IMPLEMENTATION OF XR TECHNOLOGY IN BIODIVERSITY EDUCATION

An Interactive Qualifying Project Report was submitted to the Faculty of Worcester Polytechnic Institute and Chulalongkorn University in partial fulfillment of the requirements for the Degree of Bachelor of Science.

Sponsored by:

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Abstract

This project, sponsored by the Association for the Promotion of Wetlands Sustainable Development and FabCafe Bangkok, addresses the declining biodiversity and youth engagement in the Nong Han Wetlands, located in Sakon Nakhon, Thailand. The goal was to strengthen high school students' awareness and connection to the lake through innovative educational methods. Using Extended Reality (XR) technology and project-based learning, we designed interactive activities to teach biodiversity conservation. Findings indicate that XR technology significantly enhances student engagement and knowledge retention. We recommend integrating XR into school biodiversity education to sustain long-term interest in environmental stewardship among the youth.

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2. **FabCafe Bangkok,** our second sponsor who provided us with the XR technology to implement into the students' curriculum.
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Executive Summary

The Problem

The Nong Han Wetlands are home to the largest natural lake in northeast Thailand (Office of Environmental Policy and Planning, 2002), making it crucial to the people in Sakon Nakhon for its consumption, uses, and business. Additionally, Nong Han is a natural water source that can store rainwater from the surrounding highlands during the rainy season, which reduces flooding and drought and stores carbon. However, in recent years, the local communities living along the Nong Han Lake have adopted lifestyles that have degraded the natural environment (Walailak S, 2016). The combination of releasing untreated wastewater into the lake, throwing garbage into the water, and fishing during the breeding season has created a decline in biodiversity.

Our Goal

Collaborating with President of the Association for the Promotion of Sustainable Development, Mr. Nipon Munmuangsaeng and FabCafe Bangkok, we identified the younger generation as the main population to study. The goal of this project was to instill a passion for the conservation of the Nong Han Wetlands and an awareness of these environmental concerns in local high school students. Through the use of XR technology, we strived to provide a sustainable and long-term educational approach.

Our Plan

To achieve our goal, we defined three key objectives to guide our efforts:

(1) Explore students' and local communities' backgrounds

Our first objective was to explore students' and local communities' backgrounds. We conducted focus groups in the Tha Rae village, a nearby community that heavily relies on Nong Han's resources, as well as government officials, the Department of Agriculture, and Rajabhat University researchers, to gain a better understanding of the wetlands, its biodiversity, and the nearby community.

We collaborated with two schools in the Sakon Nakhon province: the Dan Muang Kham Phitthayakhom School and the Municipal 3 School. Through these collaborations, we conducted focus groups with teachers and gathered initial insights on XR technology through surveys distributed by teachers to their students.

(2) Design & explore an effective and engaging activity to educate students

The first activity, XR Wildlife Matching, involved students observing 3D images of animals and plants from Nong Han Lake through the XR application Styly and then matching them with the correct descriptions of each animal and plant. The purpose of this activity was to

encourage students to learn more about biodiversity and identify the species of the Nong Han Wetlands.

The second activity, Conservation Posters, focused on creating posters that proposed solutions for addressing various challenges in the Nong Han Wetlands, aiming to inspire students to reflect on how they can contribute to conservation. Students expressed their creativity and knowledge from the XR Species activity on the posters. These posters were then put into a virtual gallery for the students and teachers to view through the XR technology. Finally, the teachers distributed surveys to the students so they could share their opinions and provide suggestions on our team's activities.

(3) Evaluating students' knowledge of the lake and efficiency of XR technology with feedback surveys and observations from their work

To analyze the success of our activities, teachers distributed a post-activity survey to their students. This survey was meant to gauge the effectiveness of our activities by comparing responses to similar questions in the pre-activity surveys. We needed to answer the main questions to realize our objective: (1) What are students' views of Nong Han Wetlands before and after experiencing our activity? (2) How likely will the students participate in conservation efforts after our activity? (3) How effective was the use of XR technology for education? Additionally we looked at the final presentations of the posters, and observed that the students added in species from the XR technology activity, giving evidence that the information presented via XR technology was memorable.

Findings & Recommendations

Through the results of the implementation of our XR Wildlife Matching and the Poster Conservation activities, we curated these conclusions as follows:

1. **The use of XR technology enhances students' learning.**
   Based on the teacher interviews and student responses on the post-survey, the majority supported and were intrigued by the XR Wildlife Matching and Conservation Posters activities.
2. **Background knowledge does affect students' activity performance.**
   The success rate of the XR Wildlife Matching Activity of both schools was different, possibly due to the differences in both school curriculums about Nong Han Lake conservation. At the Dan Muang Kham Phitthayakhom School, where there was no prior education about the lake, the responses to the effectiveness and amount learned were greater than those of the Municipal 3 school, where they already had education about the wetlands in their curriculum.
3. **XR technology and hands-on learning can be further developed into a biodiversity curriculum.**
   Our activities can be a sustainable and long-term option to use as an alternative to the traditional learning style. When questioned about a future with these

activities and XR technology in their curriculum, teachers were supportive and interested in responding with, "(The activities) should be held yearly to help conserve the condition of Nong Han Lake in terms of reducing the problems of garbage and fishing (Janthakorn)."

4. **Motivation is an important factor in promoting student engagement, and it can be stimulated through competition and regularly re-engaging the students' focus.** Both intrinsic and extrinsic motivation play a crucial role in increasing students' interest and engagement during learning activities. To enhance interaction, our team incorporates competitions as a motivation tool, whether there are tangible rewards such as a certificate or a symbolic reward like receiving praise from the public or the pride of creating the best poster.

Recommendation for Teachers

1. **Reduce group size for activities**
   Based on observations during the activities and existing research, our team concluded that smaller groups are more effective in encouraging student participation.
2. **Set limitations on electronic device usage during activities**
   Unrestricted use of smartphones and other electronic devices may distract students and reduce learning efficiency. Therefore, appropriate measures should be implemented to regulate their usage.

Recommendation for The Association for the Promotion of Sustainable Development

1. Conducting activities at schools to promote conservation activities yearly can help students continue to think about and participate in the conservation of Nong Han.
2. Inviting experts from the Department of Fisheries and the Department of Agriculture to give lectures will help students gain a better understanding and awareness of Nong Han Lake conservation.

Conclusion

The results of the activities conducted at both Municipal 3 School and Dan Muang Kham Phitthayakhom School, in collaboration with the Association for the Promotion of Sustainable Development and FabCafe Bangkok, aimed to develop interactive XR experiences that strengthen students' connection with Nong Han. Our findings highlighted the crucial role of youth and schools in future environmental conservation. We made recommendations for both teachers and The Association for the Promotion of Sustainable Development to support the continued implementation of the project and enhance the role of schools in fostering environmental awareness about Nong Han among students

Abstract บทคัดย่อ

โครงการนี้ได้รับการสนับสนุนจากสมาคมส่งเสริมการพัฒนาพื้นที่ชุ่มน้ำอย่างยั่งยืนและ FabCafe Bangkok โดยมีเป้าหมายเพื่อแก้ไขปัญหาความหลากหลายทางชีวภาพที่ลดลงและการมีส่วนร่วมของเยาวชนที่ลดน้อยลงในพื้นที่ชุ่มน้ำหนองหาร จังหวัดสกลนคร ประเทศไทย วัตถุประสงค์ของโครงการคือการเสริมสร้างความตระหนักรู้และความเชื่อมโยงของนักเรียนมัธยมศึกษากับหนองหาร ผ่านวิธีการศึกษาที่เป็นนวัตกรรมใหม่ โดยใช้เทคโนโลยี Extended Reality (XR) ร่วมกับการเรียนรู้แบบโครงการ เราได้ออกแบบกิจกรรมเชิงโต้ตอบเพื่อส่งเสริมการอนุรักษ์ความหลากหลายทางชีวภาพ ผลการศึกษาแสดงให้เห็นว่าเทคโนโลยี XR ช่วยเพิ่มความสนใจและการจดจำความรู้ของนักเรียนได้อย่างมีนัยสำคัญ ทางคณะวิจัยจึงเสนอแนะให้บูรณาการเทคโนโลยี XR เข้ากับหลักสูตรด้านความหลากหลายทางชีวภาพของโรงเรียน เพื่อส่งเสริมความสนใจในระยะยาวเกี่ยวกับการอนุรักษ์สิ่งแวดล้อมในกลุ่มเยาวชน

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Executive Summary (บทสรุปโครงงาน)

ปัญหา

พื้นที่ชุ่มน้ำหนองหารเป็นที่ตั้งของทะเลสาบธรรมชาติที่ใหญ่ที่สุดในภาคตะวันออกเฉียงเหนือของประเทศไทย (สำนักงานนโยบายและแผนสิ่งแวดล้อม, 2545) ซึ่งมีความสำคัญอย่างยิ่งต่อประชาชนในจังหวัดสกลนคร ทั้งในด้านการบริโภค การใช้ประโยชน์ และการดำเนินธุรกิจ นอกจากนี้ หนองหารยังเป็นแหล่งน้ำธรรมชาติที่สามารถกักเก็บน้ำฝนจากพื้นที่สูงโดยรอบในช่วงฤดูฝน ซึ่งช่วยลดปัญหาน้ำท่วมและภัยแล้ง รวมถึงเป็นแหล่งกักเก็บคาร์บอน อย่างไรก็ตาม ในช่วงไม่กี่ปีที่ผ่านมา ชุมชนท้องถิ่นที่อาศัยอยู่ริมหนองหารมีรูปแบบการดำรงชีวิตที่ส่งผลกระทบต่อสิ่งแวดล้อม (Walailak S, 2016) การปล่อยน้ำเสียที่ไม่ได้รับการบำบัดลงสู่ทะเลสาบ การทิ้งขยะลงน้ำ และการทำการประมงในช่วงฤดูวางไข่ ส่งผลให้ความหลากหลายทางชีวภาพลดลง

เป้าหมายของโครงการ

ทางคณะวิจัยได้ร่วมมือกับนายนิพนธ์ มูลเมืองแสง ประธานสมาคมส่งเสริมการพัฒนาที่ยั่งยืน และ FabCafe Bangkok โดยระบุว่ากลุ่มเยาวชนเป็นประชากรหลักที่ควรศึกษา เป้าหมายของโครงการนี้คือการปลูกฝังจิตสำนึกในการอนุรักษ์พื้นที่ชุ่มน้ำหนองหารและสร้างความตระหนักรู้เกี่ยวกับปัญหาสิ่งแวดล้อมให้กับนักเรียนระดับมัธยมศึกษาตอนปลายในพื้นที่ ด้วยการใช้เทคโนโลยี XR เพื่อเป็นแนวทางการเรียนรู้ที่ยั่งยืนและต่อเนื่อง

แผนการดำเนินงาน

ทางคณะวิจัยได้กำหนดวัตถุประสงค์หลัก 3 ประการเพื่อเป็นแนวทางในการดำเนินงาน ดังนี้

(1) ศึกษาภูมิหลังของนักเรียนและชุมชนท้องถิ่น

ทางคณะวิจัยจัดทำกลุ่มสนทนาในหมู่บ้านท่าแร่ ซึ่งเป็นชุมชนใกล้เคียงที่พึ่งพาทรัพยากรจากหนองหารอย่างมาก รวมถึงร่วมพูดคุยกับเจ้าหน้าที่รัฐ กรมวิชาการเกษตร และนักวิจัยจากมหาวิทยาลัยราชภัฏสกลนคร เพื่อให้เข้าใจเกี่ยวกับพื้นที่ชุ่มน้ำ ความหลากหลายทางชีวภาพ และวิถีชีวิตของชุมชนโดยรอบ

ทางคณะวิจัยได้ร่วมมือกับโรงเรียนสองแห่งในจังหวัดสกลนคร ได้แก่ โรงเรียนด่านม่วงคำพิทยาคม และโรงเรียนเทศบาล 3 โดยทำกลุ่มสนทนากับครูและแจกแบบสอบถามให้นักเรียนผ่านครู เพื่อเก็บข้อมูลเกี่ยวกับความคิดเห็นและความเข้าใจเบื้องต้นเกี่ยวกับเทคโนโลยี XR

