Promoting ocean and water literacy

in school communities

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Deliverable 3.3

Digital teaching aids to explore the future of ocean and freshwater resources

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Executive summary

This report describes the ProBleu resources intended to equip educators with advanced digital teaching aids, enabling learners to explore, model, and forecast future conditions of oceanic and freshwater systems. This report builds on the previous ProBleu report "Digital teaching aids to assess the state of ocean and freshwater resources" (D3.2) by introducing three interlinked components:

• Predictive simulation models: Interactive modules allowing students to test "what-if" scenarios such as nutrient loading changes, ocean warming, and acidification under future climate trajectories. Students explore ecosystem responses by adjusting model parameters, analysing outputs, and comparing results with established scientific projections.

• Ocean Explorer tool: A time-series analysis platform that provides access to 30 years of oceanographic data (chlorophyll-a, temperature, salinity, pH, dissolved oxygen). Exportable datasets facilitate cross-disciplinary activities in mathematics and data science. Learners can then select variables, define historical and future projection windows, and forecast changes.

• Citizen science integration: Classroom protocols and standardised data templates that guide students in collecting local water-quality measurements (e.g., pH, temperature, turbidity). Aggregated class datasets can be used in conjunction with model forecasts to compare regional predictions with local observations, thereby enhancing engagement and understanding.

This report describes digital teaching tools whose aims include:

- Strengthening the predictive reasoning skills of students through hands-on scenario modelling.
- Enhancing data literacy by integrating exported projections into spreadsheets and coding workflows.
- Providing educators with structured evaluation tools focused on assessing hypothesis formulation, methodological rigour, and forecast accuracy.
- Prompting classroom discussions on the impacts of long-term environmental change on ocean systems.

By focusing on future-oriented digital simulations, trend-projecting tools, and participatory monitoring, these classroom assets transform ocean and water literacy education, preparing students to understand and address emerging marine and freshwater challenges effectively.

List of abbreviations

GDPR - European and UK General Data Protection Regulation

IPAs - interested parties and actors

NEBS - Network of European Blue Schools

UI - user interface

1. Introduction

Ocean and freshwater systems face environmental pressures from pollution and human activities. Understanding these challenges requires not only knowledge of current conditions but also the ability to explore potential future scenarios and their implications for ecosystem health and human well-being. This report addresses this critical need by providing educators with specialised digital teaching aids designed to help students explore, model, and simulate future states of oceanic and freshwater resources.

1.1. Scope

This report focuses on future-oriented exploration and predictive modelling tools within the ProBleu digital teaching suite. This work is closely linked to the previous report, "Digital teaching aids to assess the state of ocean and freshwater resources" (D3.2), which can be found on the project website, and focuses on assessing the state of ocean and freshwater resources through data visualisation and analysis tools. Here, we focus on forward-looking capabilities that enable students to investigate potential future scenarios and develop predictive reasoning skills.

The functionality of the digital teaching aids presented in this report is specifically designed to support:

- **Scenario-based learning**: Students can manipulate environmental parameters to explore "what-if" scenarios and observe the projected responses of the ecosystem.
- **Trend analysis and forecasting**: Time-series data exploration tools enable the identification of patterns and the extrapolation of future conditions.
- **Hypothesis testing**: Interactive simulations offer a safe environment for testing predictions about environmental change.
- **Data-driven decision making**: Integration of observational data with predictive models helps students understand the relationship between current measurements and future projections.

1.2. Core components

This work introduces three interconnected components that work complementarily to provide comprehensive future-exploration capabilities:

1. Digital simulation models for future scenarios
Interactive ecosystem models enable students to explore future states under different environmental conditions. These simulations focus on critical processes, including eutrophication dynamics, thermal stratification effects, and the impacts of ocean acidification. Students can adjust model parameters representing nutrient inputs, temperature changes, and atmospheric CO_2 concentrations to investigate potential ecosystem responses over timescales ranging from years to decades.

