NTI GYMNASIET

HydroTeach: A Complete Guide for Teaching Hydroponics

The website is more than a website.

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1. Introduction

1.1 Abstract

This formal thesis presents HydroTeach, an educational website developed for teachers and students to learn about hydroponic growing, including how to construct hydroponic systems and what varieties of systems exist. The project is the primary deliverable of Work Package 4 (Digital Toolbox) within a larger Erasmus+ KA220-VET Cooperation Partnership entitled European Partnership in Hydroponics 2 (EUPiH2), a 30-month inter-European collaboration co-financed by the European Union and running from September 2024 to February 2027.

To promote effective learning, the platform integrates several evidence-based pedagogical models, including interactive learning, practical learning, theoretical learning, competitive learning, repetitive learning, and quiz-based learning. The development of the website can be divided into several distinct workstreams: design, prototyping, development, feedback collection, and evaluation.

The development team at NTI Gymnasiet Lund consists of the following individuals:

- Chaspian Stoltz Johannesson – Lead of Development and Infrastructure
- Timo Hirsch Mörk – Lead of Design
- Alexander Wollmér – Lead of Infrastructure
- Ludvig Larsson
- Johann Albrecht – Design

1.2 Background

HydroTeach is the primary digital output of the European Partnership in Hydroponics 2, a project submitted to the Erasmus+ KA220-VET programme under Call 2024 Round 1 (Form ID: KA220-VET-AAFE5AC7). The project was awarded a lump sum grant of €250,000 and operates across five partner institutions in four countries: NTI Vetenskapsgymnasiet Gävle (Sweden, applicant and coordinator), NTI Gymnasiet Lund (Sweden), Roskilde Tekniske Skole (Denmark), IES Fraisoro Eskola BHI (the Basque Country, Spain), and Stichting Yuverta (the Netherlands).

The project is a direct continuation of a previous Erasmus+ Small Scale Partnership (KA210-VET-000034523), the European Partnership in Hydroponics, which concluded in January 2023. The earlier project established cross-border collaboration in hydroponics education and identified a clear need for structured teaching materials and a dedicated digital platform.

The project is structured around five Work Packages (WPs): WP1 Project Management (€45,000), WP2 Teaching Materials for Hydroponics (€64,600), WP3 Teachers Training and Guidelines (€106,400), WP4 Digital Toolbox (€12,000), and WP5 Dissemination (€22,000). NTI Gymnasiet Lund holds primary responsibility for WP4, which covers the design, development, and long-term maintenance of the HydroTeach website. The Digital Toolbox is committed to remain active and maintained for three years beyond the project's conclusion in February 2027.

The project targets students aged 16 and older in vocational education and training (VET) as well as university-preparatory programmes, and it addresses the Erasmus+ horizontal priority of inclusion and diversity, with additional priorities of contributing to innovation in VET and improving quality assurance in VET. The three thematic topics addressed are digital skills and competences, green skills, and the development of training courses.

HydroTeach itself is explicitly described in the grant application as more than a project website: it is intended as a genuine pedagogical toolbox that teachers and students can use independently of the project group. As stated in the application: “The website will be like a digital toolbox and it will be more than a website for the project, it will truly be a toolbox for teachers and student to use in education.”

1.2.1 Partner Institutions

Each partner institution brings distinct expertise to the collaboration. NTI Vetenskapsgymnasiet Gävle, the official project coordinator, has been operating a hydroponic cultivation park for nearly three years and integrates hydroponics into its Biotechnology course. The school is also developing a floating hydroponic raft system on the Gavleån river.

Roskilde Tekniske Skole (RTS) in Denmark is a UNESCO World Goal School with a long tradition of horticulture education. RTS is responsible for WP2 and WP3, and brings a journalism and graphic design resource in-house for content production. The school has been an Erasmus+ beneficiary since 2007 and has extensive experience coordinating international projects.

IES Fraisoro Eskola BHI in the Basque Country, Spain, has operated a 300-square-metre hydroponic installation for approximately 25 years and is responsible for the formal evaluation of all work packages across the project. The school collaborates with a local agricultural cooperative and is developing recirculation and biofertilizer techniques.