(2) ออกแบบและพัฒนากิจกรรมการเรียนรู้ที่มีประสิทธิภาพและน่าสนใจสำหรับนักเรียน

กิจกรรมแรก “XR Wildlife Matching” นักเรียนได้สังเกตภาพสามมิติของสัตว์และพืชจากหนองหารผ่านแอปพลิเคชัน XR “Styly” และจับคู่กับคำอธิบายที่ถูกต้องของสิ่งมีชีวิตแต่ละชนิด วัตถุประสงค์ของกิจกรรมนี้คือการส่งเสริมให้นักเรียนเรียนรู้เกี่ยวกับความหลากหลายทางชีวภาพของหนองหาร

กิจกรรมที่สอง “โปสเตอร์อนุรักษ์” นักเรียนได้สร้างโปสเตอร์นำเสนอแนวทางแก้ไขปัญหาต่าง ๆ ที่เกิดขึ้นในพื้นที่ชุ่มน้ำหนองหาร เพื่อกระตุ้นให้เกิดการคิดวิเคราะห์และการมีส่วนร่วมในการอนุรักษ์ นักเรียนสามารถนำความรู้ที่ได้จากกิจกรรม XR มาใช้ในการออกแบบโปสเตอร์ จากนั้นโปสเตอร์เหล่านี้ถูกนำไปจัดแสดงในแกลเลอรีเสมือนจริงเพื่อให้นักเรียนและครูสามารถรับชมผ่านเทคโนโลยี XR หลังจากจบกิจกรรม ครูได้แจกแบบสอบถามให้นักเรียนเพื่อรวบรวมความคิดเห็นและข้อเสนอแนะเกี่ยวกับกิจกรรมของเรา

(3) ประเมินความรู้ของนักเรียนเกี่ยวกับหนองหารและประสิทธิภาพของเทคโนโลยี XR ผ่านแบบสอบถามและการสังเกตผลงานของนักเรียน

เพื่อวิเคราะห์ผลลัพธ์ของกิจกรรม ครูได้แจกแบบสอบถามหลังทำกิจกรรมเพื่อเปรียบเทียบความคิดเห็นของนักเรียนก่อนและหลังเข้าร่วมกิจกรรม คำถามหลักที่เราต้องการคำตอบ ได้แก่ (1) ทัศนคติของนักเรียนที่มีต่อหนองหารก่อนและหลังเข้าร่วมกิจกรรมเป็นอย่างไร? (2) นักเรียนมีแนวโน้มจะเข้าร่วมกิจกรรมอนุรักษ์มากขึ้นหรือไม่? (3) เทคโนโลยี XR มีประสิทธิภาพต่อการเรียนรู้หรือไม่? นอกจากนี้ เรายังพิจารณาจากผลงานโปสเตอร์ของนักเรียน ซึ่งพบว่านักเรียนได้เพิ่มข้อมูลเกี่ยวกับสิ่งมีชีวิตจากกิจกรรม XR ลงในโปสเตอร์ของตนเอง แสดงให้เห็นว่าข้อมูลที่นำเสนอผ่านเทคโนโลยี XR สามารถช่วยเสริมความจำได้

ผลการศึกษาและข้อเสนอแนะ

1. การใช้เทคโนโลยี XR ช่วยเสริมการเรียนรู้ของนักเรียน

จากการสัมภาษณ์ครูและการตอบแบบสอบถามหลังทำกิจกรรม พบว่านักเรียนส่วนใหญ่ให้การสนับสนุนและสนใจในกิจกรรม XR Wildlife Matching และโปสเตอร์อนุรักษ์

2. ความรู้พื้นฐานมีผลต่อประสิทธิภาพของกิจกรรม

พบว่าอัตราความสำเร็จของกิจกรรม XR Wildlife Matching แตกต่างกันระหว่างสองโรงเรียน อาจเกิดจากหลักสูตรที่แตกต่างกันเกี่ยวกับการอนุรักษ์หนองหาร โดยที่โรงเรียนด่านม่วงคำพิทยาคม ซึ่งไม่มีหลักสูตรเกี่ยวกับหนองหารมาก่อน นักเรียนมีการตอบสนองด้านการเรียนรู้สูงกว่าโรงเรียนเทศบาล 3 ซึ่งมีการสอนเกี่ยวกับหนองหารอยู่แล้ว

3. เทคโนโลยี XR และการเรียนรู้แบบลงมือปฏิบัติสามารถพัฒนาเป็นหลักสูตรด้านความหลากหลายทางชีวภาพได้

กิจกรรมของเราสามารถเป็นทางเลือกที่ยั่งยืนและระยะยาวสำหรับการเรียนรู้แบบดั้งเดิม โดยครูให้การตอบรับว่า “(กิจกรรมเหล่านี้) ควรจัดขึ้นทุกปีเพื่อช่วยอนุรักษ์หนองหาร ทั้งในด้านการลดปัญหาขยะและการทำประมง” (จันทกร)

4. แรงจูงใจเป็นปัจจัยสำคัญที่ช่วยกระตุ้นการมีส่วนร่วมของนักเรียน

ทั้งแรงจูงใจภายในและภายนอกมีบทบาทสำคัญในการเพิ่มความสนใจและการมีส่วนร่วมของนักเรียนในกิจกรรมการเรียนรู้ ทีมงานของเราใช้การแข่งขันเป็นเครื่องมือกระตุ้นแรงจูงใจ ไม่ว่าจะเป็นรางวัลที่จับต้องได้ เช่น ใบประกาศนียบัตร หรือรางวัลเชิงสัญลักษณ์ เช่น การได้รับคำชมจากสาธารณะ หรือความภาคภูมิใจในการสร้างโปสเตอร์ที่ดีที่สุด

ข้อเสนอแนะนำสำหรับครู

1. **ลดขนาดกลุ่มในการทำกิจกรรม** เพื่อเพิ่มการมีส่วนร่วมของนักเรียน

2. **กำหนดขอบเขตการใช้โทรศัพท์มือถือและอุปกรณ์อิเล็กทรอนิกส์ระหว่างกิจกรรม** เพื่อลดสิ่งรบกวน

ข้อเสนอแนะสำหรับสมาคมส่งเสริมการพัฒนาที่ยั่งยืน

1. จัดกิจกรรมอนุรักษ์ในโรงเรียนเป็นประจำทุกปี เพื่อให้นักเรียนยังคงให้ความสนใจกับการอนุรักษ์หนองหาร

2. เชิญผู้เชี่ยวชาญจากกรมประมงและกรมวิชาการเกษตรมาให้ความรู้แก่นักเรียน เพื่อเพิ่มความเข้าใจและความตระหนักรู้เกี่ยวกับการอนุรักษ์หนองหาร

สรุป

ผลลัพธ์จากกิจกรรมที่ดำเนินการในโรงเรียนเทศบาล 3 และโรงเรียนด่านม่วงคำพิทยาคม ร่วมกับสมาคมส่งเสริมการพัฒนาที่ยั่งยืน และ FabCafe Bangkok ชี้ให้เห็นว่า เทคโนโลยี XR สามารถช่วยส่งเสริมประสบการณ์การเรียนรู้แบบโต้ตอบที่ช่วยให้นักเรียนมีความเชื่อมโยงกับหนองหารมากขึ้น ผลการศึกษาของเราสะท้อนให้เห็นถึงบทบาทสำคัญของเยาวชนและโรงเรียนในอนาคตของการอนุรักษ์สิ่งแวดล้อม

Authorship

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Title Page	-	Lalita	Lalita
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Authorship	-	Zion	All
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List of Figures & Tables	-	Vittawit	All
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The Booming Biodiversity in the Nong Han Wetlands	2.1.1	Gretchen	Brendan
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Environmental Concerns of the Nong Han Wetlands	2.1.3	Gretchen, Peyton	All
Overview Education in Rural Areas in Thailand	2.2	Zion	All
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1. Introduction

Thailand is known as one of the most biodiverse countries in the world, but when it comes to its current efforts to maintain this, there is plenty of room for improvement. The Convention of Biological Diversity, which is a treaty signed by over 150 countries devoted to the protection and conservation of the Earth's biological diversity, states that "'Biological diversity' means the variability among living organisms, inter alia, terrestrial, marine, and all other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and ecosystems" (Gaston, et al., 2004). Many elements contribute to biodiversity, namely ecological, genetic, and organismal. Due to the depth of each component, there is no one way to measure biodiversity; there are multiple measurement methods for each element (Gaston et al., 2004).

The Environmental Performance Index (EPI) ranks Thailand 107th globally in their Biodiversity and Habitat issue category (EPI, 2022). This category assesses countries' actions toward retaining natural ecosystems and protecting the full range of biodiversity within their borders. The index highlights the trend of declining biodiversity in the Nong Han Wetlands, which has led to problems such as floods, droughts, an increasing number of indigenous species becoming extinct, degradation of the water quality, as well as other issues that have been at the foreground of conversation (Ngamjan & Chaturabul, 2019). We can alleviate these environmental challenges with a more focused effort on conserving Thailand's biodiversity.

Focusing on the northern province of Sakon Nakhon, the Thai government recognized Nong Han Lake as a wetland of international importance in 2001.

Figure 1
Illustration of Thailand Map with Sakon Nakhon highlighted

The Nong Han Lake is a crucial body of water that supports the surrounding community through industries like fishing, agriculture, and water supply. However, it suffers from numerous issues, such as chemicals in the groundwater seeping into the lake, habitat degradation, pollution, and lack of water regulations. Due to these factors, the lake's biodiversity and the community that depends on it are at risk. Without intervention, the ecological health of Nong Han Lake will continue to deteriorate. The Nong Han Lake is a crucial body of water that supports the surrounding community through industries like fishing, agriculture, and water supply. However, it suffers from numerous issues, such as chemicals in the groundwater seeping into the lake, habitat degradation, pollution, and lack of water regulations.

The Nong Han Wetlands have long been the focus of conservation efforts by the Thai government, NGOs, and local communities. However, despite these initiatives, recent studies and community reports highlighted persistent threats, including habitat degradation, invasive species, and declining biodiversity, exacerbated by a lack of sustained youth engagement. Our project addressed these persistent threats by focusing on one key demographic: high school

students. Through their connections with local Sakon Nakhon high schools, our sponsors believe that the younger generation is essential to ameliorate this situation.

We worked with FabCafe Bangkok and the Association for the Promotion of Wetlands Sustainable Development to address this educational need. Working with Nipon Munmuaengsean, a key figure from the Association for the Promotion of Wetlands Sustainable Development, we developed an effective educational strategy to enhance environmental awareness and stewardship among high school students. Nipon has spearheaded community-driven conservation efforts around Nong Han, and this collaboration sought to integrate local ecological knowledge into actionable learning activities. A critical part of our research involved learning about the current trends in Thai science education. By integrating Thai science education trends with FabCafe's Extended Reality (XR) technology, our project educated and engaged youth in protecting the Nong Han ecosystem. The end goal of this was to create a connection between the younger generation of high school students and the Nong Han Wetlands. This connection between the two has the potential to spread knowledge of the issues mentioned above and have a ripple effect on future generations.

The sponsoring organizations provided us the opportunity to address the root cause of environmental neglect – a lack of awareness and personal responsibility. The project's first objective was to research students' and local communities' backgrounds to understand their educational contexts and identify factors that shape their learning experience. These include the perspectives of students towards the Nong Han Wetlands and the adaptability of advanced technology. By gaining insight into these aspects, we can tailor educational strategies to address students' needs better and enhance their learning outcomes. We used archival research, semi-structured interviews, online surveys, and ethnographies to gather this information.

Throughout our fieldwork, we engaged with students, educators, local community members, relevant local organizations, and government sectors to ensure the sustainability of these efforts. Our second objective was to create engagement activities that deepen students' connection to the lake. These activities encouraged active participation and helped students understand the challenges and importance of preserving Nong Han Lake. Last but not least, evaluating the significance of the Nong Han Wetlands among students using feedback surveys and observations from the students' work played a critical role in measuring the success of this project. We traveled to Sakon Nakhon during our second and fourth weeks working on this project, where we interacted with the community, collected data, and refined our educational approach. Overall, this initiative has the potential to serve as a model for similar community-based environmental education programs across Thailand and beyond.