2. Ocean Explorer tool: temporal analysis and trend exploration
The Ocean Explorer tool enables students to examine historical trends and project future conditions for key oceanographic variables. Scenario projection capabilities transform the platform from a current-state assessment tool into a comprehensive forecasting environment.

3. Citizen science integration for future monitoring
Extended citizen science methodologies are described, which support local awareness of trends predicted at the regional scale. Students collect local environmental data using standardised protocols, contributing to long-term datasets that can be used to validate model predictions and refine forecasting approaches.

1.3. Educational objectives and learning outcomes

The digital teaching aids are designed to develop specific competencies essential for understanding and addressing future environmental challenges:

- **Predictive reasoning**: Students learn to formulate hypotheses about future environmental conditions based on current trends and scientific understanding.
- **Systems thinking**: Interactive simulations help students understand complex feedback loops and non-linear responses in environmental systems.
- **Data literacy**: Time-series analysis and trend projection activities develop quantitative skills in data interpretation and statistical analysis.
- **Scientific scepticism**: Comparing model predictions with observational data fosters a critical evaluation of modelling assumptions and uncertainties.
- **Environmental stewardship**: Exploring future scenarios under different human impact levels helps students understand the consequences of their current actions and the importance of sustainable practices.

1.4. Target audience and implementation context

This report is primarily designed for secondary school educators teaching environmental science, biology, geography, and related STEM subjects. The digital teaching aids can be integrated into existing curricula as standalone modules or combined with other tools to provide comprehensive coverage of both present conditions and future projections.

The tools are designed to accommodate diverse classroom contexts, from well-equipped computer laboratories to resource-constrained environments with limited internet connectivity. Offline capabilities and downloadable resources ensure that geographic location and technological infrastructure do not limit access to future-exploration learning opportunities. Open-source and free software can be used with these resources.

1.5. Structure of this report

In the following sections, this report provides detailed descriptions of the digital teaching aid components, implementation guidance for educators, and evaluation frameworks for assessing student learning outcomes. The focus remains consistently on how these tools enable exploration of future ocean and freshwater conditions.

Sections 2 and 3 provide essential project context and pedagogical foundations that support the future-oriented learning objectives. Subsequent sections detail the specific digital tools, their educational applications, and practical implementation strategies that enable students to become active participants in predicting and preparing for future environmental challenges.

2. Project overview and context

2.1. European Mission alignment

The ProBleu project directly supports the European Union's Mission "*Restore our Ocean and Waters by 2030*", addressing critical educational gaps in ocean and water literacy across school communities. The project recognises that sustainable ocean governance requires an informed citizenry capable of understanding complex marine and freshwater ecosystem dynamics and their responses to environmental change. The digital teaching aids of the project serve as catalysts for transforming traditional ocean and freshwater education, moving beyond passive learning toward active inquiry and environmental stewardship.

2.2. Addressing educational challenges

Contemporary ocean and freshwater education faces significant challenges, particularly due to the complexity of aquatic ecosystems. While research indicates that ocean literacy is often integrated across curricula through implicit embedding (a pedagogically sound approach that allows for natural cross-curricular connections), there remains potential to enhance student engagement and comprehension through complementary learning experiences (Freitas et al., 2022). ProBleu builds upon existing educational frameworks by providing immersive digital experiences that make remote ocean and freshwater environments accessible and comprehensible to diverse learners, thereby supporting both implicitly embedded and explicitly focused approaches to aquatic education.

2.3. Innovation in educational technology

The project leverages emerging technologies, including artificial intelligence, simulation modelling, and interactive data visualisation, to create engaging learning experiences. This technological integration aligns with contemporary pedagogical research, which emphasises the importance of multimodal learning approaches and authentic scientific inquiry in education. The digital teaching aids represent a paradigm shift from traditional textbook-based instruction toward dynamic, experiential learning methodologies.

