improve the educational value of their

activities through their instructional theory of teaching with objects, applications of the teaching with objects, and measures of teaching quality, teaching through different forms, teaching through wonderful experiences.

4. Research Methodology

4.1. Enhancing Museum-Based Learning

This study aims at discussing the possibilities of the object-based learning (OBL) opportunities availed by the university museums to transform the learning quality of students. The research questions determining this research include: 1) What are the various kinds of OBL opportunities provide by university museums? 2) In what ways can OBL opportunities enhance students' learning experiences? 3) What are the advantages of doing OBL opportunities to students? A qualitative type of research methodology will be used to answer these questions, whereby the research method will include a case study research and data will be observed and analyzed by the use of interviews, observations and answering of documents. The case study will focus on University College London (UCL) as a representative institution with robust OBL programs integrated into various disciplines. The information will be gathered by a semi-structured interview of 10-15 students who have been engaged in OBL activity at UCL museums and the interviews with museum educators and curators about program design and implementation. On-site observations of 2-3 OBL activities/programs will be conducted, documenting student interactions, behaviors, and engagement with objects. Additionally, relevant documents such as course syllabi, descriptions of OBL modules/programs, and evaluation reports will be analyzed. The existing literature on OBL case studies will be reviewed to identify key themes and construct the theoretical framework. Data analysis will involve thematic coding of interview transcripts and observation field notes to identify patterns in student experiences and perceptions of OBL, while documents will be reviewed to categorize OBL opportunities and extract intended benefits. An analytical framework based on constructivist learning theories will be developed to understand how OBL enhances learning. The study acknowledges limitations in terms of generalizability due

to its focus on one case institution and ensures ethical considerations by obtaining informed consent, ensuring anonymity and confidentiality, and obtaining necessary approvals. This qualitative case study aims to provide an in-depth understanding of OBL approaches and their benefits from the perspectives of students and educators, offering valuable insights for advancing the educational activities of university museums. The validity and the reliability of the research findings are increased by inclusion of the case study method. Key factors contributing to this improvement include the use of triangulation, where researchers' observations [25-42] serve as data collection methods, thereby strengthening the validity of the findings. Thorough discussions with diverse stakeholder groups, such as students and educators, help capture a range of perspectives and minimize bias. The adoption of a single-case design enables an in-depth exploration of case contexts, programs, and experiences, thereby enhancing construct validity. Also its reliability is guaranteed by the fact that there are several sources of information on which one can base his data i.e. documents and observations and the application of multiple criteria to evaluate a phenomenon, thus improving reliability. Consistency in the data collection protocol, with the same researcher conducting observations, facilitates more reliable and replicable findings. The utilization of a theoretical framework and predefined coding scheme for qualitative data analysis brings structure and objectivity, thus, the results are achieved with a more exact degree of reliability. The situation that can be attributed to the mixture of the case study method, use of various data sources, and adherence to systematic methods strengthens the validity and reliability of the insights obtained. While each method has limitations, their combined use achieves triangulation and effectively addresses concerns regarding validity and reliability in this exploratory study.

4.2.Constructivist Object-Based Learning: Theoretical Foundations

The theoretical underpinnings of this study are grounded in constructivism, which serves as the fundamental epistemological foundation. OBL is considered a constructivist pedagogy that promotes active learning through the exploration of objects. The study draws upon John

Dewey's experiential learning theory, which influenced the development of interactive and hands-on OBL activities that utilize real-world objects as catalysts for experiential learning. Also, the model of learning through concrete experience, observation, reflection, and experimentation made by Kolb on an experiential learning process gives an idea about how OBL can contribute to the learning process. The literature review conducted for this study encompasses a comprehensive examination of previous research, which establishes the core concepts, principles, and benefits associated with OBL across various disciplines such as archaeology, art, and science. Furthermore, studies emphasizing the multi-sensory and experiential aspects of OBL provide additional support for its efficacy in enhancing engagement and comprehension. The identification of gaps in the existing literature concerning outcomes and the specific contexts of Asian universities justifies the necessity of conducting the current study.

In this article, we demonstrate several key strengths in our significant research methodology. To begin with, it is innovative because it covers a rather unexplored field OBL in university museums and offers new insights and possible solutions as to how to incorporate it into the curriculum. Secondly, it is a mixed case study and qualitative data are collected with the help of interviews, observations and analysis of documents. Together with triangulation, this thorough method helps increase depth and precision of the findings. Third, the methodology is based on constructivist learning theory and experiential learning making a strong theory grounding. The literature review is also complete to enhance the conceptual basis of the research. Moreover, single-case design on UCL provides not only a chance to explore OBL programs in the context of a natural environment thoroughly but also a possibility to answer questions about how they are carried out and what effects they produce. The principles of ethics, i.e. voluntary participation and confidentiality add to the validity and reliability of the study. The methodology used in the research proves to be strong (in regards to innovation, comprehensiveness, theoretical foundation, probing of the context, incorporation of several points of views, practical importance, analytical rigor and consideration of the limitations), therefore establishing it as a quality and viable research exercise.

4.3.ANN Modeling

To undertake this study, a shallow progressive ANN was used as a model to anticipate transformations in the successful assimilation of OBL in the UCL curriculum (%), enhancement of teaching performance of university museums (%) and participation in the entire learning experience (%). The network was trained on 10 samples, varying in marginalization (%) and lack of clear direction (%), within a range of 0 to 90%. The neural network model also had an input generation of marginalization (%) and lack of clear orientation (%) in the design with one hidden layer of 5 neurons and outputs for successful OBL integration (%), enhanced teaching performance in university museums (%), and contribution to the overall learning experience (%). The Sigmoid form of activation function was used to make precise prediction and to accelerate convergence. Training and estimation was performed using gradient descent algorithm in minimizing the error. Table (1-5): Normalization of input data enhanced the accuracy and convergence, whereas, the final results were denormalized to produce a report. The accuracy of ANN was evaluated by the linear regression analysis, analyzing the similarity between the diagram of fitting the line and the y=x line. The results of ANN in this study are going to be discussed in the following sections.

5. Conception of Object-Based Learning

Starting from the 1960s, the United States embarked on a transformative movement in education, shifting the focus from "education" to "learning." By the 1980s, the progressive education movement gained prominence, led by influential American philosopher and educator John Dewey. Dewey advocated for student-centered teaching, prioritizing students' personal interests and utilizing their experiences as a foundation for instruction. He opposed the absolute authority of teachers and emphasized the guidance of educators as facilitators. Concurrently, the museum field underwent a shift in its approach, transitioning from a primary emphasis on collection preservation to collection interpretation. This shift prompted scholarly exploration into "learning" based on audience experiences and the construction of

individualized learning experiences. In the context of museology, numerous researchers have highlighted the significance of "OBL" This approach encourages active engagement with authentic collections, aiding learners in processing a range of professional concepts based on prior experiences, and transforming them into understanding, mastery, and practical application. Dewey's educational theory is rooted in the concept of experimental experience, positing that education evolves and develops through continuous constructive experiences. It underscores the notion that experience serves as both the purpose and method of education. Additionally, Dewey emphasized the value of subject initiative, experimental engagement, and reflective thinking. Knowledge is viewed as the accumulation of experiences derived from social and historical practices, representing the collective effort of generations and the experiences of the entire human "race". Experience is fluid and necessary within the context of social development in a wider sense of the word. Learners actively engage with knowledge from a developmental perspective, rather than passively receiving knowledge infusion. Dewey argued that natural objects are not experiences in themselves; they merely serve as objects of experience. It is through individuals' interaction with various objects of experience that actual experiences are generated. In the museum field, knowledge is transformed into individual experiences for students through the dynamic interaction between the learner and the museum environment and objects.