2. Background

2.1 Nong Han Wetlands

The Nong Han Wetlands are home to the largest natural lake in northeast Thailand, covering approximately 123 square kilometers (Office of Environmental Policy and Planning, 2002). This expansive freshwater ecosystem supports diverse animals and plants (Ngamsnae, 2011). The lake's surrounding areas are characterized by lush greenery, providing an essential habitat for various plant species. These plants play a vital role in maintaining the lake's ecological balance by stabilizing the shoreline and providing a habitat for wildlife (Ngamsnae, 2011).

Insights from our sponsors and archival research reveal a troubling decline in youth engagement with the lake's conservation, reinforcing the urgency of our educational efforts. This lack of understanding of the lake's biodiversity stems from various factors, including inadequate environmental education, limited exposure to wetland ecosystems, and the perception of wetlands as unproductive or undesirable landscapes.

2.1.1 The Booming Biodiversity in the Nong Han Wetlands

Preserving the biodiversity of the Nong Han Wetlands is crucial for maintaining the ecosystem's functionality and supporting the communities and wildlife that depend on its resources. The lake provides essential services, such as clean water, food, and a habitat for countless species. Many environmental problems stem from a need for more government regulation and enforcement. According to the 57th Section of the Kingdom of Thailand Constitution B.E. 2560 (2017), "The state shall conserve, protect, maintain, restore, manage and use or arrange for utilization of natural resources, environment, and biodiversity in a balanced and sustainable manner, provided that the relevant local people and local community shall be allowed to participate in and obtain the benefit from such undertaking as provided by law." In Thailand's environmental law, power tends to be concentrated at a federal level. According to the Enhancement and Conservation of National Environmental Quality Act, B.E 2535, a board makes the country's most significant decisions. However, there have been several reported cases where the government and state agencies have not taken the proper measures to enforce environmental protection. One example of this is unchecked developmental projects (Xinhua, 2005). Biodiversity needs active efforts to maintain; without enforced laws and protections, biodiversity cannot be sustained.

The threats to Thailand's biodiversity vary depending on the ecosystem. Urbanization near forest ecosystems has resulted in the loss of indigenous plant and animal species. The coastal ecosystems are continuously affected by illegal logging, overfishing, community settlement, industrialization, and tourism development, with little being done to prevent this

(CBD, n.d.). Rubbish, pollution, boat anchors, and the collection of seashells and ornamental fish threaten ecosystems that have become popular tourist destinations (CBD, n.d.). The government has unchecked developmental projects in Sakon Nakhon, leading to ecological devastation at the Nong Han Wetlands (Xinhua News Agency, 2005). Biodiversity in any ecosystem is vital to sustaining as poor biodiversity can lead to the emergence of infectious diseases and cause health defects (Clark et al., 2014).

Figure 2

Photo of Egret and scenery at the Nong Han Wetlands: Photo Credit Gretchen Ames

2.1.2 Ecological systems

The Nong Han Wetlands are a vital hub for aquatic and terrestrial ecosystems, fostering a rich diversity of life. Within its waters, the lake supports numerous fish, amphibians, and invertebrates that thrive in its nutrient-filled environment. (Ghimire, 2021) Aquatic plants such as water lilies and submerged vegetation provide essential habitats for these species, serving as breeding grounds and protective shelters (Watersheds & Watersheds, 2024). These interconnected species create a balanced and resilient aquatic ecosystem. The lush vegetation surrounding the lake provides terrestrial wildlife food and shelter. This dynamic interface between water and land allows diverse plant and animal species to flourish, making the lake an ecological hotspot. Its connection to the Mekong River creates a flowing network that further enhances the vitality of the surrounding environment (Ghimire, 2021).

Figure 3

Aerial view of Sakon Nakhon flood from 2017 (posttoday, 2017)

The ecological systems of the Nong Han Wetlands are a lifeline for the region, providing essential services that benefit both the environment and the people who rely on its resources. From maintaining biodiversity to filtering water and preventing floods, the lake and its wetlands play an indispensable role in sustaining life (Wetlands International, 2025). Preserving these systems is critical for ensuring that the lake continues to thrive as a natural resource and a symbol of the region's environmental richness for future generations.

The wetlands are critical in sustaining the ecosystem's health. These wetlands act as nature's filtration system, capturing sediments, nutrients, and pollutants from surface runoff before they reach the main body of the lake (United States Office of Water et al., 2001). The plants and soil in the wetlands naturally absorb and break down these contaminants, improving water quality and contributing to the well-being of aquatic species. Beyond filtration, the wetlands are crucial for flood prevention (Ramsar Convention Secretariat, 2021). Acting like giant sponges, they absorb excess rainfall and surface water, slowing water flow and reducing the risk of downstream flooding. This natural process protects local communities from flood damage and prevents soil erosion, ensuring the surrounding landscapes remain stable and fertile (Tinker's Creek Watershed Partners, n.d.).

The ecological systems of the Nong Han Wetlands offer a lifeline for the region, providing essential services that benefit both the environment and the people who rely on its resources. From maintaining biodiversity to filtering water and preventing floods, the wetlands play an indispensable role in sustaining life (Wetlands International, 2025). Preserving these

systems is critical for ensuring that the wetlands continue to thrive as a natural resource and a symbol of the region's environmental richness for future generations.

2.1.3 Environmental Concerns of the Nong Han Wetlands

Being such a large body of water, Nong Han is home to many different species of flora and fauna. At least 53 species of fish, around 156 species of birds (Ghimire, 2021), and 31 species of aquatic plants (Rayan et al., 2021) call the Nong Han Wetlands home. However, the wetlands aren't just a home for wildlife; it is a source of livelihood for countless people in Sakon Nakhon. Tourism thrives around Nong Han, with its natural beauty and ecological diversity attracting visitors for activities like boating, birdwatching, and cultural exploration. These activities generate employment in the hospitality and craft industries, further boosting the local economy (Ghimire, 2021)**.** On top of this, Nong Han supports industries like fishing and agriculture. Two of Nong Han Lakes's most common fish species, the Golden Little Barb and the Beardless Barb, are sold in the ornamental fish market (Rayan et al., 2021). Nong Han also acts as the primary source of water for more than 240,000 people in the area surrounding the lake (Supakosol & Boonrawd, 2019). However, the connection between biodiversity and livelihoods is deeply interwoven; any lake ecosystem degradation threatens fish stocks, agricultural productivity, and tourist appeal, directly affecting household incomes. Efforts to conserve and sustainably manage the lake are essential to preserve its ecological balance and ensure the region's long-term prosperity.

In Nong Han's current state, it is clear that work needs to be done to address its numerous problems. In 2019, a large-scale focus group with stakeholders from different villages in Sakon Nakhon identified 11 issues currently putting the health of the Nong Han ecosystem and the well-being of the people of Sakon Nakhon at stake. The problems identified were water quality degradation, reduction and extinction of indigenous fish species, flooding, and drought (Chaturabul et al., 2019).

Traditional fishing practices remain a cornerstone of life for many communities, although environmental challenges, such as declining fish populations due to upstream developments, have impacted yields. Among the prominent causes are overfishing and migration restriction via artificial dams (Phongkaew et al., 2014). One example of a fish species affected by human behavior is the Whisker Sheatfish. The Whisker Sheatfish is a rare catfish whose meat is popular among Sakon Nakhon locals. Overfishing caused by high demand and restrictions on fish migration has resulted in a population 9 - 29 times smaller than the estimated historical populations (Phongkaew et al., 2014). Numerous other fish species have been struggling as well. Dams along the Mekong River have also decreased the populations of migratory fish species altogether by 50% (Ghimire, n.d.).

Figure 4

Photo of Water Hyacinth Credit Peyton Moriarty

Issues like flooding and drought are connected to climate change. The rising temperatures due to climate change increase the energy in the water cycle, evaporating more water and causing more rain, leading to greater severity of weather-related problems such as droughts and flooding (Supakosol & Boonrawd, 2019). Increased rain will also cause more runoff to flow into the wetlands. This runoff into the wetlands adds more pollutants from herbicides and pesticides to the water, meaning all sorts of problems. These pollutants travel up the food chain causing health problems for the whole ecosystem, including humans (Mushtaq et al., 2023). When water has high levels of nutrients due to runoff, it causes algal blooms, which can block sunlight from getting to aquatic plants, then reducing the amount of oxygen the plants add to the water, effectively suffocating aerobic aquatic organisms (Mushtaq et al., 2023).

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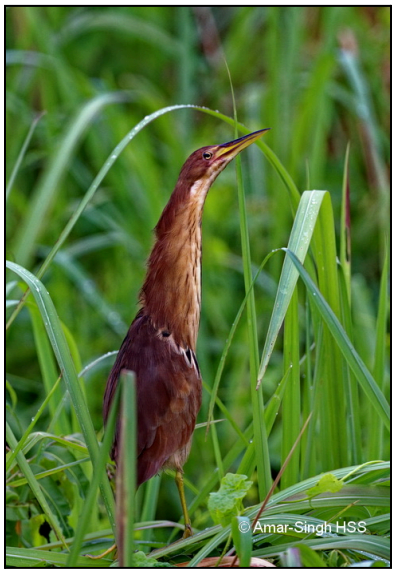
getting to aquatic plants, then reducing the amount of oxygen the plants add to the water, effectively suffocating aerobic aquatic organisms (Mushtaq et al., 2023).

A study done in 2003 showed that the Nong Han Wetlands already had high levels of ammonia-N and phosphate in its water during the wet season (Settacharnwit et al., 2003). Both chemicals are natural to aquatic ecosystems; however, fertilizer runoff can raise concentrations. High levels of phosphorus lead to increased algae growth, which is dangerous to aquatic life (US EPA, 2013). Excess ammonia is directly toxic to marine life and can lead to a buildup in internal tissues and blood, possibly leading to death (US EPA, 2015). Experts predict that the average rain and runoff will continue rising from 2021 to 2050 (Supakosol & Boonrawd, 2019), meaning current issues will likely worsen unless addressed.

The World Wildlife Fund (WWF) has been working to make the Nong Han Wetlands a Ramsar site (Srijaroen, 2018). Ramsar sites are wetlands on the List of Wetlands of International Importance (Centre, n.d.). According to the Ramsar Fact Sheet 6, The Ramsar Convention, otherwise known as the Convention of Wetlands of National Importance, is a global treaty promoting the conservation of wetlands. This national and international recognition would give the Nong Han Lake further ecological protection.

Figure 5

Photo of Cinnamon Bittern (Cinnamon Bittern – Bare Parts & Plumage - Bird Ecology Study Group, 2019)



2.2 Overview Education in Rural Areas in Thailand

Education systems in rural and urban areas can differ vastly depending on location, particularly when comparing rural and urban areas. According to the Programme for International Student Assessment (PISA) Thailand research, rural students are 63 points lower in science in the Thai school system than urban students or the equivalent of two years of learning difference. In Organisation for Economic Co-operation and Development (OECD) countries, rural students are 31 points lower in science than urban students or the equivalent of one year of learning difference. Differences in the socioeconomic status of students and schools explain this discrepancy (OECD, 2022). In OECD countries, only 30% of rural students expect to complete at least a university degree, while 50% of urban students do. In Thailand, 50% of rural and 80% of urban students expect to complete at least a university degree. (OECD, 2022).

2.3 Effective Student Teaching Methods

2.3.1 XR Technology Applied in Education

Integrating extended reality (XR) technology into education, specifically virtual reality (VR), offers excellent potential for enhancing learning experiences, particularly for Thai students studying biodiversity. Technological advances have allowed VR classrooms to be designed to simulate a lifelike and genuine classroom setting (Westphal et al., 2024). These realistic environments enable students to engage with learning materials in a way that traditional classrooms cannot replicate. Engaging with an interactive space allows students to immerse themselves in complex ecological systems and visualize biodiversity in ways that textbooks and images cannot achieve.

Figure 6

AR of Black Shark Minnow in "STYLY" application Credit Pattaraporn Chartpumruje

Research highlights several key factors that influence successful adoption and practical usage. Included are perceived ease of use, usefulness, self-efficacy, and overall support from the institution. (Bower et al., 2020). Addressing these factors is essential to ensure the successful implementation of XR technology in schools due to its direct impact on student engagement, teacher adoption, and the overall learning experience.