3. Theoretical framework and pedagogical foundations

3.1. Ocean literacy conceptual framework

Ocean literacy encompasses seven fundamental principles that define essential understanding of ocean-Earth system interactions. These principles are detailed in the Ocean Literacy Framework published by the U.S. Ocean Literacy Network (2024) and are:

1. The Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of the Earth.
3. The ocean is a major influence on weather and climate.
4. The ocean made Earth habitable.
5. The ocean supports a great diversity of life and ecosystems.
6. The ocean and humans are inextricably interconnected.
7. The ocean is largely unexplored.

ProBleu's digital teaching aids are systematically aligned with these principles, ensuring comprehensive coverage of critical concepts, including ocean-climate interactions, marine biodiversity, human impacts, and sustainable resource management. The project's teaching aids adopt an interdisciplinary approach that integrates physical oceanography, marine ecology, chemistry, and social sciences to provide a holistic understanding of ocean and freshwater systems.

The pedagogical framework draws upon the constructivist learning theory, which emphasises active knowledge construction through hands-on exploration and inquiry-based investigation. Students engage with authentic scientific data and modelling tools, developing both conceptual understanding and scientific thinking skills essential for addressing complex environmental challenges.

3.2. Integration of creative and digital pedagogy

Building upon research in creative pedagogy for water education, ProBleu incorporates innovative approaches that combine artistic expression, scientific inquiry, and technological innovation. This integration recognises that environmental education requires both cognitive engagement and emotional connection to foster long-term behavioural change and environmental stewardship. The digital simulations and interactive tools of the project provide opportunities for creative problem-solving and exploration of potential futures for ocean and freshwater systems.

4. Digital simulations

This section highlights the forward-looking teaching aids featured in the ProBleu catalogue [https://probleu.pml.space/en/]. Students can adjust key model parameters (such as nutrient loading rates or temperature) to explore scenario modelling. Learners can project hypoxia events, stratification changes, and acidification impacts in sandbox environments or via datasets from established ecosystem models, gaining insight into potential ecosystem trajectories under different environmental and management scenarios.

4.1. Simulation design philosophy and educational rationale

Digital simulations address fundamental challenges in teaching the dynamics of complex aquatic ecosystems. Ocean and freshwater environments present unique pedagogical challenges due to limited accessibility and dynamics that operate on timescales ranging from minutes to centuries. Traditional educational approaches struggle to convey the dynamic, interconnected nature of aquatic systems, particularly the complex feedback loops between physical, chemical, and biological processes.

The ProBleu simulation models enable students to conduct controlled experiments that would be impossible, impractical, or ethically problematic in real-world settings. These virtual laboratories offer a safe space for exploring "what-if" scenarios, testing hypotheses, and observing system responses to various perturbations. The simulations are designed to strike a balance between scientific accuracy and educational accessibility, ensuring that complex ecological processes remain comprehensible while maintaining fidelity to the underlying scientific principles.

4.2. Thematic simulation modules

4.2.1. Eutrophication and nutrient dynamics

The eutrophication simulation module enables students to explore the complex relationships between nutrient inputs, primary productivity, oxygen depletion, and ecosystem health. Students can manipulate variables, including nutrient loading, temperature, light availability, and grazing pressure, to observe the impacts on phytoplankton populations, dissolved oxygen levels, and overall ecosystem functioning.

The simulation incorporates realistic predator-prey dynamics, enabling students to understand how changes in nutrient availability cascade through food webs and affect multiple trophic levels. Interactive visualisations display real-time changes in biomass distribution, species composition, and biogeochemical cycling, providing immediate feedback on management decisions and environmental perturbations.

4.2.2. Temperature and deoxygenation interactions

Environmental changes affecting aquatic systems pose a critical contemporary challenge that necessitates a nuanced understanding of temperature-oxygen interactions. The ProBleu simulation enables exploration of how warming temperatures affect oxygen solubility, metabolic rates, and ecosystem structure. Students can investigate the effects of thermal stratification, examine the development of hypoxic zones, and explore potential tipping points in ecosystem functioning.