OBL is a form of experiential learning and an active teaching method [3-4, 9]. Several studies have highlighted the value of OBL for students and educators, as it encourages deeper interaction and engagement with real objects and visual representations of artifacts [3-4, 9, 21]. OBL aligns with the student-centered framework, which promotes effective engagement with museum collections to foster rich learning experiences [3-4]. The terms "object-centered learning," "object-inspired learning," and "object-based inquiry" have been used to refer to OBL [3-4]. These terms emphasize the role of objects in acquiring and disseminating cross-disciplinary and subject-specific knowledge.

Moreover, the researcher gives an unelaborated definition of OBL as a pedagogical approach that affirms a guided involvement amid persons and the material culture to stimulate proper

thinking and other essential aptitudes. Material culture encompasses a wide range of items, including everyday objects, documents, artworks, biological specimens, and handicrafts [1, 4]. Similarly, Pearce [3-4] explains that the term "object" encompasses various items such as artifacts, artworks, specimens, and fossils, collectively referred to as material culture. It has also manuscripts, rare books and archives. Additionally, using modern science and technology, museum teachers and teaching personnel have come up with the aid of electronic resources that facilitate or accompany OBL. The materials covered by such resources are diverse and they include life science research artifacts. Further, the 2-dimensional pictures or the three-dimensional electronic models can be created to enable the students to study and learn especially in precious collections.

Museum objects possess the capacity to inspire, inform, attract, and motivate learners at various stages of their educational journey [3-4]. OBL is a crucial educational approach that utilizes authentic objects to foster learner-led experiences. From a pedagogical perspective, integrating objects into university curriculum promotes interactive and experiential learning, engaging multiple senses. Marie (2011) [15] shows that OBL activities enable students to practice and develop transferable skills and critical thinking. Moreover, well-designed OBL projects facilitate students' engagement with collections throughout the learning cycle, enabling them to acquire deeper knowledge. Museums in universities are important actors in the university sector in that they offer service on a subject basis and as an intermediary between higher educational institutes and target groups.

By promoting collaboration, inclusion, and access, university museums contribute to creating a more accessible educational environment.

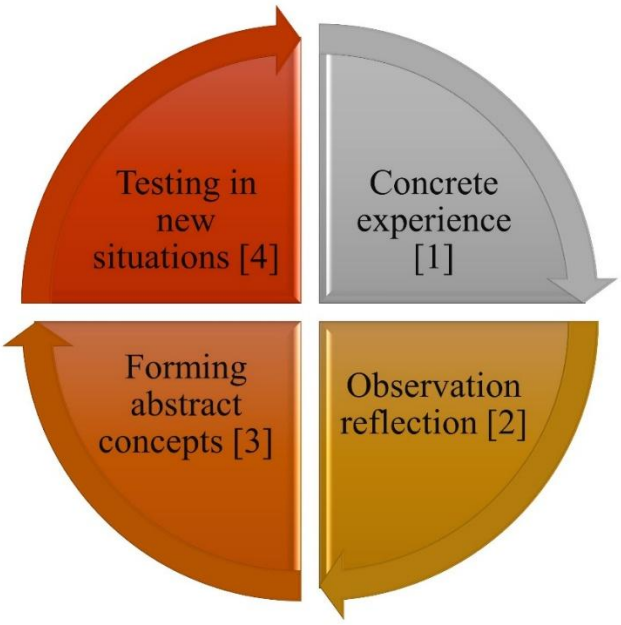

Figure 1: Kolb's experiential learning cycle (Kolb 1984, 42) [1]

According to Kolb's cycle of learning (Figure 1), learners must actively participate in experiences, employ skills to reflect on those experiences, and through experimentation, acquire new knowledge. University education encompasses complex subject-specific learning processes, presenting students with substantial challenges in acquiring conceptual knowledge. Therefore, providing students with opportunities for experiential activities, such as a sert of OBL projects, enables them to apply transferable skills, including listening, observing, communicating, and collaborating, within the learning cycle.

5.1 Values of Object-Based Learning

OBL is an invigorated educational practice whereby collections and artifacts are used as learning tools in both formal teaching facilities and specialised museum institutions [2-4]. Several researchers have noted that OBL is very useful because it promotes increased interaction and involvement among students and instructors due to direct contact with real objects and visualized portrayal of artifacts [2-9]. Therefore, the list of arguments in favor of the inclusion of museum and historical artifacts into the learning environment is rather long. The most important thing is that, OBL has a student-centered climate, which gives impetus to

active student involvement and responsibility in the process of learning [2-4]. Conversely, lectures with instructor have been known to lead to passive listening and note taking by the students. Such is the structural presentation of OBL sessions when students can imagine objects in different aspects, creating extremely subjective interpretations that can deepen their perception of a subject. Critical observation skills of students can also be trained with the help of series of activities which presuppose close observation of objects and sensory feeling connection with objects [10]. As sources, the material culture and works of art can act as a main source, having a different point of view to be used in the problem-solving. OBL also helps in better understanding of the subjects that are under study by students [10]. Although the given literature is mostly dedicated to the theoretical dimension of OBL, empirical studies research in this area is limited. The opportunity to discuss how university museums can provide OBL experiences exists due to the fact that such institutions have a wide range of primary resources that are used in teaching and research. Secondly, OBL has a strong connection with multisensory learning in which different senses e.g. sound, hearing, sight and touch are used to interact with real objects. Simpson et al. [20] conducted the study on how multisensory involvement helps to retain the information. They formed two groups with students where one group was able to have a direct experience with the objects and the second group had an interaction with digital alternatives.

5.2. Object-Based Learning: Enhancing Knowledge, Critical Thinking.

The results of the survey showed that the students who got direct access to real objects had a probability of recognizing their usage and remembering information about them [20]. In an analogous manner, it has been also found out that Tactile encounter with the actual objects builds the bond between students and the information, cementing the memory, and facilitating in the academic process. Further, tiballi (2015) [24] illustrates through haptics or the active touching, complemented by haptics (cognitive processing), students are taught to feel things differently. These three articles underline the role of multisensory learning in OBL and underline the positive effect that it has on the learning levels of university students.

According to Chatterjee et al. [3], OBL may be applied when examining cultural outlooks to the extent that they encourage individual discussions and make it possible to exchange values, beliefs, and ideas when dealing with objects. This generates chances of communication especially in light of the fact that students are of different backgrounds hence provide varying perspectives when they discuss and when there are group assignments. Personal access to objects will give students an opportunity to break the stereotypes and restructure their biases. The Object Lessons: Communicating Knowledge through Collections program organized by UCL Culture provides the undergraduate students of arts and sciences with the opportunity to discuss different topics including the Cultures, Health and Environment, Societies, or Sciences [1, 4]. The objectives of the project are to build knowledge and skills of students in-depth. Having common ground in the personal knowledge about the collection and exposure to various points of view by means of this program, students with different backgrounds and major spheres of interest strengthen their skills of communication and critical thinking.

Various studies have already proved the great usefulness of OBL both to the teachers and students. The direct encounter with real collections or visual representation of collections provides a way of engaging the participants within OBL programs. Unlike conventional teacher-centered classrooms in which learners listen passively and make notes, OBL creates the student-centered environment that promotes active involvement and the ownership of the learning process. Students thus get the chance to examine the objects in a versatile manner hence the learning process is very individualized whereby each student would have a different meaning to all such objects. This learning strategy deepens the learning of the topic and improves the powers of critical thinking and observation of the participants by paying much attention to the both observations and looking of objects and their multi-sensual activities. Learning is mainly accomplished by artworks and material culture as the basis of learning.