VR's immersive qualities are often highlighted as a key benefit for teaching biodiversity, as they create vivid, interactive environments that increase student engagement and aid in retaining complex information through experiential learning (McGovern et al., 2020). This is particularly relevant for abstract scientific concepts like biodiversity, where visualization of unseen processes, such as nutrient cycling or predator-prey relationships, is essential for student comprehension. Additionally, "The integration of educational activities which involves learners in the learning process has shown to be a successful teaching method. Students learn by doing things and thinking about what they are doing" (Holly et al., 2021). The experiential nature of VR supports this learning model by placing students in control of their learning experience and encouraging problem-solving, critical thinking, and decision-making skills.

While VR presents significant educational opportunities, practical constraints like device availability, cost, and teacher training pose challenges, especially in rural areas like Sakon Nakhon (Cvetković, 2021). Limited access to head-mounted displays (HMDs) and other necessary VR equipment can make it difficult for underfunded schools to integrate this technology fully in the long term. Furthermore, teachers may require significant training to

incorporate XR effectively into their lessons since many traditional teaching methods do not include hands-on, student-centered learning. However, if we can address these barriers, XR could allow local students to explore biodiversity firsthand, making ecological interactions more accessible and engaging while fostering a deeper understanding and appreciation for local ecosystems. Implementing shared VR resources, mobile VR systems, or dedicated project days where students rotate through VR learning experiences could mitigate some challenges, allowing equal access to these advanced learning tools. As the cost of VR headsets decreases and mobile-based VR systems become more available, large-scale adoption in resource-limited areas becomes more feasible.

AR and VR technologies are commonly used in the XR platform. The first case is about *"The Immersive Antarctic,"* a VR project to bring Antarctic history to life. This case was led by the UK Antarctic Heritage Trust (UKAHT) and uses VR/AR applications, as well as potential 360° video experiences. The project incorporates scientific research focused on data collection and remote collaboration, where they collect data on user interactions and learning outcomes to assess the effectiveness of the XR experience in conveying scientific information and then facilitate cooperation among scientists and researchers working on Antarctic projects, regardless of their physical location. The VR app allows users to explore Antarctica's landscapes, wildlife, and extreme conditions. It raises awareness about the importance of Antarctic conservation and the impacts of climate change on this fragile ecosystem. XR technologies make Antarctica accessible, enhance learning about its science and conservation, and inspire support for protecting its environment. (UK Antarctic Heritage Trust, 2024)

Another case is medical education. This case focuses on a medical education called the "*Anatomy Experience*." Developed by EdAR in collaboration with the University of Edinburgh Medical School, this innovative tool aims to help medical students better understand complex anatomical structures, such as the pelvis. The AR experience integrates interactive 3D-printed models and mobile-based AR visualizations to teach the orientation and positioning of X-rays in relation to anatomy. The tool provides students with an immersive and hands-on learning experience for remote and in-person education. Subject matter experts' (SMEs) feedback informed its instructional content and functionality during its development, ensuring relevance and effectiveness. Pilot testing with students and trainers during a workshop yielded highly positive feedback, with participants noting improved comprehension of pelvic anatomy and suggestions to expand the tool to other anatomical areas. Despite challenges like mobile screen size limitations and the logistics of shipping 3D models, the study concluded that AR, combined with physical models, offers a valuable alternative to traditional learning resources, enriching the educational process and enhancing understanding in medical education (Korre & Sherlock, 2023).

Figure 7

Photo of medical students and EdAR members trying out the Anatomy Experience (Korre & Sherlock, 2023)

2.3.2 Project Based Learning

Project-based learning is a method of education centered around the student and provides students with an independent way of gaining knowledge through a hands-on approach (Ralph, K., 2020). Building the curriculum around the student rather than the faculty makes them take responsibility for their learning by tackling real, tangible problems through open-ended projects. This form of active learning in higher education leads students to develop key skills and abilities—collaboration, communication, problem-solving, confidence, leadership, and more—that will prove invaluable professionally and personally (WPI, 2025).

Learning is achieved by presenting a series of tasks and combining independent work with collaborative work to create a presentation and final solution. There should be a structured thinking pattern to make the project and lead to the creation of an innovative solution. A teacher would provide guidance and feedback on the presentation to give back and have revisions done to create a better version of their work. Project-based learning offers a mixture of hands-on experiences and independent thinking to provide different motivations for learning and allow students to transfer their knowledge to real-world problems and skills such as interviews and how to speak confidently.

Dr. Wobbe, the director of the Center of Project Based Learning at WPI, stated, "(PBL) is a more inclusive way of teaching that gives students with other kinds of skills and ability, an opportunity to shine, making it memorable." Project-based Learning contextualizes what you are learning and creates confidence that something meaningful can come from this work for people

who wouldn’t get the same experience as traditional learning. Studies done on the successes of project-based learning mention that students enjoy this method of education and get more out of the activities being taught.

Project-based learning has its downsides, one being it is a more complex teaching method. Only some teachers understand all the ins and outs of PBL and the scientific method, and project-based learning can only be successful if the teacher is well-trained and has prior experience. It is common for some content to be lost when using this method because it may get lost when working in groups. Most of the negatives to PBL disappear if the teacher is well prepared and provides a comprehensive class for the students. Dr. Wobbe also mentions another downside to Project-Based Learning: "Students who have been successful with standard learning can find PBL challenging because they don't do as well and may feel like they’re not learning as much.” This needs to be thought about to mitigate certain students' resistance and unhappiness with the new way of learning.

In an IQP report titled “Project Based Learning for Middle School Students IQP: Wetland Disruptions,” they found that through an education strategy focusing on wetlands conservation through project-based learning, students were excited to come to class and learn about wetlands (Ralph, K et al. 2020). In a project-based learning survey analysis conducted by Hanover Research and WPI, 95% of respondents reported that their project experience prepared them for their current career, with 82% reporting a better understanding of the connections between technology and society (WPI, 2025)

Working in a lower-income area of Sakon Nakhon, it is essential to mention that project-based learning can be done with very little funding; Dr. Wobbe backed this up with the quote, “The support students need is more of a limitation than having the most up to date tech,” referring to the number of teachers and faculty available to guide the students on the right path.

Through hands-on learning, students can push emotion into a topic, which helps them understand and thus care about an academic topic more than they would with a regular independent-based classroom. Prior experience and research suggest that working in a PBL-based classroom benefits the students both in school and in their future outside of the classroom.

2.3.3 Experiential Learning

Field trips as an educational method offer significant benefits through increased engagement and improved understanding of complex topics like biodiversity. These immersive experiences provide a break from the traditional classroom, allowing students to engage with real-world phenomena in a way that lectures and textbooks cannot. Experiential learning allows students to interact directly with nature, which has enhanced long-term information retention and increased enthusiasm for the subject (Rijal et al., 2018). Field trips provide opportunities for

sensory engagement, like observing wildlife behavior or touching plants and soil, creating memorable learning moments that contribute to a deeper conceptual understanding.

This hands-on engagement is particularly valuable in poorer communities where students have limited exposure or knowledge of diverse ecosystems. Field trips promote positive environmental attitudes by helping connect students with less “charismatic” species, fostering empathy and appreciation for all biodiversity. For example, a study involving interaction with snakes demonstrated that students’ attitudes shifted positively toward conserving snakes due to their hands-on experience (Ballouard et al., 2012). These trips also foster collaboration, with students working in groups to share observations and discuss findings, thus building social and communication skills around a shared environmental goal (Rijal et al., 2018). The social aspect of field trips can be particularly impactful, as peer-to-peer interactions promote collective problem-solving and reflection, which are essential components of environmental literacy.

However, field trips also present challenges, especially in regions with limited resources. High costs associated with transportation, entry fees, and necessary equipment can make field trips prohibitive for low-budget schools. In such cases, educators may need to rely on low-cost alternatives like local nature walks, which still offer opportunities for place-based learning. At the same time, logistical issues such as managing large groups or ensuring student safety add further complications (Rijal et al., 2018). These logistical demands require significant planning and staff support, which can be difficult in under-resourced areas with limited access to safe, well-maintained natural spaces.

Additionally, an overemphasis on popular species risks reinforcing a narrow view of biodiversity, which can diminish students’ understanding of ecosystem interdependence (Ballouard et al., 2012). This issue emphasizes the importance of designing field trip curricula that emphasize ecosystem relationships and lesser-known species' roles. Field trips may also lack accessibility for students with mobility or health constraints, particularly challenging in areas without resources to accommodate diverse needs (Eriksson et al., 2023).

In a previous project that was examined, a group of conservation professionals guided the school’s students through various educational methods, such as field trips, songs, and hands-on activities. By the end, surveys concluded that there was a positive correlation between an interest in the conservation of the wetland and hands-on learning and education in the field (Zarate et al., 2018). This example illustrates the cumulative effect of using multiple experiential methods to reinforce conservation messages, showing that field trips can amplify student engagement and environmental stewardship

3. Methodology

Our project aimed to foster student connection and passion for the conservation of Nong Han Wetlands. We created three main objectives to meet this project goal:

(1) Explore students' and local communities' backgrounds

(2) Design and explore an effective and engaging activity to educate students

(3) Evaluating students' knowledge of the lake and efficiency of XR technology with feedback surveys and observations from their work

This chapter describes our research methods to achieve these objectives, including archival research, semi-structured interviews, surveys, focus groups, and ethnographies. Combining these approaches, we aimed to gather numerical data and different perspectives through surveys and technology integration for high school students, mainly focusing on biodiversity awareness and Extended Reality (XR) technology. In this study, we employ a qualitative multi-method research design to explore our research objectives comprehensively. By integrating multiple qualitative methods, we aim to achieve triangulation, thereby enhancing the robustness and credibility of our findings. This approach allows us to delve deeply into the nuances of our case, providing rich, contextualized insights that may not be readily captured through a single method.

3.1) Objective 1: Explore Students' and Local Communities' Backgrounds

We aimed to understand the relationships between the local community and the lake. Knowing how individuals value the lake and how younger generations view its importance provided relevant data that shaped the direction of our project.

Using scheduled focus groups and interviews with community members and local leaders, we gained an understanding of their perspectives on the lake and its significance. This also gave us great insight into their passions and experiences regarding preserving the wetland's biodiversity. This approach allowed for deeper insights into traditional practices, cultural heritage, and the challenges faced by the community.

We created a survey to learn more about students' experience with XR technology, device accessibility, and their daily lives related to Nong Han Lake. We sent the post-survey to Dan Muang Kham Phitthayakhom School teachers to forward to students and received 62 responses. We conducted the same process with Municipal 3 schools and received 60 responses. By understanding students' backgrounds, we designed effective activities that were appropriate for our students.

Students:

While on-site in Sakon Nakhon, we distributed surveys to teachers, who then sent them to students and we received over 150 responses. The surveys were scale-based to measure initial knowledge levels about Nong Han wetlands and encourage students to reflect on their daily behaviors affecting wetlands, with questions such as rating their feelings towards the lake and their interactions with it. Other questions regarding their education around the wetland and preferred learning methods were used to determine what works and what doesn't with the current education. Responses like "always, "often," "once in a while," or "never" help analyze students' perspectives and habits. **(Appendix A)**

Local community:

We identified two local groups to interview within the local communities: residents living around Nong Han Lake and those who rely on wetland resources, such as fishermen and farmers. Through focus groups with the community and interviews with public officials led by Prasop - Head of the Tha Rae village, we learned of the regulations in place, native species that require protection, and current conservation efforts. This approach highlighted the importance of community involvement and the impacts of the wetland on daily life in the hope of trickling down to the younger generations. Local people in the community were interviewed about their use of Nong Han Lake in both agriculture and business terms. We interviewed locals, city leaders, organizations, and wildlife researchers at Rajabhat University. Here, we learned which species were important to focus on and ones that have the most significant impact on the community. Using scheduled focus groups and interviews with the community members and local leaders gave us an understanding of their perspectives on the lake and its significance. It also gave great insight into their passions and experiences towards preserving the wetland's biodiversity. This approach allowed for deeper insights into traditional practices, cultural heritage, and the challenges faced by the community.