The simulation incorporates both direct temperature effects and indirect impacts mediated through changes in circulation patterns. This comprehensive approach helps students understand the multifaceted nature of environmental change impacts on aquatic ecosystems while developing an appreciation for ecosystem vulnerability and resilience.

4.2.3. Ocean acidification chemistry and biology

Ocean acidification represents one of the most significant contemporary threats to marine ecosystems, yet the underlying chemistry remains challenging for many students to comprehend. The ProBleu acidification simulation provides interactive exploration of carbonate chemistry, pH dynamics, and biological responses to changing ocean chemistry.

Students can manipulate atmospheric CO_2 concentrations, examine buffering processes, and observe impacts on calcifying organisms. The simulation integrates chemistry and biology, enabling students to understand how molecular-level processes scale up to impact entire ecosystems and global biogeochemical cycles.

4.3. Integration with authentic scientific data

ProBleu simulations are designed as digital experimentation environments to complement, rather than replace, engagement with real-world data and observations.

This integration serves multiple educational purposes: it helps students understand the role of models in scientific inquiry, develops critical thinking about model limitations and uncertainties, and fosters appreciation for the value of observational data in environmental science. Students learn to use models as tools for generating hypotheses and interpreting observations rather than as definitive predictors of future conditions.

4.4. Scaffolded learning progressions

The simulation modules are designed with explicit learning progressions that support students at different levels of prior knowledge and scientific sophistication. Initial explorations focus on qualitative pattern recognition and system behaviour, while advanced activities engage students in quantitative analysis, parameter sensitivity studies, and model validation exercises.

Scaffolding features include guided tutorials, embedded assessment tools, and progressive complexity options that allow educators to tailor experiences to student needs and curricular requirements. This flexible design ensures that simulations remain accessible to novice learners while providing sufficient depth for advanced students and extended investigations.

5. Ocean Explorer tool: advanced data integration

This section presents the forward-looking capabilities of ecosystem models. Educators and students can select historical data series (chlorophyll-a, temperature, salinity, pH, dissolved oxygen) spanning 30 years, and project future conditions under different climate scenarios. Exporting files in *comma-separated values* (CSVs) format enables the integration of projections into spreadsheet or coding workflows for further analysis.

5.1. Data platform architecture

The ProBleu Ocean Explorer tool [https://probleu.pml.space/en/ocean-explorer/] provides access to high-quality oceanographic model outputs covering European regional seas. The tool integrates data from multiple sources, including the Mediterranean, Baltic, Black, and North Seas, offering wide spatial and temporal coverage of essential oceanographic variables (see next section).

The platform supports data visualisation, temporal trend analysis, and comparative studies across different marine regions. It enables students to explore spatial patterns, investigate seasonal cycles, and examine long-term trends in water properties. The tool design prioritises accessibility while maintaining scientific rigour, ensuring that complex oceanographic data remains comprehensible to educational audiences.

5.2. Essential variables and parameters

5.2.1. Chlorophyll-a and primary productivity

Chlorophyll-a concentration serves as a fundamental indicator of marine primary productivity and ecosystem health. The Ocean Explorer tool provides access to model-predicted chlorophyll-a distributions at select locations, enabling students to investigate seasonal patterns, identify productive regions, and explore relationships between nutrient availability and phytoplankton biomass.

Data allow comparison between different European seas, examination of interannual variability, and investigation of human impacts on marine productivity. Students can download datasets for quantitative analysis, developing skills in data handling and statistical interpretation, while gaining insights into marine ecosystem functioning.

5.2.2. Ocean acidity and carbonate chemistry

Ocean acidification monitoring represents a critical component of contemporary marine science. The Ocean Explorer offers access to pH model predictions, allowing students to explore spatial patterns in ocean chemistry and analyse trends in acidification across European waters.