Simpson et al. [20] conducted a research study examining the impact of multi-sensory engagement on information retention. They divided students into two groups: one group had

direct contact with physical objects, while the other group interacted with digital collections. Survey results indicated that students who directly engaged with real objects were more likely to recognize their uses and retain knowledge about them [20]. Another group of the scholars also argue that by touching actual objects a contact between the participants is established and the implicit knowledge associated with the objects, strengthening memory and further supporting the learning process. Tiballi (2015) [24] also demonstrated that tactile experiences, including active touch among the five senses, guide participants from one mode of experience to another cognitive process.

6. Educational practice at UCL

Established in 1826, UCL is a renowned comprehensive research university situated in the heart of London, England. UCL espouses an educational philosophy characterized by its commitment to free-thinking, openness, and inclusivity. The institution places great emphasis on the integration of teaching and research with real-world issues and societal needs. The primary goal is to foster students' innovative thinking and practical skills while serving the advancement of both society and industry. The introduction of UCL Museums has played a pivotal role in supporting the university's corporate identity and public engagement initiatives. Previously, collections held significant importance in teaching and research endeavors, with student engagement being viewed as instructive, investigative, and experiential. The collections were regarded as objects worthy of contemplation. Rather than being sourced externally, the community is naturally drawn to the institution, partially due to the ideological utilization of the collections.

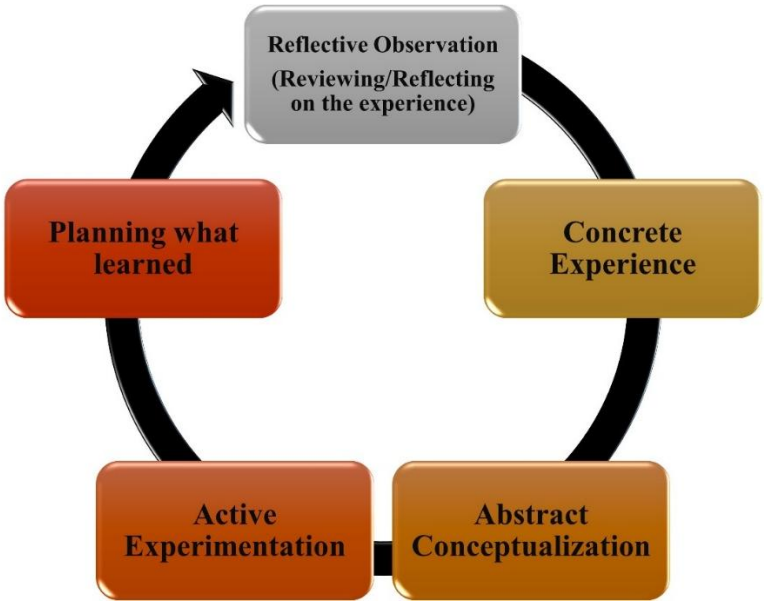

Figure 2: Interconnected Elements of Objective-Based Learning: Artefacts, Museum Space, Peers, Knowledgeable Others, and Specimens

Figure 2 illustrates the interconnected elements of an objective-based learning experience, including the role of artefacts, the museum space, peers, knowledgeable others, and specimens.

6.1 Overview of UCL Museum

UCL University Museums help in enhancing the corporate identity of UCL and in engaging with the population. Collections are deeply integrated into teaching and research, with student participation viewed as instructive, research-oriented, and experiential. The collections are highly regarded as objects worthy of contemplation. The UCL museums and collections include four publicly-accessible museums (the Petrie Museum of Egyptian Archaeology, the Grant Museum of Zoology, the Pathology Museum and the UCL Art Museum). These collections cover a wide range of disciplines, including anthropology, archaeology, history, science, medicine, and arts. Additionally, there are 14 thematic collection departments, spanning from anatomy to space exploration, housing a total of approximately 800,000 preserved items. Many of these collections consist of instruments, samples, and other artifacts from past research. Galton, a geneticist at UCL, bequeathed around 500 items related to his laboratory and research to the college in 1911, including craniometers and hair samples. UCL

Museums and Collections, often referred to as the "Academic Support Department," serve the university's teaching and research endeavors. UCL Museums play a critical role in collection management, providing students and faculty with access to diverse collections from 18 major teaching collections.

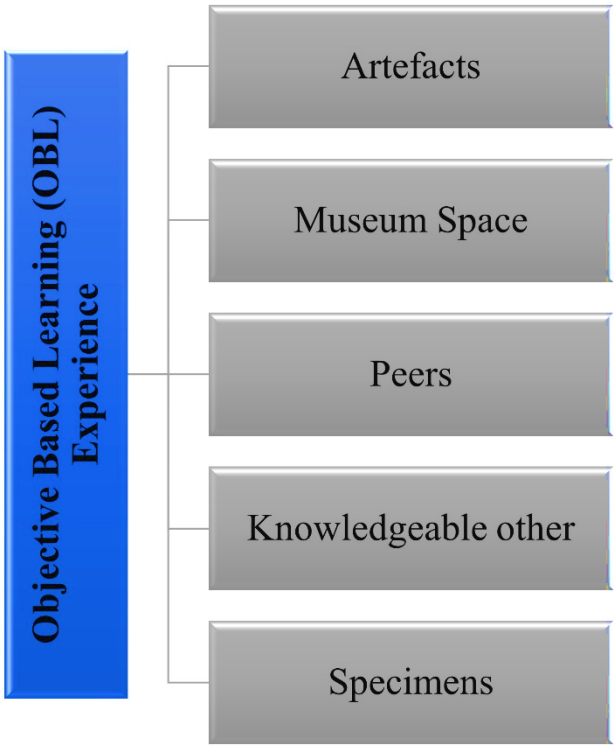

Figure 3: Exploring the Components of an Objective-Based Learning Experience: Artefacts, Museum Space, Peers, Knowledgeable Others, and Specimens

OBL is cherished in UCL and considered to be part and parcel of undergraduate and postgraduate studies in almost all subjects, which include engineering sciences, life sciences (anatomy, biology and zoology), mathematics and physical sciences (chemistry, earth sciences and paleontology), and social and historical sciences (anthropology, archaeology, art history, museums, conservation and heritage studies). In support of this approach, UCL has developed a research plan specifically focused on utilizing collection-based learning and has established an OBL Lab to meet the space requirements for this pedagogical approach (see Figure 1: OBL Lab). This research plan aims to promote the effective utilization of UCL collections in teaching and research across the university, ultimately enhancing the learning

experiences of students.

Figure 3 shows the key components of an objective-based learning experience. Figure 3 shows the central role of various elements, including artefacts, museum space, peers, knowledgeable others, and specimens. There is an interaction between these components and they support the overall purpose of objective based learning process that makes the educational environment dynamic and immersive. The artefacts can be used as a physical means of exploring and analysing and the museum space is a special location to get involved to explore. Research has asserted that peers have an important role in collaborative learning whereby students transfer ideas, views and insights. Knowledgeable others or in other words educators or experts offer a guiding principle and expertise in assisting the students in their learning process. Finally, specimens also provide a certain illustration and practical experiences that also improve comprehension and logic. The combination of the interrelated parts constitutes an enriching objective-based learning process that facilitates the active approach, multi-disciplinary relationships, and an enhanced understanding of the learning material.

6.2 UCL Culture

UCL Culture is a vibrant group found within the whole campus of UCL and is in complete charge of generating and sharing the cultural contents of UCL. It also builds network with UCL and foreign universities and museums. The principal work of the team will include managing and running any museums, any collections, as well as any theaters under the University of London. In order to fulfil these duties, UCL Culture leads a variety of professionals both in the realms of curatorial practices, conservation, education and the involvement of the community. UCL Culture offers professional services to the students of the university through this team of specialists, thus enabling them to have different varieties of learning opportunities and being able to design new teaching projects. The staff is engaged in promoting interdisciplinary partnership among the members of different disciplines and supports alignment of collection material with their use in new forms of teaching in their

specific discipline. Its overall aim is to revitalize the campus life of students by offering them the latest culture. According to official statistics provided by UCL there are about 3,000 teachers and students using on-campus collections annually and over 100 courses integrate those collections [14]. UCL Culture has developed a system of object-based courses as well as provided the electronic resources connected with OBL and which can be downloaded on the official university site. The aim is to provide opportunities to the students in close observations, learning and sharing knowledge with collections both on-campus. The students are free in the design of their research projects, picking the research topics of culture, health and environment, society or science.