Stichting Yuverta in the Netherlands is the result of a merger of three agricultural VET providers and serves over 21,800 students across 55 locations. Yuverta has been ranked the most sustainable VET school in the Netherlands and holds Erasmus+ accreditation with a maximum score of 100/100. It leads WP5 (Dissemination) and contributes extensively to content production, particularly on system definitions and light and temperature topics.

NTI Gymnasiet Lund, the school responsible for HydroTeach, is one of only four institutions in Sweden recognised as a Microsoft Datacenter Academy. With approximately 180 students and 28 staff, the school provides university-preparatory programmes in Technology and VET with a focus on IT. Its students operate as webmasters for the Digital Toolbox within their Web Development and Digital Creation courses, creating a real-world client–developer dynamic between the Swedish schools and the other partner institutions.

1.2.2 Word List

The following terms and definitions are used throughout this thesis:

Hydroponics: A method of horticulture and a subset of hydroculture in which plants, typically crops or medicinal species, are grown without soil using water-based mineral nutrient solutions in a controlled artificial environment.

Work Package (WP): A defined unit of work within the Erasmus+ project framework, grouping related activities that contribute to a specific deliverable or milestone. The EUPiH2 project is divided into five work packages.

Digital Toolbox: The term used within the EUPiH2 project to describe the HydroTeach website, emphasising its function as a practical pedagogical resource for teachers and students rather than merely a project information site.

Next.js: An open-source web development framework created by Vercel, built on top of React, providing capabilities for server-side rendering and static site generation. Used as the initial framework for HydroTeach before being replaced by SvelteKit.

SvelteKit: An open-source full-stack web framework built on Svelte, which compiles component code to optimised vanilla JavaScript at build time. Selected as the final production framework for HydroTeach.

Traefik: An open-source HTTP reverse proxy and load balancer used to route incoming web traffic to containerised services.

Figma: A collaborative, browser-based application for interface design, used throughout the HydroTeach design process.

Reverse Proxy: A server positioned in front of web servers that forwards client requests to those servers, providing load balancing, caching, and security benefits.

Matomo: An open-source web analytics platform, formerly known as Piwik, planned for deployment on HydroTeach to track visitor behaviour in compliance with GDPR.

Grafana: An open-source monitoring and observability platform used to visualise server infrastructure metrics and logs.

PostgreSQL (Postgres): A powerful, open-source relational database management system.

SeaweedFS: A distributed file storage system designed for storing and serving large volumes of files efficiently.

VPS (Virtual Private Server): A virtualised server environment offering dedicated resources at a lower cost than a dedicated physical server.

Web Server: Software that receives and processes HTTP requests from clients and returns the appropriate responses.

Hosting: The provision of server infrastructure and network connectivity to make a website or application accessible via the internet.

DDoS (Distributed Denial of Service): A cyber attack in which a large volume of requests is sent to a target server simultaneously with the intent of overloading it.

Caching: The process of storing copies of frequently requested data in a temporary storage location to serve future requests more quickly and reduce load on the origin server.

Git: A distributed version control system used to track changes in source code and enable collaborative development.

GitHub: A developer platform providing Git repository hosting along with collaboration features such as pull requests, issue tracking, and project management tools.

GitHub Actions: A built-in CI/CD tool within GitHub that enables automated workflows for building, testing, and deploying applications.

CI/CD (Continuous Integration/Continuous Deployment): An automated software delivery methodology in which code changes are automatically built, tested, and deployed to production upon being merged into the designated branch.

Branch: A separate line of development within a Git repository allowing developers to work in isolation before merging changes into the main codebase.

Docker: Open-source software for building, deploying, and running containerised applications in isolated environments.

Docker Container: A lightweight, standalone, executable software package containing everything needed to run an application.

Docker Image: A read-only template used to create Docker containers.

UI (User Interface): The visual and interactive elements of a digital product through which a user interacts with the system.

UX (User Experience): The overall experience a user has when interacting with a product, encompassing usability, accessibility, efficiency, and satisfaction.

Fixed Price Model: A pricing model in which the customer pays a predetermined, fixed amount at each billing interval regardless of actual usage.

Pay-As-You-Go Model: A pricing model in which the customer is charged based on actual usage within a given time period.

CVE (Common Vulnerabilities and Exposures): A publicly accessible reference system maintained by MITRE and the National Vulnerability Database (NVD) that assigns unique identifiers to known information-security vulnerabilities.