The digital teaching aids incorporate educational resources that help students understand the fundamentals of carbonate chemistry while exploring real-world data on ocean acidification. Interactive visualisations demonstrate how increases in atmospheric CO_2 translate into changes in seawater chemistry and potential impacts on marine organisms.

5.2.3. Dissolved oxygen and hypoxia

Oxygen depletion represents a concern in many marine environments, particularly in semi-enclosed seas like the Baltic. The Ocean Explorer tool provides comprehensive oxygen data enabling investigation of hypoxic zones, seasonal oxygen cycles, and long-term trends in water column oxygenation.

Students can explore relationships between oxygen levels, temperature, stratification, and biological activity. The tool supports the investigation of eutrophication impacts and enables comparison of oxygen conditions across different European marine regions.

5.2.4. Salinity and water mass properties

Salinity serves as a fundamental tracer of ocean circulation and the characteristics of water masses. The Ocean Explorer provides access to modelled salinity data across European seas, enabling the investigation of circulation patterns, freshwater inputs, and the impact of climate on ocean properties.

Interactive features of the digital teaching aids support exploration of salinity gradients, examination of seasonal cycles, and investigation of how precipitation, evaporation, and river discharge affect regional ocean conditions. Students can develop an understanding of physical oceanography while exploring connections between terrestrial and marine systems.

5.2.5. Temperature and thermal structure

Ocean temperature data provides insights into climate variability, ecosystem dynamics, and physical oceanography. The Ocean Explorer provides comprehensive temperature datasets that cover both surface and subsurface waters, enabling the investigation of seasonal heating cycles, thermal stratification, and the impacts of environmental change.

Students can explore temperature trends, investigate marine heatwaves, and examine the relationships between temperature and biological processes. The tool supports both qualitative exploration and quantitative analysis of thermal dynamics in European waters.

5.3. Educational applications and pedagogy

The Ocean Explorer tool is designed to support inquiry-based learning and the development of scientific thinking. Instead of simply presenting data, the digital teaching aids include scaffolding features that guide students through scientific investigation processes, such as hypothesis formation, data analysis, and interpretation.

Educational applications include comparative studies across regions, temporal trend analysis, and investigation of human impacts on marine systems. The tool supports both individual exploration and collaborative projects, enabling diverse pedagogical approaches while maintaining focus on authentic scientific inquiry.

6. Citizen science integration and community engagement

The ProBleu approach extends student learning of future ecosystem trends into local engagement. The models presented in the previous section are based on vast datasets of global-scale ocean and weather observations and predict regional trends. Locally, environmental change may be experienced in the same or very different ways. Students are encouraged to collect (ideally over multiple years and seasons) standardised water-quality measurements (temperature, pH, turbidity, nitrate, phosphate). These student-generated time series can be compared with data from local or regional monitoring bodies, scientific organisations, as well as the model projections from the Ocean Explorer tool. This approach builds an appreciation of the efforts required to capture long-term trends, the scientific methodology behind and the value of individual scientific observations, and the critical thinking needed to assess local impacts compared to regional understanding.

6.1. Participatory science framework

The integration of citizen science represents a fundamental commitment to participatory approaches to environmental education and scientific inquiry. This recognises that authentic scientific participation enhances learning outcomes while contributing to genuine research efforts that advance understanding of ocean and freshwater systems.

The citizen science component enables students to contribute to the digital teaching aids and (typically in collaboration with scientific public or non-governmental organisations) other scientific databases while developing authentic research skills and environmental monitoring capabilities. This approach transforms students from passive consumers of scientific information into active contributors to scientific knowledge, fostering deeper engagement and long-term environmental stewardship.