The program will create an interdisciplinary knowledge and skill in the students. People of different cultures and fields will bring their personal vision towards the knowledge of collections, thus developing their social and analytical skills. Organized usage of natural objects to strengthen and teach subject-specific knowledge, to develop ability to observe and draw. In addition, where Master students in Museology do not only teach and conduct research using collections they also undertake practical work like putting together exhibition in the exhibition space of UCL.

6.3 UCL studies into object-based learning in higher education

OBL is fully embedded in undergraduate and postgraduate training at UCL across subjects including Engineering Science, Life Science (Anatomy, Biology, and Zoology), Math and Physical Science (Chemistry, Earth Science, Paleobiology), and Social and Historical Sciences (Anthropology, Archaeology and History of Art, Museums, Conservation and Heritage studies). Formal statistics show that there are about 3,000 students annually in 100 courses of the university who make use of the collections in their research. Various objects are used to improve and communicate subject-related insights to encourage the development of functional skills, the eye, and creativity Object integration happens not only among definite disciplines, but also along disciplinary boundaries. Installation studies given by art students are made in the Grant and Petrie museums, and MA Museum Studies students do not

simply use collections to teach and researches, but also create exhibitions in UCLs temporary exhibition buildings.

Table 1: Core Courses Related to "OBL" at UCL (Data Sourced from UCL Office Website)

Subject	Main course
Department of Archeology (Archaeology)	(Egyptian Archeology: An Object based theoretical Approach) Collections Curatorship
Arts and Humanities	Architectural History (Object lessons: teaching by means of Collections)
Biology (Biological sciences)	Biologist science communication Medical Science
Art History (History of Art)	Art History Symposium: Life, Love and Death in Early Modern Europe
Science and Technology Studies	Curatorial Science and Technology
Social and Historical Sciences Program	Archeology and Museum Management

Adoption of the museums within the university this central strategic objective of UCL museums is to reposition the collections as part of its university teaching and research. As an example, figure 2 (data obtained at the UCL office website) displays some of the core modules that are related to every faculty dealing with undergraduate and postgraduate courses. All the relevant modules at UCL are included in Table 1 and the example of a few object-based courses within the module system is brought to the fore. It is also necessary to add that the courses are obligatory on some subjects of the study and witness the importance of OBL as one of the main aspects of the university academic support. Through this strategy, the students get a chance and room to learn and discover about individual learning processes

and the strategies of making decisions, which is more critical when it comes to creative academic endeavors.

6.4 UCL students in OBL biology/bioscience program

Grant Museum of zoology at UCL is an explanatory example of the museum collections made in such a way as to respond to emerging priorities. As the biological sciences have advanced at an unprecedented rate in the 21 st century, there has been a focused attention to prepare students in biology with transferable skills in fields like genetics, ecology, modeling and this has increased the burden on biological science education. Consequently, the Zoology departments within universities has been integrated into the Department of Biology. Initially, a standalone degree program in Zoology was offered, but eventually, Zoology modules became incorporated within Biology or Biological Sciences programs. To bridge theory and practice in the field of zoology and the at the Grant Museum, the staff together with the teaching staff of the Department of Genetics, Evolution, and Biology have come up with the Mystery Specimen Project. This project leverages OBL to encourage students to apply biological theories in practical contexts as presented in Table 1 and Table 2. The project spans one semester and comprises 50% of the final examination grade, concentrates on the evolution and life of the vertebrates. This is a module offered at third/fourth undergraduate level.

Table 2: OBL Opportunities in University Museums

OBL Opportunity	Description
Guided Tours	Guided tours are given by museum personnel or educational practitioners, their interpretation and explanation of objects is detailed. The students can discuss and ask questions.
Hands-on Workshops	The use of interactive workshops in which the students work actively with objects (creating replicas of objects, conducting experiments, studying artifacts, etc.)
Object Study	Special workshops when students perform in-depth studying

Sessions	and observation of particular objects with the help of professionals of the museum or experts in the field.
Exhibitions and Display Spaces	The exhibitions in the museum that contain curated collections of objects enable the students to discover and learn the objects of different topics or themes.
Collaborative Research Projects	Students carry out research projects either in team work or individually and studying, analysing objects, they add to academic knowledge or an exhibition development.
OBL Modules	Courses or specialized learning modules that are created with an emphasis on object-based learning (OBL) and include a number of object-centered activities and assessments.

The lesson is carried out in the Grant Museum and learners are given a deaccessioned (specimen) vertebrate in this case, one with all attachable labels and labels giving directions of identification have been removed. The sample may be hunk of bone to a bit of skin. Their first challenge is to allow the students to find out the seat of specimen inside the animal with observations that must be careful in terms of anatomy and that might consider drawing or photographs with full utilization of Grant Museums collection. There are multiple interesting experiences of OBL opportunities in university museums. There are guided tours which are taken by the staff members or educators who give and explain in details about the objects and encourage students to discuss and ask questions. The practical workshops allow the active involvement in mechanisms like the making of replicas, experiments, or artifacts analysis.

Table 3: Benefits of OBL Opportunities

Benefits	Description
Active Engagement	OBL fosters active engagement and experiential learning, enhancing deeper understanding and learning.
Critical Thinking and Analysis	Students acquire critical thinking abilities as they view, analyze, and interpret objects, making evidence-based

	conclusions and meanings.
Multidisciplinary Connections	OBL enables the studentsto connect ideas between courses, understanding the interdisciplinarity of different fields.
Contextual Understanding	Direct experience with objects gives students contextual knowledge of the subject matter, which adds to their knowledge beyond theoretical realities.
Experiential and Immersive Learning	OBL promotes a stronger bond with the material by providing an immersive and engaging learning environment.
Collaboration and Communication	In OBL opportunities, collaborative activities foster communication, teamwork, and idea sharing among students.
Lifelong Appreciation for Objects	OBL encourages inquiry and discovery while establishing a lifetime appreciation for things, relics, and specimens.

Special sessions of studying of the objects give the students an opportunity to study and analyze certain object under the close guidance of specialist, museum employees, or subject experts and improve their knowledge about the historical, cultural or scientific background of that object. Museum display areas and exhibits present the arranged exhibits, which provide the students with the possibility to learn and discover diverse topics or themes. Joint research and study the students work with the objects in the collective research and analysis work, focused on contribution to the academic knowledge or development of exhibitions. OBL modules or courses specifically related to objects (i.e. specialized courses) give students expert knowledge of a subject area and enable them to develop skills in critical thinking through assessment and course activities. By means of such variety of opportunities, OBL in the museums at the universities enables active learning, healthy critique and a greater relevance to the objects in the museum and what they mean. There are numerous advantages of OBL opportunities to the

students. Hands-on participation actively develops involvement and promotes students to become deeply involved into the learning process and helps to understand the knowledge and grasp it better. Another skill developed in OBL is the ability to think and analyze as the students observe, analyze and interpret objects and therefore develop the capability of making evidence-based conclusions and interpretations. Moreover OBL enables students to draw multidisciplinary linkages and realize that different subjects are related to one another and hence expands their horizons. The first-hand interaction with objects gives the students a contextual knowledge of the subject matter as well so that they can move beyond the theoretical concepts and get to know the implication and practical uses of the same. This hands-on and active learning allows feeling the subject matter deeply and leads to better results in the overall study outcomes of students in general. OBL also helps to build collaboration and communication since students will have to collaborate on projects, work in groups, exchange ideas, and thus will improve their interpersonal and communication skills. Lastly, OBL cultivates a lifelong appreciation for objects, artifacts, and specimens, instilling a sense of curiosity and exploration that extends beyond the educational setting (see Table 3). The students in this class are all different with some studying biological sciences, geography, and anthropology as well as humanities. Nevertheless, the majority of them have never studied unknown specimens as the part of the curriculum earlier. The students meet a few times in the course of the semester to view specimen in the class site. The first lesson is about learning to examine the specimens using a complicated process, beginning with the general overview and ending with minor details. Various questions are raised to them concerning the specimens like what the specimen is made of and is it complete or is it part. In the course of the process, other museum collections and other relevant publications are recommended to visit by the student so that to reduce the scope of identification and achieve probable identification of the correct category, family, genus or species. The assessment part is the written assessment of this session, which is to come in the form of writing a diagnosis as a scientific journal article.