Erasmus+: The European Union’s programme for education, training, youth and sport. The KA220-VET action type supports cooperation partnerships in vocational education and training.

VET (Vocational Education and Training): Education and training that equips learners with skills and knowledge relevant to a specific occupation or trade.

1.3 Purpose and Research Questions

The purpose of this project is to develop, deploy, and evaluate HydroTeach — a modular, configurable educational website designed to teach hydroponics to secondary school students and teachers across multiple European countries. The project sits at the intersection of educational technology, web infrastructure, and user-centred design, and it operates within the formally defined framework of the EUPiH2 Erasmus+ cooperation partnership.

The research questions guiding the project are as follows:

1. Is it possible to develop a modular and configurable digital learning system that can be adapted to the educational contexts and requirements of different partner institutions across multiple countries?
2. What learning methods are most effective for engaging secondary school students in the subject of hydroponics within a digital environment?
3. Which elements of a website’s design most effectively capture and sustain the attention of the target audience of students and teachers?
4. How can UI/UX design principles be applied and targeted specifically towards the dual audience of students and teachers in an educational technology context?

These questions are grounded in the stated objectives of the EUPiH2 grant application, which identifies the need for a “user friendly and easy accessible webpage as a digital tool box, with collected information on how to get started with hydroponic farming" that is accessible "to people of all backgrounds and abilities, with a clear and user-friendly interface."

1.4 Methodologies

The development of HydroTeach was divided into several parallel workstreams: user interface design, user experience research, server infrastructure provisioning, content development, and the integration of evidence-based learning methods. Each workstream is described in the sections below.

1.4.1 User Research and Needs Analysis

Prior to the commencement of design work, the development team and project partners conducted structured user research to establish the requirements and expectations of the platform's intended audience. This research took the form of a survey distributed to students and teachers across the partner schools in April 2025. The survey collected responses from approximately 25 participants spanning multiple countries.

The survey results revealed strong and consistent preferences across the respondent group. An overwhelming majority of respondents indicated that information should be presented in a combination of formats, with text, images, videos, and interactive learning games all receiving significant support. This finding directly shaped the multi-modal content strategy of HydroTeach. Representative responses included preferences such as "a simple platform in a nice layout without too much text but more interactive and video content" and "I expect good videos that explains but also lots of photos + little text that summarises the overview."

When asked to define hydroponics in three words, respondents' answers reflected a broad conceptual range, including "fun, future and technical", "water, soilless, lettuce", and "modern and sustainable agriculture." This diversity of understanding confirmed that the platform would need to accommodate users from very different starting points of knowledge.

Respondents' expectations of the site were similarly revealing: several called for content "at VET level", others requested "an in depth explanation of hydroponics in theory with practical examples", and one respondent — identifying as a textbook editor — described the site's potential as constituting "a whole chapter on its own." These responses validated the project's dual-audience design philosophy.

Regarding dissemination, respondents most frequently suggested Instagram and school networks as the most effective channels for reaching the target audience, with additional suggestions including YouTube, TikTok, and QR codes distributed through schools.

1.4.2 Steering Group Feedback – May 2025

Following the first public prototype deployment, formal feedback was collected from the Steering Group at a meeting held on 23 May 2025. Representatives from all five partner institutions reviewed the prototype and provided written responses via a structured feedback form. The responses were consistently positive, with comments including “looks really good”, “it is really great”, and “a very good first draft. You have done a good job.”

The feedback also produced a set of concrete improvement requests and feature wishes that directly informed subsequent development iterations. Key actionable items included: the recommendation to rename the ‘Blog’ section to something more appropriate such as ‘Guides & Posts’, since the content would not be updated as a conventional blog after project completion; a request to include clickable school profiles for each partner institution; a call for a clearly visible ‘For Teachers’ section; the suggestion to add an explicit description of the target audience on the site; and the recommendation to optimise SEO targeting teachers searching for educational material.

One partner provided the particularly useful observation that the site should be “more connected to our project” and include photographs from the partners’ own hydroponic work, rather than stock imagery. Another noted a preference for a more prominently green colour palette “with a feel of growing plants.”

A second round of feedback (Revision 2) further developed these themes, with one respondent specifically requesting a division between teacher material and student teaching materials as distinct sections of the site.