6.2. Community-based environmental monitoring

ProBleu supports the integration of low-cost environmental monitoring tools that enable schools and communities to collect authentic scientific data relevant to their local aquatic environments, which can be uploaded to the digital teaching aids platform. These monitoring programs and the Ocean Explorer tool provide datasets for classroom analysis, while also contributing to a broader scientific understanding of environmental conditions and trends. Through longitudinal data collection and scenario modelling, students can explore potential future environmental states and understand how current monitoring efforts inform predictions about ecosystem trajectories and sustainability outcomes.

Monitoring activities include water quality assessments, biodiversity surveys, and environmental observations that complement the digital simulations and modelling tools. These data collection efforts are designed not only to document current conditions but also to enable exploration of future scenarios through trend analysis and predictive modelling exercises. Students learn to use scientific instruments, follow standardised protocols, and contribute data to professional databases, developing authentic scientific skills while addressing local environmental questions and strengthening their capacity to anticipate and prepare for future environmental challenges.

6.3. Data quality and scientific validity

Recognising the importance of data quality in both scientific research and educational applications, ProBleu supports comprehensive quality assurance protocols for citizen science contributions. Training materials, standardised protocols, and data validation procedures (e.g., FreshWater Watch or MINKA) ensure that student-collected data meet scientific standards while maintaining educational value. These robust datasets not only support current research needs but also enable reliable projections and scenario modelling for exploring future environmental conditions and ecosystem responses.

Quality control measures, including calibration procedures, duplicate sampling, and expert validation, enable the confident use of citizen science data in both educational and research contexts. The temporal complementarity of these datasets with respect to government data makes them particularly valuable for trend analysis and future state modelling, allowing students to understand how data coverage directly impacts our ability to predict and prepare for environmental changes. Students learn about measurement uncertainty, quality control procedures, and the importance of standardised methods in scientific research while developing skills to evaluate data reliability for forward-looking environmental assessments and sustainability planning.

6.4. Connection to professional research networks

ProBleu facilitates connections between student citizen scientists and professional research networks, enabling authentic participation in ongoing scientific investigations. These partnerships provide mentorship opportunities, access to skilled expertise, and pathways for advanced student engagement in environmental science.

Professional connections also ensure that citizen science activities remain relevant to contemporary research priorities while providing students with insights into scientific careers and research methodologies. Guest scientist interactions, virtual laboratory visits, and collaborative data analysis projects enhance the authenticity of student scientific experiences.

6.5. Impact assessment and evaluation

The citizen science component incorporates comprehensive evaluation frameworks that assess both educational outcomes and scientific contributions. Mixed-methods evaluation approaches examine knowledge acquisition, skill development, attitude changes, and behavioural outcomes while also evaluating data quality and scientific impact.

Evaluation results inform continuous improvement of citizen science programs while contributing to a broader understanding of effective practices in environmental education and public participation in science. Long-term tracking will enable the assessment of sustained engagement and the influences of career pathways resulting from citizen science participation.

7. Implementation guidelines for predictive scenario activities

To integrate the future-focused digital teaching aids effectively, educators are encouraged to follow these steps:

1. **Select scenario objectives**
    - Define a learning goal (e.g., projecting hypoxia under different nutrient inputs, modelling pH changes with rising CO_2 levels).
    - Choose the relevant simulation module or Ocean Explorer variable that aligns with the objective.
2. **Design “what-if” exercises**
    - Use the provided worksheets to set up parameter values for each scenario.
    - Encourage students to formulate hypotheses about expected outcomes before running the model or trend analysis.
3. **Facilitate data exploration and projection**
    - Guide students through running simulations and using the Ocean Explorer to generate future projections.
    - Demonstrate how to export CSV outputs for further analysis in spreadsheets or simple scripts.
4. **Build a deeper understanding of spatio-temporal variations**

- Implement citizen science protocols to collect local water measurements.
- Compare student-collected data with local/regional public datasets and model forecasts to compare observations with projections and discuss discrepancies.