3.2) Objective 2: Design and explore an effective and engaging activity to educate students

We researched Nong Han flora and fauna, identified ecologically significant species, recognized endangered species requiring immediate conservation efforts, and examined human activities that threaten the wetland ecosystems. This information was gathered using three research methods: archival research, semi-structured interviews, and focus groups. We sourced relevant data for archival research from The Nong Han Ecological Database created by the Nong Han Center, Research and Development Institute, and Sakon Nakhon Rajabhat University, which provided information about Nong Han wetlands and the ecosystem around Nong Han. We conducted focus groups with locals and researchers and interviews with government officials to gather information about the species and environmental concerns to focus on.

3.2.1) Investigating Potential Scenarios for XR Tools

We explored potential uses for the XR tools by looking into the activities FabCafe has hosted and the information from their Facebook. The “Endangered Species Lab” workshop provided participants with hands-on experience creating Augmented reality (AR) content using the STYLY application. This workshop inspired us to apply these XR tools to raise awareness of endangered species, potentially demonstrating how technology can bridge the gap between education and environmental conservation.

When observing students' adaptations to new technologies, it is essential to understand how these tools are integrated into classrooms. Focus groups with teachers helped us identify key technologies they use regularly, such as interactive whiteboards, educational apps, or online learning platforms utilized in the classrooms. Questions such as, “What are the key technologies you currently use in the classroom?”, “How have you seen technology impact students' engagement and learning outcomes?” “What challenges do you face when integrating new technologies into your teaching methods?” These questions gave us key insights into the current science curriculum and which technology is used most often.

XR technology enhances learning adaptability and provides a more interactive environmental education. A specific question-based approach (e.g., “What is your preferred method of learning?”) helped assess students’ learning styles (e.g., hands-on or lecture-based). To prepare students for XR tools, gaining initial opinions during the development phase of our methods was crucial to predict the effectiveness of XR technology. Introducing examples of XR technology during the early stages ensured students developed foundational technical skills before fully engaging with XR technology. The student’s initial enthusiasm and passion for the technology gave us the confidence to continue the development of XR technology in the classroom.

3.2.2) Creating a Reward System

According to Wong & Thomson's (2014) research, our archival research suggests that incentives and rewards significantly enhance students’ motivation and participation in educational activities. They provide extrinsic and intrinsic motivation (external rewards) (internal drive to learn). Public acknowledgment, such as certificates or verbal praise, can represent the value of student hard work and contribution. This validation makes students feel seen, appreciated, and proud of their accomplishments (Wong & Thomson, 2014). During the conclusion of our activity, students will receive a participation certificate. For the students who create the best poster, we will give them Chulalongkorn jerseys and custom-made Nong Han Lake stickers.

3.2.3) Designing our activities

We named the first activity XR Wildlife Matching. This activity aimed to give students an immersive experience, learning about critical species in the Nong Han Wetlands. XR Wildlife Matching strongly incorporated XR technology by using 3D models that we made of some of Nong Han's most noteworthy species of plants and animals. We selected the plants and animals we made into 3D models for different reasons, some because of their iconic status among locals and others because they were endangered or invasive. The directions for conducting this activity were: first, we broke students up into groups; next, we gave each group a guide containing wildlife descriptions for all of the previously chosen XR animals; then we set up QR codes around the room, each corresponding to a different XR animal model; finally, we instructed the students to match the wildlife descriptions to the correct XR animal model. We originally planned to give the students 40 minutes to match 11 descriptions and XR animal models.

We named the second activity Conservation Posters. This activity aimed to get students to think creatively about ways to conserve Nong Han's biodiversity after XR learning. This activity was created as a follow-up to the first activity, building off concepts introduced in the first activity and placing a more supplementary role on XR technology. We planned to conduct a short break after the first activity so the students could recharge and be ready to pay attention again. Assuming the students are still in groups, the directions are: first, a short introduction to Nong Han's issues affecting biodiversity; next, we hand out posters and art supplies so the students can create posters demonstrating their ideas to solve Nong Han's issues; after all of the groups finish their posters, we scanned all of their posters into STYLY, and created a virtual gallery for everybody to walk through, allowing easy viewing of every group's posters to all students. We initially allotted 40 minutes to the students to create their posters.

3.2.4) Modifying Our Activities

After we visited the first school, the Dan Muang Kham Phitthayakhom School, we found that there were some improvements we could make to the structure of our activities. The changes we made were in response to student feedback gathered through observation. One change we made between the first and second schools was the difficulty of the XR Wildlife Matching 2 activity. The Dan Muang Kham Phitthayakhom School students had trouble completing the first activity in the 40 minutes assigned initially. We hypothesized that this was because we made the activity too difficult. Initially, we had 14 XR models and 12 species names to assign to the models, meaning 2 XR models didn't correlate to a name on the wildlife guide. For the second school, we removed these extra XR models.

Another change we made for the second school was the time allotted to the Conservation Posters activity. The original 40 minutes we gave the first school was not enough. Although the students were working very hard, after 40 minutes, many of the groups did not finish their

posters. Some students asked us for more time, but this was at the end of our 3-hour time slot with them. For the second school, we decided to make room for the students to have an hour to work on the posters by doing a shorter introduction.

3.3) Objective 3 Evaluating students' knowledge of the lake and efficiency of XR technology with feedback surveys and observations from their work

Using information gathered from our focus groups at the communities, conversations with our sponsors, and interviews with government officials, we created two activities incorporating XR technology with project-based learning. After piloting them at both high schools, we needed to answer the following questions to achieve this objective: (1) What are students' views of Nong Han Wetlands before and after experiencing our activity? (2) How likely are the students to participate in conservation efforts after our activity? (3) How effective was the use of XR technology for education? We collected responses for improving our activities through our experiences at the schools, observations, and feedback surveys.

The strengths of surveys are establishing general views or opinions, rapid scaling and distribution, a large number of observations, and easily quantifiable data (Berg & Lune, 2017). One hundred fifty high school students from two different Sakon Nakhon High Schools responded to scale-based questions to measure changes in their attitudes toward the importance of Nong Han Wetlands. These responses were collected through a post-survey distributed to the students by the teacher in the form of a QR code shortly after the conclusion of the activity created in objective (2). These survey questions were closely related to the pre-survey questions used to evaluate knowledge for objective (1). Due to their similarity, we could compare students' answers from before and after the activity to gauge our activity's effectiveness.

After reviewing the students' posters from the Conservation Poster activity, it was evident that the XR Matching activity increased knowledge about the different species of the Nong Han Wetlands. The posters displayed drawings of the Pink Water Lilies and the different species of fish that were in the XR activity. The students were able to draw species based on what they saw in the XR from memory. This proves that the XR technology and visualization of species had positive retention results.

3.4) Challenges and Limitations

Some limitations to these methods were ensuring we ask meaningful questions that elicit an answer, answer quality, and how representative the sample is of the population (Berg & Lune, 2017). To guarantee that we wrote meaningful questions, we gave the teachers test surveys to send out during our first trip to Sakon Nakhon. Answer quality is an issue that depends a lot on the student's willingness to write what they think. We limited this issue by creating engaging, easy-to-read, and concise questions. Finally, we needed to ensure that our sample represents the

entire population of Sakon Nakhon high school students. We minimized this by performing the activity in two schools, decreasing the bias by increasing the population size.

Some further difficulties we experienced with our research design came from the extensive range of ages of the students who participated in our activity. Students' grade levels spanned from 10 to 12. With such a broad range of ages, additional factors may contribute to how a student responds to the activity. We would change the activity to be catered to one age group, potentially to the grade that responds the most positively to the activity.

We also faced challenges while researching the backgrounds of students and locals, along with their relationship with the wetland. One main concern is observer bias and our lack of expertise in collecting data in a foreign environment. To mitigate cultural misunderstandings, we remained observant and critically aware of subtle interactions and followed structured observation protocols to standardize our data collection. To combat our lack of experience, we recorded as much data as possible and compared observations with each other to prevent any oversights that we may recognize later. Additionally, we ensured enough flexibility in our standard observation methods to adapt to on-the-ground realities.

4. Findings

The results from our research and implementation of XR in biodiversity education lead to the curation of four findings. Each relating to the current and future possibilities of XR technology in biodiversity education.

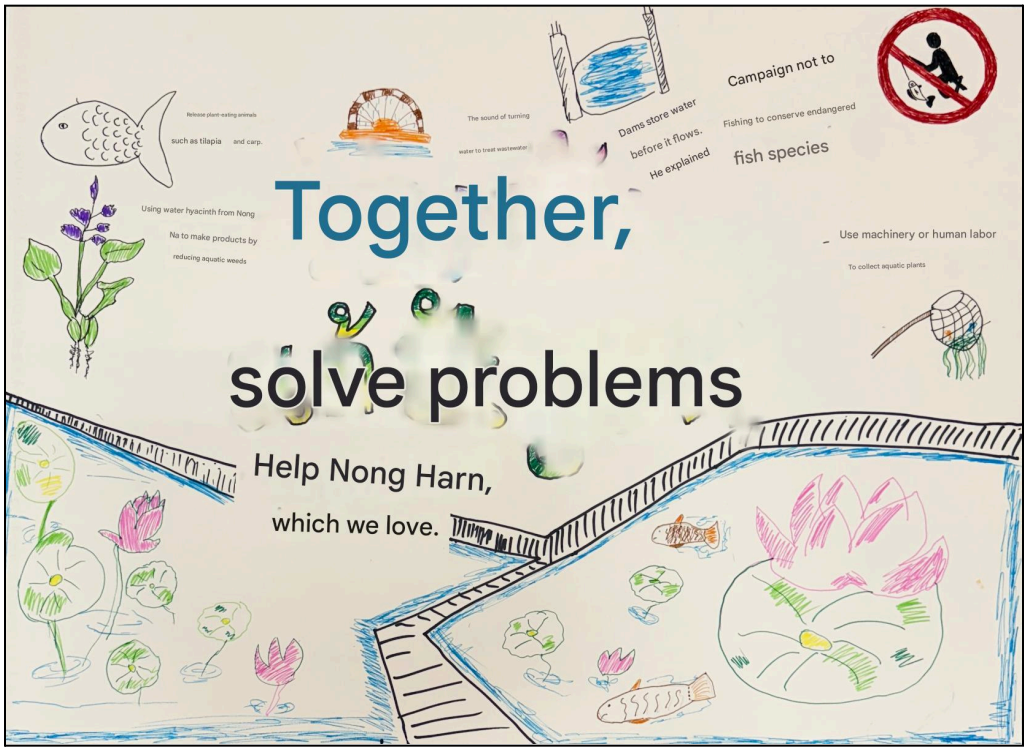
4.1) Finding 1: XR technology enhances student learning.

The integration of XR technology has shown promising results in enhancing student learning. Ms. Janthakorn, a biology teacher from the Dan Muang Kham Phitthayakhom School, said, “Any XR helps enhance students' learning a lot, attracts attention, is new and exciting, and (student) wants to learn more. Students can see real images, and it is interesting to learn.” Teacher support and enthusiasm towards implementing XR into their curriculum is vital as they will guide the students. According to research, teachers can leverage this interest in XR technology through enhanced visualization, developing empathy, and increasing information retention (Bower et al., 2020). Additionally, of the 103 student responses to the post-activity survey distributed by the teachers, 95% of students responded that they gained a lot of knowledge about Nong Han. These responses suggested that our activities had a positive impact on the students’ understanding of the wetland.

While reviewing the posters created by the students during the Conservation Posters activity, we observed they could remember many of the species they saw during the XR Wildlife Matching activity and whether they are beneficial or harming the ecosystem. For example, one of the species in the XR activity was the water hyacinth, and many students drew this plant on their poster. Knowing that the water hyacinth is invasive, students devised ways to remove it from the ecosystem and create a product of it. Figure 8 is an example of a poster made by student group 2 of Dan Muang Kham Phittayakhom School. This visualization of what they learned suggests that students could use the knowledge they learned in the previous activity to improve their poster’s design and content. The student's ability to recall the species they learned about over an hour before and their impact on the wetland is noteworthy. It shows the efficacy of XR technology in learning.