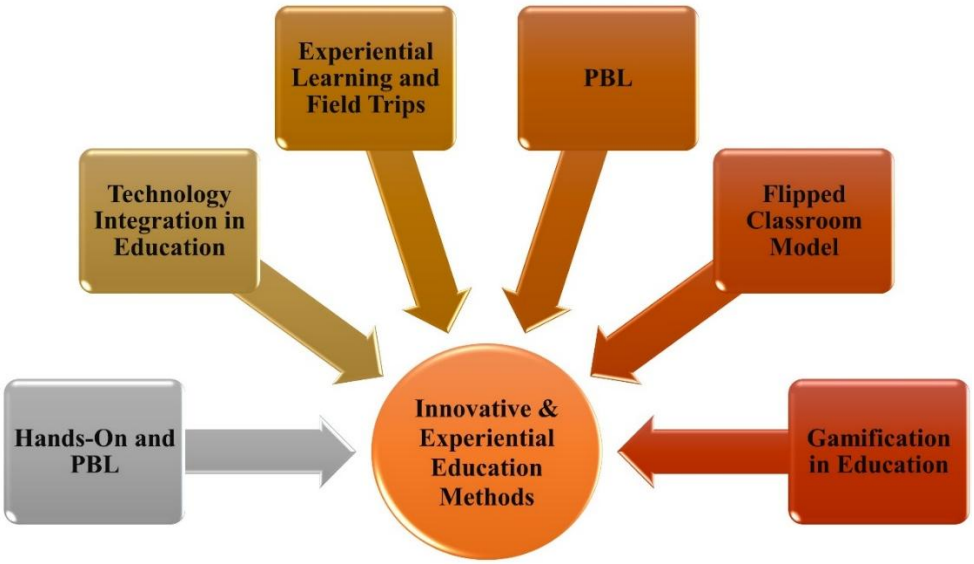

Figure 4: Experiential Learning Pyramid is a representation of the hierarchical arrangement of the experiential learning techniques in the innovative and experiential education

This problem is introduced to students who are required to think and analyze critically as the fuel behind all the PBL process. It is followed by another phase in which students are asked to brainstorm cooperatively and to share the previous knowledge base as well as experiences in relation to the problem that is identified. This was an interactive discussion that would help to assess the knowledge base they already possess and generate some preliminary hypotheses or ideas related to the problem. The pyramid has five levels and each of them corresponds to an experiential learning approach. The bottom of the pyramid is experiential learning that is facilitated by hands on and project based learning (PBL). On top of those is technology integration in education with examples of digitally based tools and resources used to improve the learning process. The second level constitutes experiential learning and field trips, whereby the authors emphasised that direct experience beyond the classroom learning is essential. The fourth level portrays PBL, which occupied focus on real world problem solving and critical thinking. And lastly, the flipped classroom model and the gamification in education is on top of the pyramid, and it shows innovative solutions to involving students and encouraging them to participate more actively. The pyramid explains that these three approaches stack on top of each other and in this case hands-on and PBL are the foundational

requirements to which the other techniques are applied. The higher the educator is in the pyramid, the more improved experiential learning techniques he/she can integrate into the learning process and make it more engaging and help students learn it better. This graphic illustration highlights the variety of experiential learning types in existence and how amazing it could turn out to be the teaching experience to students as depicted in Figure 4.

The given practice enables students to master the skills of transferring their observations and descriptions, as well as analyses, into a language form and observe the instructions regarding the form of descriptive classification. Students tend to be uncertain where to start when they are faced with some mysterious specimens. Without the capacity to describe or define the specimen adequately, it becomes difficult to access the answers through the popular internet search engines. The staff of the Grant Museum specifically chooses the specimens that will help the students get some diagnostic materials and familiar specimens on a basic level. At this point students should be able to read an extensive list of literature, such as articles in the journals, citation indexing services on the internet and newer and old works which have been published and provide the original descriptions.

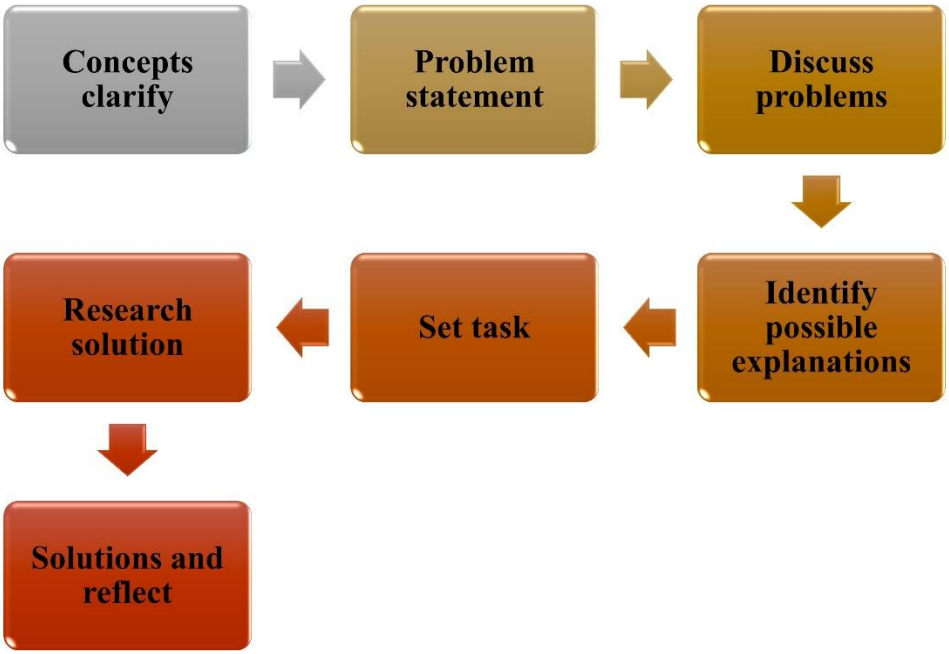

Figure 5: A collaborative problem-based learning (PBL), where the students are supposed to check their current knowledge, is utilized.

Figure 5 shows the systematic approach employed in PBL. Figure 5 shows the various stages involved in the PBL process, emphasizing the crucial elements necessary for promoting effective problem-solving and facilitating learning. The initial stage highlighted in Figure 5 involves the identification of a real-world problem or complex scenario that acts as the foundation for the learning experience.