The Steering Group meetings occur monthly and are attended by representatives from each partner institution. Within the context of WP4, dedicated website review meetings are scheduled every October and May throughout the project’s duration and for three years after its conclusion.

1.4.3 UI – User Interface

The User Interface of HydroTeach was designed with the primary goal of creating a visually coherent, accessible, and engaging experience for two distinct user groups: students and teachers. The design process employed Figma as its primary tool throughout, progressing through approximately five major redesigns and approximately 25 full rewrites of the site over the development period. This iterative approach reflects the principle that effective educational interfaces are rarely produced through a single design pass, but rather through progressive refinement informed by feedback and testing.

The initial public-facing design, first published in December 2025, featured a structured homepage with a hero section, a Types of Hydroponics grid showcasing Deep Water Culture, Nutrient Film Technique, Ebb and Flow, and Drip systems, and a Hydroponic Guides blog section. Subsequent iterations responded directly to partner feedback received at the May 2025 Steering Group meeting, which resulted in changes to the site’s navigation structure, content labelling, and visual identity.

Research in educational interface design consistently identifies minimalism and clarity as the most effective principles for reducing cognitive load in learners. According to studies on e-learning platform usability, layouts that prioritise clear navigation and reduce extraneous visual noise allow students to focus cognitive resources on learning content rather than on operating the interface.

The dual-audience requirement — serving both students and teachers — informed several key design decisions. Research in EdTech UI design recommends developing distinct user personas for each audience segment: students require engagement, visual appeal, and interactive elements, while teachers prioritise functional dashboards, ease of content access, and instructional resources. The HydroTeach interface addresses this through a proposed ‘For Teachers’ section, requested explicitly in Steering Group feedback, which would provide direct access to lecture materials, guides, and assessment tools without requiring navigation through student-facing content.

The visual identity of HydroTeach, including its logo, was developed manually by the design team rather than through AI generation — a deliberate decision noted in the project presentation materials. The logo depicts a stylised plant growing from water within a circular frame, reinforcing the hydroponic theme while projecting a modern, technology-oriented aesthetic.

1.4.4 UX – User Experience

User Experience design for HydroTeach was approached as a discipline distinct from, yet deeply intertwined with, UI design. While UI concerns the visual presentation of the interface, UX encompasses the totality of the user’s interaction with the platform: how they navigate, how they find information, how they feel during use, and whether they achieve their learning goals. Research in the field confirms that UI and UX are “two of the quintessential mechanisms that play a crucial role in the development of a user-friendly and high-quality product” in educational technology contexts.

The UX design process was grounded in a user-centred methodology, directly informed by the survey data collected in April 2025. The survey responses established clear user expectations: content should be multi-format, not text-heavy, and the platform should be “easy to use and interactive.” These findings align with established UX principles for educational platforms, which emphasise prioritising ease of use, supporting engagement through interactivity and rewards, and demonstrating user progress as core design requirements.

Accessibility was a further consideration in the UX process. The EUPiH2 grant application explicitly commits the platform to serving students with fewer opportunities, noting that “students with special needs are addressed using videos, pictures and other visual materials.” This commitment is consistent with established accessibility guidelines and the GDPR obligations associated with the project’s European context, as the platform handles data from student users across multiple countries.

The UX of the platform was also designed to support the specific learning methods described in Section 1.4.7, including interactive exercises, quiz-based activities, and practical guides. Research recommends that UX designers in education understand how to reflect good pedagogical practice within a product, choosing features that facilitate learning and sequencing content in alignment with learning science principles.

A key UX challenge identified through the feedback process was the navigation and labelling of the content sections. The Steering Group’s recommendation to rename ‘Blog’ to ‘Guides & Posts’ is an example of UX refinement driven by user input: the original label created false expectations about the type and frequency of content updates, which would have confused returning users.

1.4.5 Server Infrastructure

The selection and configuration of the server infrastructure constituted a significant component of the project. Initial consideration was given to platform-as-a-service providers such as Vercel and Heroku, which offer streamlined deployment pipelines for Next.js applications. However, it was determined early in the process that the project's requirements exceeded the capabilities of these platforms and that a Virtual Private Server (VPS) solution would be more appropriate.