Figure 8

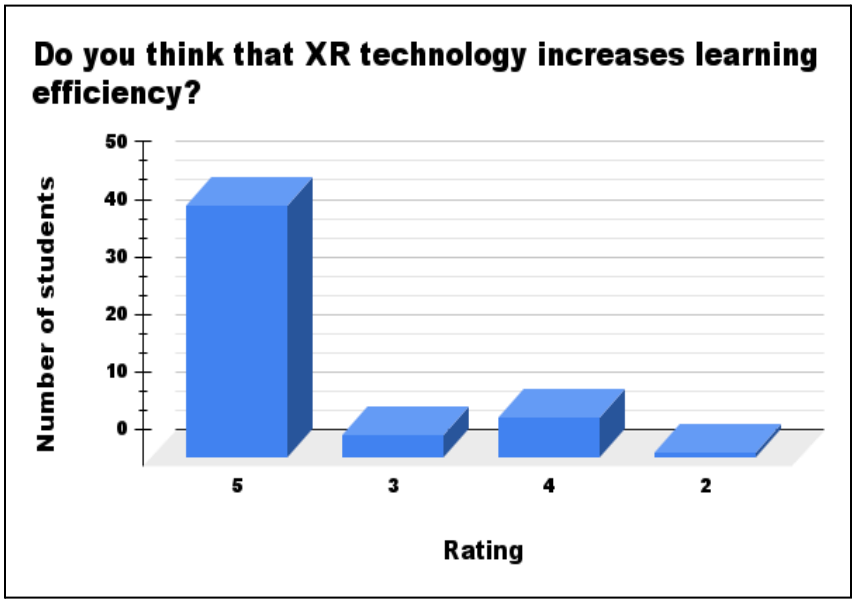
Photo of a translated poster created by group 2 from Dan Muang Kham Phittayakhom school



From the 103 student responses to the post-activity survey distributed to the students by the teachers, 95% of students responded that they gained a lot of knowledge about Nong Han. These responses suggested that our activities had a positive impact on the students' understanding of the wetland. At the Municipal 3 school specifically, we observed that during the XR technology activity, students were engaged and motivated by using XR technology. The data from a post-survey conducted by the teachers, shown in Table 1, backs up this claim by showing that more than 78% of students' responses say that XR technology increases learning efficiency. Research supports this idea that XR technology has potential to enhance students' education. The experiential nature of XR technology as well as its ability to display interactive environments capable of increasing student engagement are just a few of its strengths that can be used to enhance student learning (McGovern et al., 2020).

Table 1

Bar chart showing students' responses on a scale of 1-5, 5 being the most efficient.



Through open ended survey questions, we were given positive feedback about how students felt about the activities. Some responses included “activities were easy to understand,” “I like learning in new and modern ways,”and “enjoyed 3D pictures.” Quotes like these suggest that the students felt that XR technology enhanced their learning experience.

The advantages of XR technology in learning are noteworthy. It provides a more engaging alternative to traditional classroom learning that helps students recall information. It is no surprise both teachers and students are enthusiastic about the use of XR in the classroom. We believe this technology can promote learning through its immersiveness and interactivity.

4.2) Finding 2: Previous knowledge of the wetlands impacts the effectiveness of our activities

The combination of XR technology and the poster activity lead to a positive growth of knowledge about the Nong Han Lake at both schools. However, the success rate varied between the two schools, possibly due to previous curriculum differences surrounding the Nong Han Lake. We learned about each school’s previous curriculum through our interviews with the teachers. At the Dan Muang Kham Phitthayakhom School, where the curriculum did not include education about the Nong Han Lake, we asked students, "How much more knowledge do have about Nong Han than before?” Out of 45 responses, 95% of students said they gained much knowledge about it in the post-survey. Conversely, the students' responses reflect less being learned at the Municipal 3 school, where their current curriculum does include education around the Nong Han Lake. Data from the Municipal 3 School shows that out of 56 student responses,

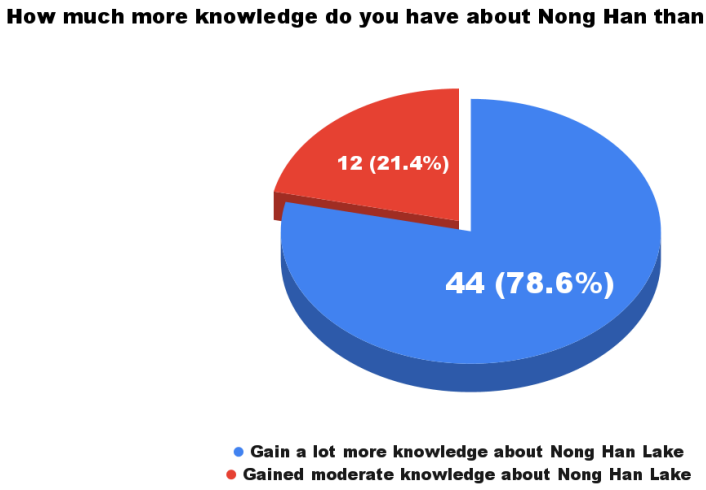
78% gained much knowledge, with the rest saying that their learning was moderate. This means students from the first school were 17% more likely to reply that they gained much knowledge than the second school.

Table 2

Pie chart showing Dan Muang Kham Phitthayakhom School Students' responses to "How much more knowledge do you have about Nong Han than before?"

Table 3

Pie Chart showing Municipal 3 School student responses to the question, "How much more knowledge do you have about Nong Han than before?"



The information we collected suggests that the students at Municipal 3 learned less from our activities than the Dan Muang Kham Phitthayakhom School students. This could be explained by a greater background knowledge of the lake, due to more conservation education in their schools curriculum. We know of this difference in conservation education from the teacher

interviews. If there were species or topics that the students already knew they could not report that they learned more from activity done with them.

Another possible reason for that the Municipal 3 School students may have learned less comes from responses from the pre-survey. One question we asked during the pre survey was have you ever participated in any activities that help preserve Nong Han? 68.7% of participants from the Municipal 3 school reported having participated in activities that help preserve Nong Han, while only 14.8% of participants from the Dan Muang Kham Phitthayakhom School reported the same. This difference in conservation background suggests that students from the Municipal 3 school have more conservation knowledge, meaning they already knew some of what we tried to teach them with our activities.

Table 4

Pie Chart with Dan Muang Kham Phitthayakhom School student responses to the question, "Have you ever participated in any activities that help preserve Nong Han?"

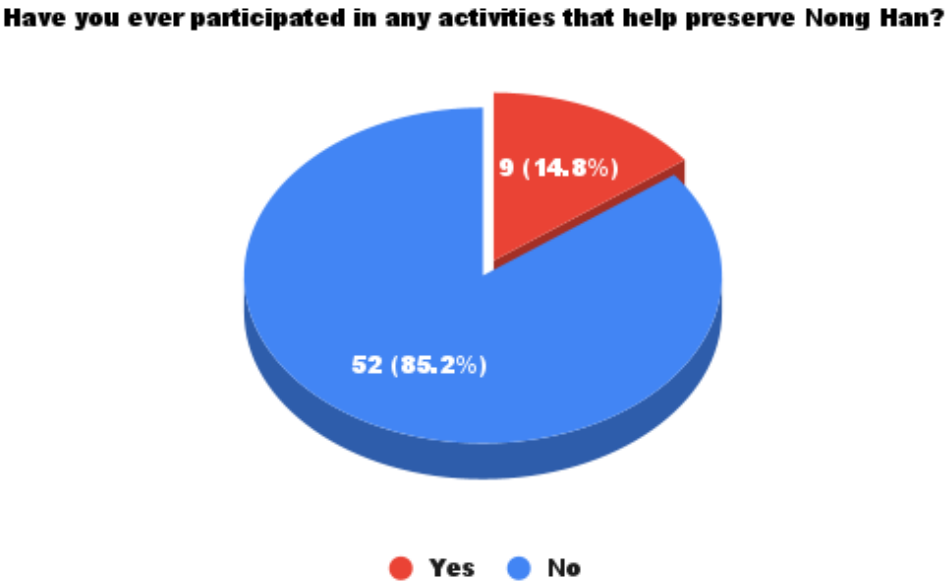
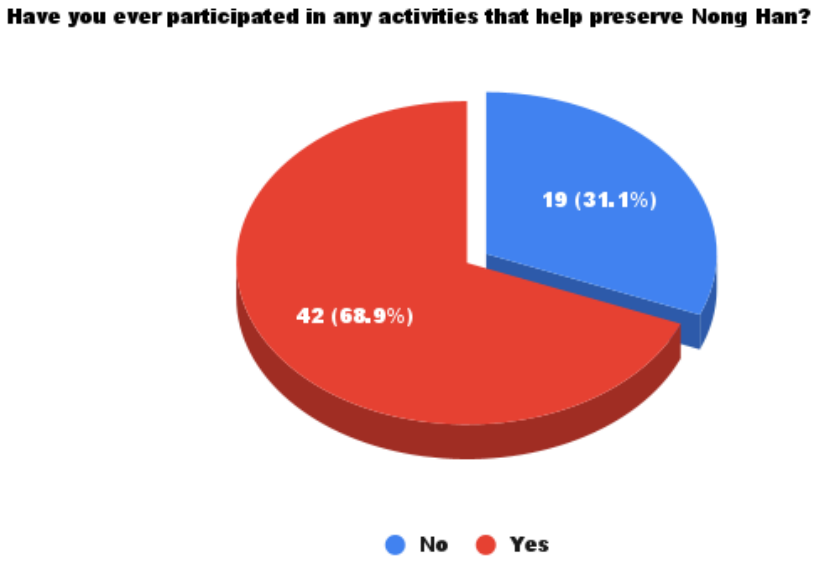


Table 5

Pie Chart with Municipal 3 School student responses to the question, "Have you ever participated in any activities that help preserve Nong Han?"



4.3) Finding 3: XR Technology & Project Based Learning can be further developed into schools' biodiversity curriculum

XR technology can be a long-term and impactful tool used in biodiversity education by providing students with immersive learning experiences that increase student engagement and understanding. Traditional biodiversity education often includes field trips that involve transportation and lectures, which have few opportunities for interaction. XR technology offers an alternative by simulating real-world ecosystems and enabling interactive learning more effectively than lecture-based teaching without the need for travel.

Janthakorn, a biology teacher at Dan Muang Kham Phitthayakhom School, supports using XR tools in their education. When asked, "Do you think an activity like this should be done every year to promote the conservation of Nong Han?" Ms. Janthakorn responded, "It should be held yearly to help conserve the condition of Nong Han Lake in terms of reducing the problems of garbage and fishing." This suggests that Ms. Janthakorn supports the idea of an XR activity like this being incorporated into their future curriculum and the positive impacts the activity can have on the environment. Research supports Janthakorn by highlighting the benefits of active learning in classrooms. A study on the effects of active learning in science, engineering, and mathematics classes shows that students in traditional lecture courses are 1.5 times more likely to fail the class than students in an active learning class (Freeman et al., 2014).

Additionally, during our initial visit to the second school, we tested a sample XR model with a group of 60 students. We found that many of them had a device capable of running the XR software. The availability of these compatible devices combined with other school resources like a computer lab found at the Municipal 3 school suggests that it is feasible to incorporate XR technology in the long term.

Through our interviews with teachers, we found that they were confident that using XR technology to teach students about species of animals and biodiversity can be an effective alternative to typical education strategies. It keeps students engaged and actively learning with the content since they can interact with and enjoy the activities visually and not just on paper. In our interview with Mr. Prakong Pilanek, an astronomy teacher from Municipal 3 School said, “Virtual is better than traditional teaching. It stimulates excitement and participation, you may not see the fish in the real area.” This teacher highlights an important point: while field trips to go and see the environment and animals in person might be ideal, sometimes there are unexpected challenges, such as having difficulty finding different species. XR technology allows students to explore environments and species consistently and engagingly, making lessons more reliable, effective, and memorable.

Abeywardena, an IT professional experienced in steering technology initiatives, supports the potential of XR technology as a sustainable and impactful tool in biodiversity education. The Open XR for Education Framework (OXREF) provides a scalable and sustainable approach to integrating XR technologies into educational settings, including AR, VR, and MR. By making use of open educational resources, practices, and free and open-source software, the framework focuses on accessibility, equity, and reusability, overall making XR-based education more sustainable in the long term. Additionally, OXREF addresses key barriers to XR adoption, such as the lack of open content, tools, and skills, while emphasizing the importance of sound pedagogy and instructional design (Abeywardena, 2023). This collaborative approach enables educational institutions and governments to develop effective XR experiences that align with sustainability goals.