5. **Assess learning and forecasting skills**
   - Use predictive reasoning quizzes to gauge understanding of model mechanics.
   - Evaluate lab reports and presentations with rubrics focused on hypothesis clarity, methodological accuracy, and interpretation of future outcomes.

8. Recommendations for interested parties and actors in the education domain

8.1. Recommendations for schools

1. **Embed ProBleu resources into lesson sequences**

Integrate slides, simulations, and Science Stories directly into existing modules on ecosystems, chemistry, and environment. Use the age- and topic-filtered resource bundles in the ProBleu catalogue to align activities with specific curriculum standards and learning outcomes.

2. **Leverage simulations for inquiry-based labs**

Supplement traditional lab exercises with ProBleu digital simulations (eutrophication, acidification, thermal stratification). Structure lab assessments around hypothesis testing and parameter exploration within the virtual environment.

3. **Implement Ocean Explorer projects**

Assign data-analysis projects using the Ocean Explorer tool. Provide students with guided worksheets to retrieve chlorophyll-a or pH time-series data, analyse trends, and present findings. Use exported datasets to develop quantitative research skills.

4. **Use Science Stories for contextual engagement**

Adopt complete Science Story modules to humanise water science. Incorporate researcher videos and guided activities to motivate students and illustrate real-world applications of scientific concepts.

5. **Customise and translate content**

Take advantage of AI-enabled multilingual support to adapt materials for diverse classrooms. Localise slide decks and worksheets using the catalogue's translation feature, then verify and refine language for cultural relevance. Educators are encouraged to resubmit versions of ProBleu slides and worksheets with corrected translations to the online catalogue of teaching aids.

6. **Facilitate digital skill development**

Use spreadsheet templates and data-visualisation guides to teach students digital data management, visualisation, and interpretation skills. Scaffold instruction from guided templates toward independent data-analysis projects.

8.2. Recommendations for the Network of European Blue Schools

1. **Establish digital resource sharing hubs**

Create NEBS subgroups dedicated to exchanging custom resource bundles, simulation scenarios, and Science Story adaptations. Use shared online folders or collaborative platforms for version control and peer feedback.

2. **Coordinate cross-school virtual projects**

Organise inter-school challenges using the Ocean Explorer tool. Schools can compare regional ocean data (e.g., Baltic vs. Mediterranean) and jointly present findings in virtual symposiums, fostering collaboration and comparative analysis skills.

3. **Curate best-practice digital pedagogy webinars**

Host regular online workshops where educators demonstrate effective use of ProBleu digital aids, showcasing classroom integration strategies, assessment approaches, and localisation techniques.

4. **Support educator mentorship in digital tool use**

Pair tech-savvy teachers with colleagues new to digital pedagogy. Mentors can guide mentees through catalogue navigation, simulation facilitation, and troubleshooting, bolstering network capacity.

8.3. Recommendations for educational policy makers

1. **Incentivise digital innovation in curriculum guidelines**

Encourage the use of interactive digital tools, such as simulations and data platforms, within science and geography curriculum frameworks. Advocate for the inclusion of ProBleu learning modules and tools in national and regional education policy guidelines as officially endorsed digital teaching aids.

2. **Allocate funding for digital infrastructure**

Ensure schools have adequate devices, a reliable internet connection, and software support to run ProBleu simulations and the Ocean Explorer tool. Prioritise equitable access to avoid digital divides.

3. **Support professional development in digital pedagogy**

Fund certified training programs focused on effectively integrating ProBleu teaching aids. Include digital assessment design, data literacy instruction, and best practices for AI-supported translation improvement.

4. **Promote research on digital ocean literacy outcomes**

Sponsor longitudinal studies evaluating the impact of digital teaching aids on student learning, engagement, and environmental stewardship. Use findings to refine resource development and policy directives.

These targeted recommendations empower interested parties and actors to harness the full potential of the ProBleu digital teaching aids, ensuring effective implementation, collaboration, and sustained impact in ocean and water literacy education.

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