Table 4: Comparison of PBL, Hands-On and PBL, and OBL Opportunities

Aspect	PBL	Hands-On and PBL	OBL Opportunities
Definition	Presents real-world problems for solving	Engages students in practical activities,	Provides direct experiences with objects
Emphasis	Critical thinking, analysis, and problem-solving	Application of knowledge and skills	Observing, exploring, and interacting with objects
Student Role	Active participant and problem solver	Active participant and project collaborator	Active observer and learner
Learning Outcomes	Problem-solving, decision-making,	Critical thinking, teamwork,	Observation skills, critical thinking,
Contextualization of Knowledge	Application of knowledge in real-world	Application of knowledge in real-world	Making connections between theory and practice
Assessment Methods	Performance on problem-solving tasks	Evaluation of project outcomes	--

Examples	Solving a fictional business challenge	Designing and building a working model	Visiting a museum exhibit or artifact

Table 4 shows three prominent experiential learning approaches in education. PBL, Hands-On and Project-Based Learning, and OBL Opportunities. This comparative analysis highlights the distinct features and learning outcomes associated with each approach, shedding light on their unique contributions to the educational experience. Table 4 shows various aspects of these experiential learning methods, including their definitions, emphasis on critical thinking and problem-solving, student roles, learning outcomes, contextualization of knowledge, assessment methods, and notable examples. By systematically presenting these aspects side by side, educators and researchers are capable of obtaining precious information on what is similar and what is different about these approaches enabling them to make informed decisions about incorporating experiential learning in their instructional practices.

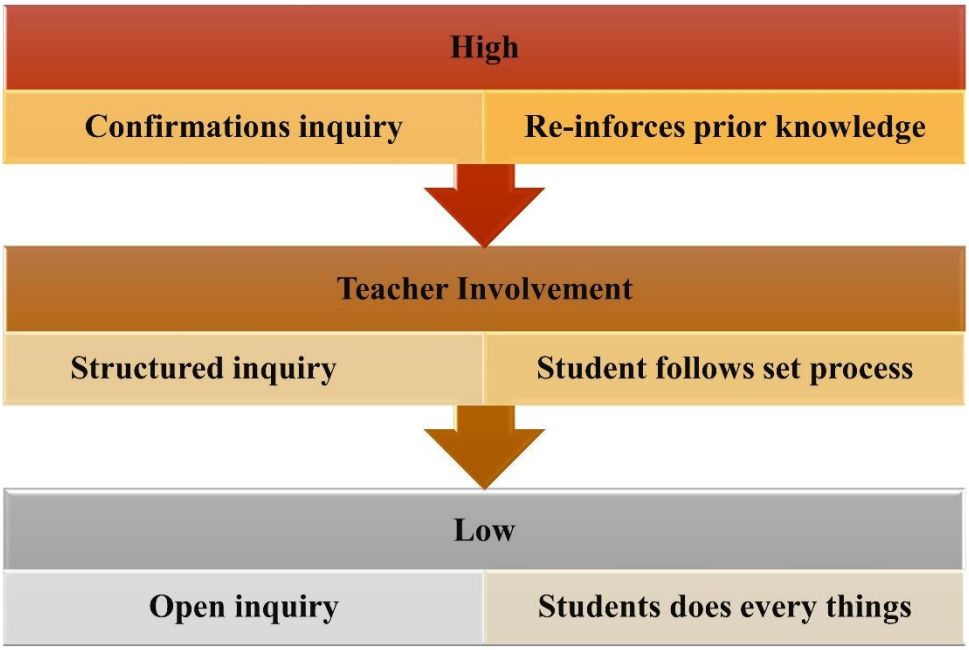

Figure 6: Levels of inquiry-based learning, from Banchi and Bell (2008)

Figure 6 showed from Banchi and Bell's work in 2008, presents a visual representation of the various levels of inquiry-based learning. This framework offers a structured approach to

engage learners in the process of inquiry, fostering their curiosity and developing their critical thinking skills. At the first level of inquiry-based learning, known as confirmation inquiry, students are provided with a question or problem and guided towards finding a predetermined answer or solution. This level primarily focuses on reinforcing existing knowledge and understanding.

As shown earlier, a progressive neural network was formulated to provide change in terms of successful integration of OBL into the curriculum of the UCL (%), improvement in teaching performance of university museums (%), and contribution to the overall learning experience (%) under varying levels of marginalization (%) and lack of clear orientation (%), as outlined in Table 5. The network's performance was evaluated by assessing the reduction rate of successful integration of OBL into the curriculum at UCL, educational performance of university museums, and overall learning experience. Figure 7 displays the predicted results for the reduction rate of successful integration of OBL into UCL's curriculum.

Figure 7 illustrates that an increase in lack of clear orientation has a negligible impact on successful integration, while an increase in marginalization leads to a slight improvement. However, when both parameters are simultaneously increased, it further enhances successful integration.

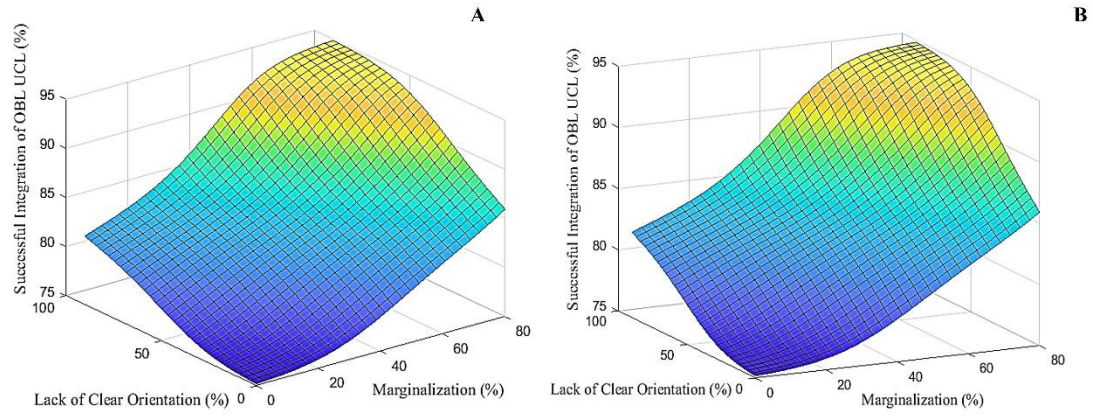

Figure 7: ANN prediction outcomes of the successful incorporation of OBL in the curriculum of UCL

Figure 8 shows the estimated results for the improvement in educational performance of university museums. It shows that an increase in lack of clear orientation decreases

educational performance, as does an increase in marginalization. The lowest values for both parameters correspond to the highest improvement in educational performance.

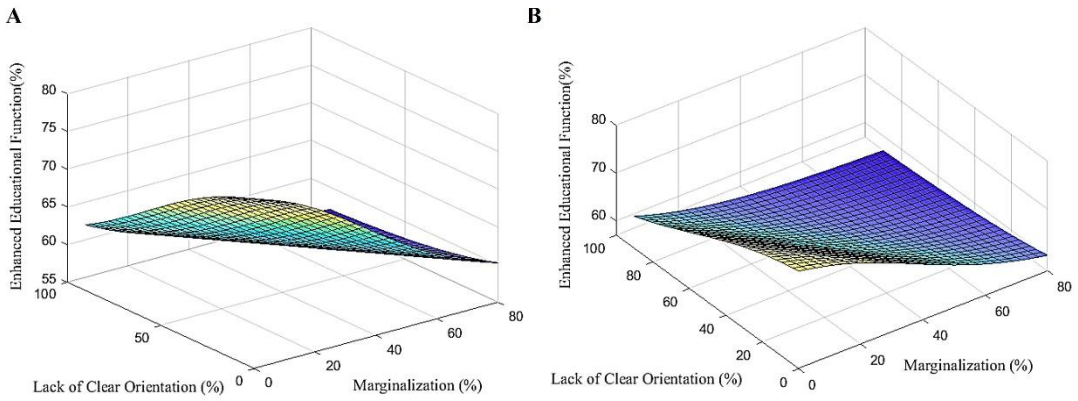

Figure 8: Findings of the ANN with respect to predicting the enhancement educational performance of the museums in the university

Figure 9 presents the estimated results for participation in the overall learning experience. As lack of clear orientation increases, participation decreases. Conversely, an initial decrease in participation occurs with an increase in marginalization, followed by subsequent growth.