In the context of biodiversity education, XR technology allows students to engage with digital representations of ecosystems, species, and conservation challenges in an interactive and immersive manner. Unlike traditional field-based learning, which often requires significant logistical and financial resources, XR provides an alternative that reduces environmental impact while maintaining educational effectiveness. The adaptability of XR also makes it a valuable tool for reaching students in remote areas, ensuring broader access to quality biodiversity education (Abeywardena, 2023).

The potential of XR technology as a sustainable and impactful tool in biodiversity education. This technology can enhance student engagement by leveraging immersive

experiences through XR and provide scalable, adaptable learning opportunities. Integrating open educational resources and open-source platforms further supports its sustainability and accessibility. This finding aligns with broader research on XR in education, emphasizing its role in creating interactive and engaging learning environments. Nevertheless, careful implementation is necessary to address accessibility challenges, ensure meaningful real-world connections, and optimize its long-term educational impact.

4.4) Finding 4: Motivation is crucial for student engagement and can be enhanced through competition and periodically re-engaging students' focus

Incentives, both intrinsic and extrinsic, significantly increased student participation and motivation during the learning activity. To encourage more interaction, we introduced rewards as a motivational tool. These incentives were designed to provide immediate reinforcement for participation and long-term motivation through symbolic rewards. The intended impact was to foster a more dynamic and engaging learning environment, ensuring students remained actively involved throughout the session.

Based on our observations initially, student engagement in answering questions during the presentation was low. However, once they observed a peer receiving a snack as a reward for participating, the number of volunteers increased. Additionally, when we announced the Chula jersey as the prize for the poster competition, students displayed high enthusiasm and dedication, putting considerable effort into decorating their posters and ideas. Each group also came up to the front of the class to present their poster and the ideas they came up with, as shown in the image below. It is possible that a friendly competition between the groups to win the jerseys over each other provided a motivational spark that they wouldn't have gotten otherwise.

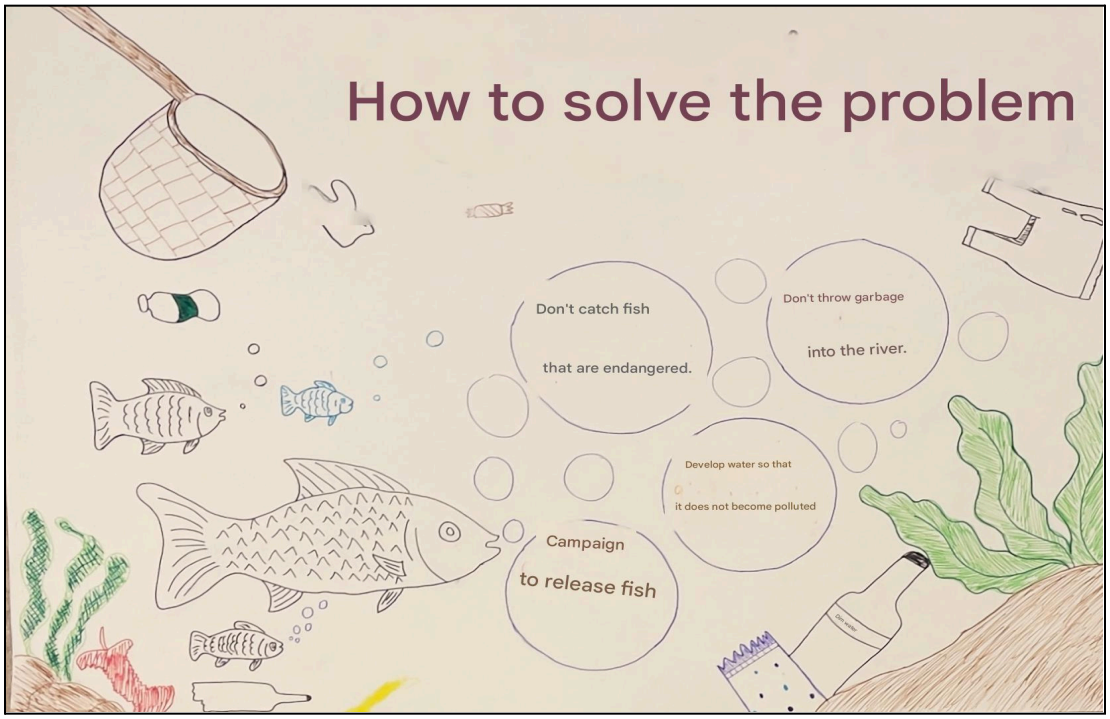
Figure 9

Photograph of Municipal 3 School students presenting their poster in front of the class

Announcing that we were displaying the posters on our booth at the World Wetlands Day Celebration motivated students to put their best work forward. The displayed posters would receive feedback from the public and two votes per person on which posters they thought were the best. This added layer of their posters being judged by the public resulted in the students trying their best to come up with ideas that would resonate with the locals and design a poster they were proud of. Some examples of ideas that were prominent in the highly ranked posters were solutions for the abundance of water hyacinths, promoting policies that conserve endangered species, limiting the usage of water from the lake, and educating the general public. These solutions were supported by the general public, as shown in their feedback. For example, one comment for school 1 group 6's poster below was, "I like the student's reasoning, especially where they wrote about not catching endangered fish during their seasonal fish lay eggs, and the poster is cute." This is one of many examples of the community supporting the ideas presented on the student-made posters and shows the effort the groups put into making the best poster.

Figure 10

Translated poster created by group 6 from Dan Muang Kham Phittayakhom school



Incentives are crucial in encouraging motivation, primarily through extrinsic reinforcement. According to research on extrinsic motivation, tangible rewards such as snacks can serve as immediate motivators, enabling students to participate in activities they might otherwise avoid (Deci et al., 2001). However, if overused, extrinsic rewards can diminish intrinsic motivation by shifting the focus from personal interest to external gain. In this case, using sporadic and meaningful rewards helped sustain engagement without creating dependency on incentives (John et al., 2023). This is why we limited the amount of incentives to not take away from their learning.

The findings suggest that a balance between intrinsic and extrinsic motivation was at play. While some students may have participated initially due to the promise of a reward, others became more engaged once they realized the intrinsic value of the activity, particularly in the poster competition. While the snacks provided immediate gratification and short-term motivation, the Chula jersey and feedback they received from the public served as a status symbol that they made the best poster, fostering a deeper level of investment in the activity. This aligns with studies suggesting that symbolic and achievement-based rewards can be more effective in sustaining motivation over time than material incentives (Deci et al., 2001).

5. Conclusion and Recommendations

Through collaboration with the Association For the Promotion of Wetlands Sustainable Development and FabCafe Bangkok, we created interactive and enjoyable activities using XR technology to engage students' connection to Nong Han Lake. We conducted interviews and focus groups to obtain information to reach our objectives and goals. We piloted our activities at two schools to see how the implementation of our activities worked initially, using feedback to improve student's knowledge of Nong Han Lake leading to creating a mindset of preserving Nong Han Lake.

Nong Han Lake is the central heart of the people of Sakon Nakhon. It serves as a crucial freshwater ecosystem, supporting diverse aquatic life, regulating water quality, and influencing local climate. Youth and schools should be involved in conservation efforts because they represent the future stewards of the environment. Through our recommendations for two groups: teachers and sponsors (the Association For the Promotion of Wetlands Sustainable Development), we can strengthen the bond between the younger generation and Nong Han.

5.1) Recommendations for Teachers

Effective teaching strategies are essential for enhancing student engagement and improving learning outcomes. Educators should integrate innovative approaches that cater to different learning styles to create a more dynamic and interactive classroom environment. XR technology combined with Project-Based Learning is an effective alternative to traditional learning and should be implemented into the conservation education curriculum.

Our research supports this recommendation. Throughout both of our activities, our observations showed the students were engaged and attentive. On top of this, student responses to post-activity survey questions such as: How much more knowledge do you have about Nong Han than before? and Do you think that XR technology increased learning efficiency? Were very positive. The vast majority of students in both schools answered that they gained a lot more knowledge and a 5 on a scale from 1-5 of XR technology increased learning efficiency.

Teacher testimony also supports this recommendation. During post-activity interviews, many of the teachers who were present during our activities vocalized their positive views towards our activities

Looking into the feasibility of including XR technology in schools, our research shows that even for schools in a more rural setting with less resources, there is still potential for the integration of XR. During our initial visit to the Municipal 3 school, we tested a sample XR model with a group of 60 students. We found that many of them had a device capable of running the XR software. The availability of these compatible devices combined with other school resources like a computer lab found at the Municipal 3 school suggests that it is feasible to

incorporate XR technology in the long term. Additionally research shows that through the use of open educational resources, XR-based education becomes more sustainable in the long term (Abeywardena, 2023). This approach of using existing assets makes XR accessible without the need for specialized skill sets.

Integrating Extended Reality (XR) technology and hands-on learning activities into future curricula can revolutionize education by making learning more immersive, engaging, and effective.

Figure 11

Students use XR technology to see species from Nong Han Lake.

Expanding on the integration of XR and hands-on learning, teachers can add these methods into existing biodiversity units. For example, before a field trip or as an alternative to preparing a field trip, utilize a VR simulation to familiarize students with the target ecosystem, highlighting key species and ecological relationships. This shows that XR can also be combined with field trips by incorporating augmented reality apps to identify plants and animals or to overlay data visualizations onto the real-world environment. The Cognitive Affective Model of Immersive Learning (CAMIL) suggests that XR technologies enhance learning by increasing interactivity and presence, which are beneficial for understanding complex environmental systems (Mulders, M., & Träg, K. H., 2023). A study evaluating an XR application on biodiversity in German classrooms found that such tools effectively promote pro-environmental attitudes and enhance student knowledge retention (Mulders et al., 2025).

Suggestions for future work we came across during our site visits were optimizing group sizes for engagement, implementing a reward system, and managing electronic device usage to maximize focus and participation. By adopting these strategies, educators can create more effective and stimulating learning experiences for students. Additionally, we created a teacher manual that assists teachers in incorporating XR into their lessons. Teachers can adapt these strategies and resources to actively engage students in learning and create a more dynamic classroom environment.

Use the Teacher Manual

We created a teacher manual designed to support teachers in integrating XR (Extended Reality) technology into biodiversity education, specifically in Nong Han. It provides step-by-step guidance on using XR tools, including virtual and augmented reality applications, to create immersive learning experiences for students. The manual includes detailed instructions on accessing and utilizing 3D models. Additionally, it offers a collection of activity assets, such as 3D model QR codes and answer sheets. This manual equips teachers with the resources to effectively implement XR technology in their classrooms. The teacher manual is included in our report submission as a supplemental resource and shared with the teachers for their use.

Figure 12

Snapshot of the Teacher Manual created by BSAC incorporation with Fabcafe Bangkok

A smaller group size is more effective for fostering engagement in school activities.

Smaller group sizes are more effective in maintaining student engagement during XR-based learning activities. As shown by our observations and current research, students in larger groups were more likely to be distracted, particularly when sharing a mobile device. This aligns with research by Kutnick & Blatchford (2014), which found that while working individually can support practice and revision, group learning offers additional benefits attributable only if the group sizes are appropriately managed. Groups of four to six can enhance collaboration and peer learning, but larger groups increase the likelihood of disengagement (Kutnick & Blatchford, 2014).

When using shared technology, four groups are the optimal size for fostering engagement. Four-member groups provide a middle ground: small enough to promote collaboration and large enough to encourage diverse perspectives (Melero et al., 2015). Educators must especially limit group sizes to four when using shared mobile devices to improve engagement in future conservation education initiatives. This structure can minimize distractions while allowing students to engage meaningfully with the content (Melero et al., 2015).

Reward systems should be included in classroom teaching.