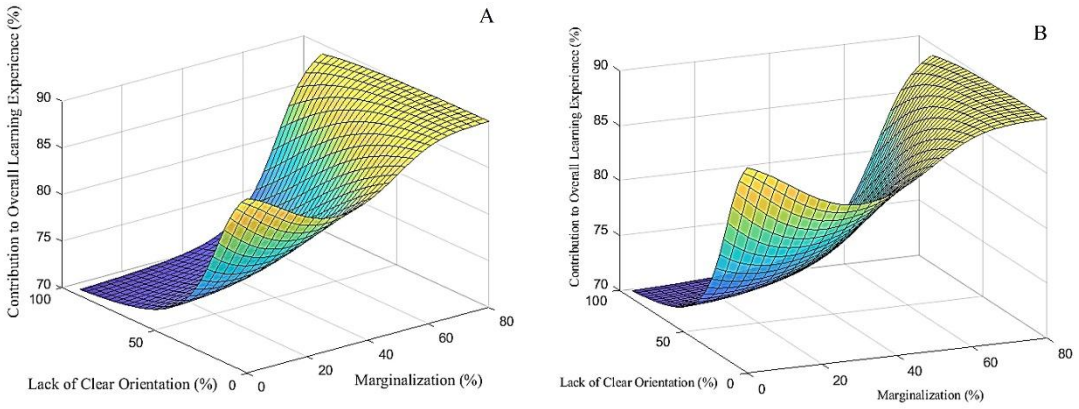

Figure 9: Results of the ANN predicting participation in the overall learning experience

The output of linear regression analysis Figure 10 shows that ANN successfully predicts the integration of OBL into the curriculum at UCL, educational performance improvement in

university museums, and participation in the total learning process with the error rate being less than 1 percent as compared to the targets listed in Table 5.

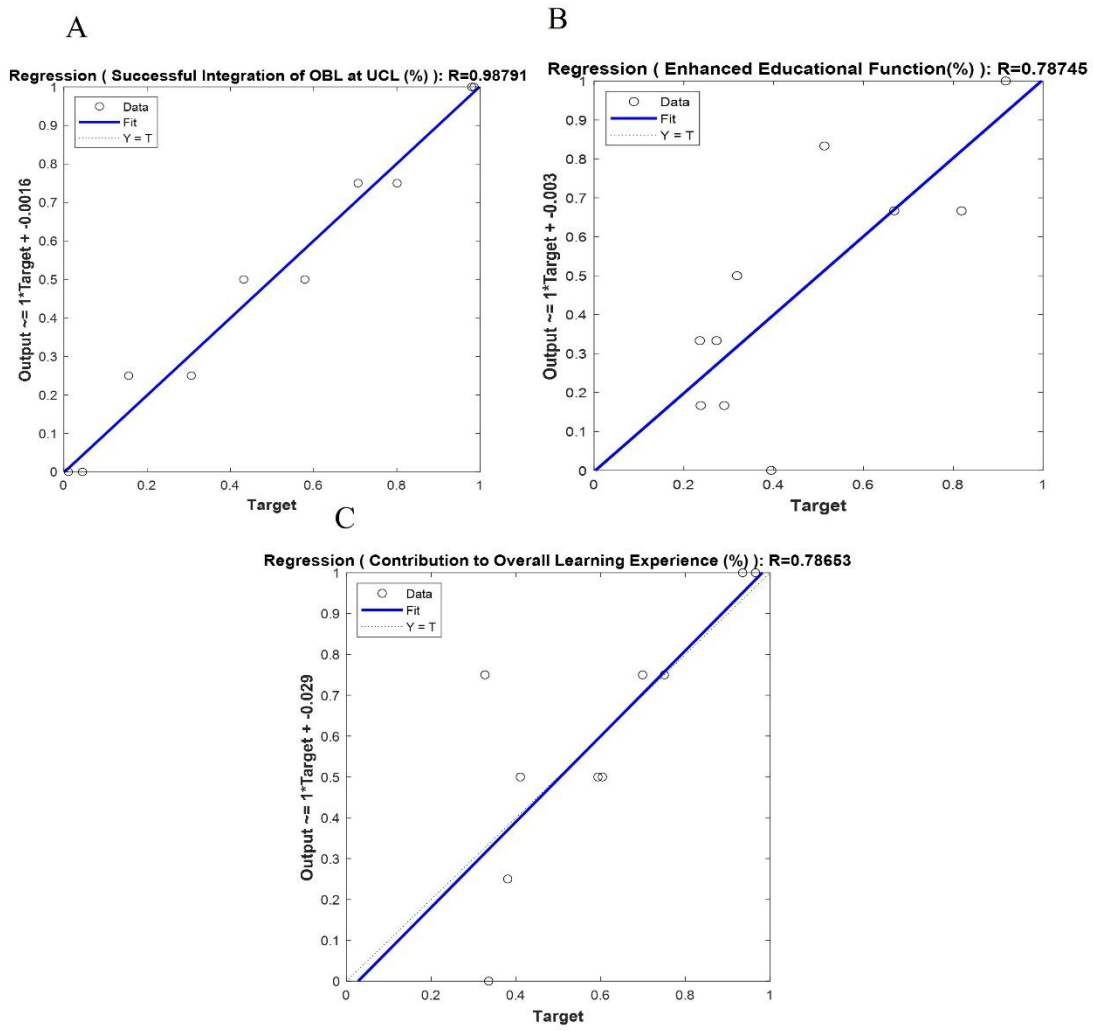

Figure 10: A linear regress analysis of error of ANN in predicting the successful integration of OBL into the curriculum at UCL (%), improvement in teaching performance of university museums (%), and contribution to the overall learning experience (%).

By manipulating the parameters of marginalization and lack of clear orientation, successful integration, educational performance, and contribution to the overall learning experience can be enhanced. Maximum successful integration is achieved when both marginalization and lack of clear orientation are maximized. The highest improvement in educational performance occurs when both parameters are minimized. Participation in the overall

learning experience is maximized when marginalization is at its highest, regardless of the level of lack of clear orientation.

6.5 Master of Arts / Master of science in digital Humanities at UCL

A master program in digital humanities, called Digital Technologies in Art and Cultural Heritage was created at UCL. This program offers a historical perspective on the interplay between technology and art/cultural heritage, challenging students to utilize this knowledge in studying the impact of new technologies on contemporary cultural practices [27]. The students are then asked to think of how this learning may be applicable to culture practices in the digital world. The course is expressly concerned with developments in the following four technical areas reproduction technology, color and light theory, materials/appearance, and illustration/abstraction. It relies on a variety of scientific and philosophical and even political writings. The museums and collections of UCL serve as case studies and learning spaces for comprehending the influence of existing and emerging technologies on heritage practices and the consumption of artistic and material culture [28-31]. The major assignments in the given module are turning OBL into a collaborative project. The goal is to pick an object and use digital reproduction technology to answer some of the so-called realistic curatorial questions in museums (e.g. apply 3D printing to answer the realistic curatorial question regarding addressing the issue of object accessibility to visually impaired visitors). The last student report contains a critical analysis of the methods adopted and solutions taken along with experiential practice and trial and error process. This component carries a weightage of 50% towards the overall module grade. OBL, centered on objects, has proven efficacy in facilitating the acquisition of subject-specific knowledge and transferable skills [28-34].

Over the past few years, there has been a surge in interest regarding the exploration and resolution of various facets concerning education and innovation. Scholars have investigated factors associated with innovation inequality [46], the impact of individuals with multidisciplinary backgrounds on faculty placement and academic advancement [47], the correlation between peer feedback and burnout in online learning environments [48], and the

intricacies of rural special education and its remedial mechanisms [49]. Additionally, investigations have revolved around the identification of effective approaches to harnessing the potential of public online education resource platforms [50], the implementation of virtual reality (VR) to enhance the competence and aptitude of college students [51], and the consequences of utilizing computer-based mind mapping techniques on students' introspection and academic achievements in online courses [52]. More so, researchers have created machine learning-based evaluation models that could evaluate the quality of preschool education [53], vocational education systems that utilize blockchains technology and the Internet of Things (IoTs) [54]. Moreover, in addition to neural network algorithms in measuring the effectiveness of the classroom learning experiences of college students [55]. Additionally, the propagation strategies based on micro-direction aimed at user clustering [56-57] and strengthened versions with the use of long short-term memory (LSTM) techniques to increase the accuracy rate in the text filtering [58] have been investigated.

6.6. Mathematical model for OBL

When mathematically modeling the exploration of the OBL opportunities offered to a university museum in increasing the learning experience of students, we may want to assume the following variables and parameters:

Variables:

- E: Enhanced learning experience
- OBL: Learning opportunity of objects
- U: University Museum
- Parameters:
- S: Students
- T: Time
- R: Resources
- L: Learning outcomes

The mathematical representation may be in the following form:

E = f (OBL, U, S, T, R, L) = f (A)

To investigate the OBL opportunities that a university museum offers so as to improve the learning experiences of students, a mathematical model is suggested. The model will consist of different factors that will affect the improved learning experience, represented by E, which is the targeted outcome. The relationship that the variables and parameters involved express is f (A). Such factors include the availability and quality of OBL opportunities that are created by the university museum, the materials, displays, and learning programs that are present at the museum (U), the involvement, interest and pre-knowledge of the students (S), the length of the learning experience and the amount of time that the students will spend utilizing the museum and objects (T), the access to the materials, tools and support with regards to the object-based learning (R), and the contents and aims of the learning experience, (L). Statistical analyses, regression models, or any other mathematics method can be used in the process to gauge the degree in which the OBL opportunity offered by the university museum is able to improve on the learning experiences of the students using f(x). The model can be further refined according to a given research questions, availability of data and the particular situation within the university museum and among the participating students.

7. Suggestions about ways practitioners could improve application

The key approach to promote the use of OBL in the Chinese university museums in future should be to strengthen cooperation between the museum staff, academic faculty, and students to build interdisciplinary collaboration and develop the learning process. To give focus and direction clear learning outcomes must be set and linked to the rest of the education objectives. By virtue of increased partnerships and acquisitions to expand the collections of museums, the scope of learning opportunities increases Increasing the accessibility by having longer opening hours, online catalogs, and digitization programs makes it inclusive. Training of the educators by conducting workshops and seminars enhances the knowledge and expertise of the teachers in OBL approaches. An all-round learning environment is achieved

by incorporating technology, including virtual reality and online databases. It is necessary to encourage such student research projects, which use museum objects and create evaluation mechanisms to determine their effectiveness. Sharing of knowledge at the conferences and association with other institutions promotes one to learnking with one another. Suing institutional support and recognition is guaranteed funding and resources. Through these suggestions, Chinese university museums are able to make the best of the OBL concept which will enhance the overall educational process of the students and make the work of the University museums in teaching and research quite effective. After an in-depth examination of all the existing sources, it becomes clear that due to the vast number of available algorithms, including artificial intelligence (AI) ones, scholars in various fields of science have actively employed them to considerably improve the way of prediction and optimization [59-60].

8. Limitations and Future Work

Even though OBL can offer a number of benefits in relation to the university museums, there are several limitations and future working directions that need consideration. To begin with, Chinese universities lack in museums experience where there may not be adequate resources, limited access to museum collections, lack of access to diverse collections of artifacts and specimens, etc. To be done in future, the responsibility is to increase the collections of museums and make them accessible. Second, the merging of OBL should have a high institutional base and cooperation among academic departments and the museum personnel due to the necessity to work out structures that would promote radical cooperation, and acknowledge the learning potential of museum materials. Enough funding, employees, and infrastructure must be availed to facilitate the incorporation of OBL in the curriculum. Third, museum workers and teachers should have all required skills and knowledge on object-based instructional techniques in order to succeed when applying OBL. Their pedagogical skills must be trained through specially designed program and also there should be cooperation between the professionals in the museums and the academic faculties. Also, its success as a

system to improve the learning experience of students needs to be put to test and proper modes of its assessment should be established to gauge its influence on the knowledge levels, critical thinking and overall academic performance of the students. The educational potential of OBL can be also supplemented with the technology integration, where virtual and augmented reality, digital databases, and online platforms can be used to provide more individuals with access to museum collection and the ability to learn interactively. The future research can touch upon the question of the inclusion of technology into OBL strategies but increasing the balance to experience both tangible and digital learning. Finally, Chinese university museums can profit through cooperating and sharing knowledge with international universities and museums that have effectively introduced OBL. The challenges can also be opposed by the best practices, experiences and resources shared, and the OBL programs can be fast-forwarded. To sum up, it is possible to say that since the stated limitations can be resolved by broadening resources, increasing institutional support, enhancing teacher preparation, improving evaluation and assessment practice, integrating technology, and introducing collaboration and knowledge sharing, the Chinese university museums will be capable of thoroughly utilizing educational advantages of OBL and effectively incorporating it into their teaching and research processes. The future research, innovation, and knowledge exchange will help the Chinese university museums to continue the development of OBL practices.

9. Conclusion

With a thorough analysis of the multi-level teaching combination project carried out by the UCL Museum Group, the paper has demonstrated how OBL has been effectively incorporated into UCL's curriculum, offering students immersive and captivating educational opportunities. The article's case studies have illustrated the benefits of this strategy, offering insightful information that Chinese university museums may employ to improve their instructional role and better support students' overall educational experiences. University museums distinguish themselves from other types of museums and galleries by acquiring the

oldest, rarest, and most significant objects within the university's collections. These collections are important for the general public and are useful teaching tools. Through the inquiry process, in-person OBL exchanges make it easier to acquire in-depth knowledge and analytical abilities. Thoughtfully designed preparatory and follow-up courses further enhance critical abilities and communication skills. University museums are tasked not only with serving their on-campus students but also with exposing their resources and accomplishments to the academic community and the general public, fostering public understanding. Consequently, exhibition planning and educational project design must meet higher requirements. Two distinct groups, students and the public, are both integral to providing educational opportunities to a broader audience. Engaging students through various object-based academic activities, such as academic conferences, observations, and multi-sensory experiential projects, is a hallmark of UCL. As a research-intensive higher education institution, UCL has embraced the theoretical foundations of OBL in the past few decades. This approach enables students in fields such as arts and humanities, archaeology, and the sciences to engage with project-based learning.

Some projects necessitate interdisciplinary cooperation and coordination, allowing students from different disciplines to freely exchange their perspectives and personal insights during OBL. The cultivation of interdisciplinary talents in Western universities aims to transcend disciplinary boundaries and facilitate multidisciplinary and interdisciplinary education, aligning with the trajectory of scientific development and addressing increasingly complex societal challenges. The aim is to transition from a unidirectional combination state to a bidirectional interactive combination state, thereby enhancing the quality and effectiveness of this interactive approach. Furthermore, additional combination states can be developed as needed to address specific requirements. Currently, China is experiencing a zenith in the advancement of museum endeavors. Considering that UCL Museum serves as a central hub for talent cultivation, its development may hold valuable insights for the progressive growth of domestic university museums.

Data and material availability

The article contains the datasets used to support the study's findings.

Statement of Competing Interests

There are no conflicting interests, according to the authors.

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