A well-structured reward system should be incorporated into classroom teaching to enhance student motivation and participation. The learning activity findings demonstrated that tangible and symbolic incentives significantly increased engagement, particularly in activities requiring active student involvement. To maximize the benefits of incentives without undermining intrinsic motivation, educators must carefully design their reward systems. A balanced approach that integrates extrinsic and intrinsic motivators can help sustain student interest beyond the short-term appeal of material rewards (John et al., 2023). While extrinsic motivators, such as snacks, provide instant gratification, symbolic and achievement-based rewards, such as certificates and public recognition, can foster long-term engagement by reinforcing a sense of accomplishment and social recognition (Ryan & Deci, 2020).

To ensure the effectiveness of a reward system, incentives should be meaningful and strategically distributed rather than used excessively. Research warns that over-reliance on extrinsic rewards may shift the focus from genuine interest in the learning activity to merely obtaining rewards, potentially reducing long-term engagement (Deci et al., 2001). Therefore, educators should apply sporadic reinforcement to prevent reward dependency while maintaining motivation. Additionally, assessing the long-term impact of using incentives in classroom teaching is important. While immediate participation may increase due to external rewards, educators should consider whether students will continue engaging in similar activities once the incentives are removed. Moreover, evaluating student participation over time can help educators refine their reward systems to support intrinsic motivation rather than hinder it. By carefully structuring incentives to balance extrinsic and intrinsic motivation, educators can create a

dynamic and engaging learning environment that increases immediate participation and fosters a long-term commitment to learning.

There should be restrictions on electronic device usage during the activity.

Finding 4.1 from both Dan Muang Kham Phitthayakhom School and Municipal 3 School activity revealed a notable challenge: students faced difficulties in maintaining concentration, primarily due to distractions caused by their mobile devices. This issue negatively impacted their ability to engage with the activity and absorb the presented material fully.

The unrestricted use of smartphones, tablets, and other gadgets can divert students' attention, negatively impacting both their learning and the overall atmosphere of the activity. Studies have shown that multitasking with digital devices impairs cognitive processing and retention of information, as attention becomes fragmented (Rosen et al., 2013). To mitigate this issue, teachers should establish and communicate explicit guidelines on device usage. For instance, electronic devices should be permitted only for designated educational purposes or during specific break periods,

Recommendations for Sponsors

Collaboration with local schools in Sakon Nakhon should be regularly conducted to promote the biodiversity of the Nong Han Wetlands and instill a sense of awareness. To ensure the long-term preservation of the Nong Han Wetlands, conservation activities should be conducted regularly. Collaborating with local schools is an effective way to motivate sustainable conservation efforts and encourages greater student involvement in preserving the Nong Han Wetlands. By integrating more conservation and biodiversity activities in local schools, students will develop a stronger connection to the Nong Han Wetlands. In addition to our XR and poster activities, other ideas are student awareness campaigns where students can share their knowledge with the broader community through events, presentations, and social media outreach. Ms. Janthakorn, a biology teacher from Dan Muang Kham Phittayakhom School supports a yearly activity at schools in order to promote conservation and awareness about current issues. A quote from our interview with her states, “It should be held yearly to help conserve the condition of Nong Han Lake in terms of reducing the problems of garbage and fishing.”

Sponsors can invite guest speakers, particularly those connected to the lake and its ecosystem, as they bring a deep sense of care and firsthand experience. For example, representatives from the Department of Fisheries can discuss species that require special attention, while the Department of Agriculture can provide insights on environmental impacts and conservation efforts.

Figure 13

Illustration from booth event, visitor enjoying taking pictures with XR technology

5.2) Conclusions

Preserving the Nong Han Wetlands is essential for maintaining its rich biodiversity, supporting local livelihoods, and addressing pressing environmental challenges. This research project aimed to address students' lack of awareness about Nong Han Wetlands by developing engaging activities incorporating XR technology. The objective was to gain a deeper understanding of the background of local students, communities, and their experiences with the lake, stimulate local students to become involved and passionate about conservation using XR technology, and evaluate the importance of Nong Han Lake among students using feedback surveys. Through our research, fieldwork, and engagement with local schools, we assessed the effectiveness of XR-based education while identifying key factors that influence student engagement and knowledge retention.

Our findings demonstrate that XR technology significantly enhances student interaction and provides an immersive learning experience that makes complex ecological concepts more accessible. XR technology fosters a deeper understanding of biodiversity and environmental conservation by allowing students to visualize and interact with species that inhabit Nong Han Lake. However, our observations also revealed that the novelty of XR technology diminishes over time, leading to decreased engagement. This suggests that while XR is a powerful

educational tool, it should be combined with other interactive teaching methods, such as project-based learning and experiential activities, to sustain student interest.

In the context of biodiversity education, XR technology allows students to engage with digital representations of ecosystems, species, and conservation challenges in an interactive and immersive manner. Unlike traditional field-based learning, which often requires significant logistical and financial resources, XR provides an alternative that reduces environmental impact while maintaining educational effectiveness. The adaptability of XR also makes it a valuable tool for reaching students in remote areas, ensuring broader access to quality biodiversity education (Abeywardena, 2023).

XR technology is a sustainable and impactful tool in biodiversity education. Immersive experiences through XR enhance student engagement and provide scalable and adaptable learning outcomes. With the increased student interaction, it makes complex ecological concepts more understandable and comprehensible. By allowing students to visualize and interact with species that inhabit Nong Han Wetlands, our activities fostered a deeper understanding of biodiversity and environmental conservation. The combination of the XR matching activity with the conservation poster was successful in maintaining student attention.

To continue to utilize XR technology and ensure the sustainability of conservation education efforts we propose several recommendations. First, teachers should be incorporating XR technology but complement it with hands-on, experiential learning activities such as field trips and ecological restoration projects. Second, for sponsors, conservation initiatives should be held regularly to reinforce student awareness and participation beyond a single event to further strengthen students' connection to the Nong Han Wetlands.

By inspiring passion in younger generations, we hope to make a lasting impact on both students and teachers. With continued community support, integrating XR technology into school conservation education can cultivate a deep commitment to protecting the remarkable wetlands. This, in turn, will help ensure a thriving future for both Nong Han and its community.

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Appendices

Appendix A

แบบสำรวจนักเรียน

จากกลุ่ม IQP-ISSP 3

* Indicates required question

1. Email *

2. เพศ? *

Mark only one oval.

- ชาย
- หญิง
- ไม่ต้องการระบุ
- Other:

3. อายุ? *

Mark only one oval.

- 12 - 13
- 14 - 15
- 16 - 17
- 18 - 19
- 20 - 21
- 22 +

4. ชั้นปี? *

Mark only one oval.

- ม.1
- ม.2
- ม.3
- ม.4
- ม.5
- ม.6

5. งานอดิเรก? *

_____

6. นักเรียนเคยไปเดินหนองหารบ่อยแค่ไหม? *

Mark only one oval.

- ทุกวัน
- เดือนละครั้ง
- ปีละครั้ง
- ไม่เคยไป
- Other: _____

7. ปกติใช้/บริโภคสินค้าที่มาจากหนองหารอะไรบ้างไหม? หรือสามารถยกตัวอย่างของใช้/บริโภคอะไรได้บ้าง? *

Check all that apply.

- [ ] ไม่เคยเลย
- [ ] ปลาส้ม
- [ ] น้ำพริก
- [ ] เสื่อกก
- [ ] Other: _____

8. ที่บ้านทำธุรกิจที่เกี่ยวข้องกับหนองหารมั้ยถ้าทำ ทำเกี่ยวกับอะไร? *

Mark only one oval.

- ที่บ้านไม่ได้ทำธุรกิจเกี่ยวข้องกับหนองหาร *Skip to question 10*
- ที่บ้านทำธุรกิจเกี่ยวข้องกับหนองหาร *Skip to question 9*

9. ที่บ้านของนักเรียนทำธุรกิจเกี่ยวกับอะไร? *

_____

10. เคยเข้าร่วมกิจกรรมอะไรที่ช่วยอนุรักษณ์หนองหารบ้างไหม? *

Mark only one oval.

- เคย
- ไม่เคย

11. *

นักเรียนมีความสนใจในกิจกรรมรูปแบบไหน

Mark only one oval.

- เล่นเกมแข่งขันเป็นทีม
- กิจกรรมนอกห้องเรียน
- เรียนรู้ผ่านการลงมือทำ
- บทบาทสมมุติ(Roles play)
- Other: _____

12. เคยเล่นเกมโดยใช้ VR/AR ไหม? *

Mark only one oval.

- เคย *Skip to question 13*
- ไม่เคย *Skip to question 14*
- Other: _____

13. ยกตัวอย่างเกมที่น้องๆเคยเล่น *

14. นักเรียนอยากเรียนรู้เรื่อง VR/AR มากน้อยแค่ไหน *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

15. นักเรียนภูมิใจไหมที่เป็นเจ้าของทะเลสาบหนองหาร? *

1 2 3 4 5

☆ ☆ ☆ ☆ ☆

Appendix B

Posters of student from Dan Muang Kham Phittayakhom School

Posters of student from Municipal 3 School

Appendix C

Interview for local community บทสัมภาษณ์ของชุมชนในพื้นที่

1) What products do the locals market?
   สินค้าอะไรที่ทำตลาดในท้องถิ่น?
2) Do the children of the current generation (local kids) show interest in conserving Nong Han Lake?
   เด็กๆ ในยุคปัจจุบัน (เด็กท้องถิ่น) สนใจที่จะอนุรักษ์หนองหานหรือไม่?
3) Is there a must-visit location in the area?
   มีสถานที่ท่องเที่ยวที่ไม่ควรพลาดในพื้นที่หรือไม่?
4) Are you interested in having your children continue this business?
   คุณสนใจที่จะให้ลูกๆ ของคุณสานต่อธุรกิจนี้หรือไม่?
5) Are there any new products you want to develop?
   มีผลิตภัณฑ์ใหม่ๆ ที่คุณอยากพัฒนาหรือไม่?
6) Was there ever a time when the resources in Nong Han Lake decreased? Did it impact the business or daily life? What changes occurred?
   มีช่วงเวลาใดที่ทรัพยากรในหนองหานลดลงหรือไม่? ส่งผลกระทบต่อธุรกิจหรือชีวิตประจำวันหรือไม่? มีการเปลี่ยนแปลงอะไรเกิดขึ้น?
7) What role does WWF play in conservation?
   WWF มีบทบาทอย่างไรในการอนุรักษ์?
8) Are your children nowadays interested in preserving Nong Han?
   เด็กๆ ของคุณสนใจที่จะอนุรักษ์หนองหานในปัจจุบันหรือไม่?
9) What are the key factors that make children lose interest in preserving Nong Han?
   ปัจจัยสำคัญอะไรที่ทำให้เด็กๆ ไม่สนใจที่จะอนุรักษ์หนองหาร?

Interview with teachers บทสัมภาษณ์กับคุณครู

1) What do teachers teach in the curriculum?
   ปกติคุณครูสอนอะไรในหลักสูตร?
2) Is there any content related to nature conservation in the current curriculum?
   หลักสูตรปัจจุบันมีเนื้อหาเกี่ยวกับการอนุรักษ์ธรรมชาติบ้างหรือไม่?

3) How do students respond to the teaching media?
   นักเรียนตอบสนองต่อสื่อการสอนอย่างไร?
4) How much do students have weaknesses and competitions in science knowledge?
   นักเรียนมีจุดอ่อนและการแข่งขันด้านความรู้ทางวิทยาศาสตร์มากเพียงใด?
5) What kind of teaching method do you think students can learn best?
   คุณคิดว่าวิธีการสอนแบบใดที่นักเรียนสามารถเรียนรู้ได้ดีที่สุด?
6) Have you organized practical teaching in the past?
   คุณเคยจัดให้มีการสอนภาคปฏิบัติมาก่อนหรือไม่?
   ~If yes, are there any problems with this kind of teaching?
   หากใช่ มีปัญหาอะไรกับการสอนแบบนี้บ้างหรือไม่?
   ~Or if not, does the school want to adopt this kind of teaching and learning?
   หรือหากไม่ใช่ โรงเรียนต้องการนำการสอนและการเรียนรู้แบบนี้มาใช้หรือไม่?
7) What do you think about the use of technology in teaching media?
   คุณคิดอย่างไรเกี่ยวกับการใช้เทคโนโลยีในสื่อการเรียนการสอน?
8) Have teachers taught anything about Nong Han?
   คุณครูสอนอะไรเกี่ยวกับหนองหารบ้างไหมคะ