The primary criteria for selecting a hosting provider were: European server location for GDPR compliance, cost-effectiveness relative to the project's budget, support for Linux-based virtual machines, and the availability of invoice-based billing. Following an evaluation of several providers — including Linode, Hetzner, and Karabro — the team initially selected Hetzner. However, an administrative constraint emerged: NTI Gymnasiet Lund was unable to process payments through Hetzner's card-based billing system, as the school required invoice-based payment. The project subsequently selected Karabro, a smaller hosting provider with servers located in Malmö and Lund, Sweden.

A fixed price model was also a deliberate decision, chosen over a pay-as-you-go model to ensure cost predictability throughout the project lifecycle. This decision is also consistent with the WP4 budget framework, which estimated hosting costs at approximately €240 per year over the project duration.

1.4.5.1 Web Server

The web server was initially run as a Docker container hosting the Next.js application. Following the security incident described in Section 1.4.5.7, and as part of a broader re-evaluation of the technology stack, the framework was migrated from Next.js to SvelteKit. The SvelteKit application was subsequently containerised using Docker and deployed to the Karabro VPS, where it serves as the production web server for HydroTeach.

1.4.5.2 DNS

Cloudflare was selected as the DNS management provider due to its comprehensive feature set: a granular permission system for managing DNS records, built-in caching solutions to improve global response times, and DDoS protection to defend the server against volumetric attacks. Cloudflare also provides an additional security layer between the public internet and the origin server. The domain hydroteach.eu was identified as the preferred domain during the project's planning phase, with hydroedu.eu as an alternative.

1.4.5.3 Reverse Proxy

The selection of a reverse proxy involved a structured evaluation process conducted by the lead of development and the lead of infrastructure. A shortlist of candidates was assembled comprising Nginx, Nginx Proxy Manager, Traefik, and Caddy. Each option was assessed against criteria including ease of configuration, support for Docker-native routing, automatic TLS certificate provisioning, and community support. Traefik was ultimately selected due to its native integration with Docker, its ability to automatically discover and route to containers via labels, and its support for automatic HTTPS certificate management through Let's Encrypt.

1.4.5.4 CI/CD Pipeline

The CI/CD pipeline was implemented using GitHub Actions. The workflow operates as follows: developers push code changes to a dedicated development branch. When the development branch is considered stable and ready for release, it is merged into the production branch. A merge or commit to the production branch triggers a GitHub Actions job that compiles the Docker image from the updated source code, pushes the image to the container registry, and deploys the updated container to the Karabro VPS. This pipeline ensures that the production environment is always synchronised with the latest approved code, while protecting the live site from untested changes.

1.4.5.5 Matomo

Matomo has been selected as the web analytics solution for HydroTeach and its deployment is planned as a subsequent step in the infrastructure rollout. As an open-source, self-hosted platform, Matomo enables the collection of visitor data without transmitting it to third-party commercial services, which is a critical consideration given the project’s obligations under GDPR. The EUPiH2 grant application identifies visitor analytics as a formal quantitative indicator for WP4, with a target of 500 unique visits, making the deployment of Matomo a project milestone.

1.4.5.6 Grafana

Grafana was deployed to provide infrastructure monitoring and observability for the server environment. It was configured to visualise metrics including CPU utilisation, memory usage, network throughput, and container health. The Grafana dashboard provided the development team with real-time visibility into server performance, which proved particularly valuable during the security incident described in Section 1.4.5.7, when anomalous network traffic was detected and investigated.

1.4.5.7 Security Incident – CVE-2025-29927

Approximately 24 hours after the first production deployment of HydroTeach, an anomaly was identified in the server’s network traffic. This discovery was triggered by direct communication from the owner of Karabro, who observed unusually high outbound network utilisation from the virtual machine. Subsequent analysis of network traffic confirmed a significant and sustained increase inconsistent with normal usage patterns, with data showing markedly higher throughput when the website was active compared to when it was offline.

Further investigation identified the root cause: the initial production deployment was running a version of Next.js affected by CVE-2025-29927, a critical authorisation bypass vulnerability disclosed by Vercel on 21 March 2025 and assigned a CVSS score of 9.1. The vulnerability was discovered by security researcher Rachid Allam and stems from improper handling of the internal HTTP header *x-middleware-subrequest*. This header was originally designed for internal use within the Next.js framework to prevent infinite middleware execution loops. However, due to a design flaw, its value could be predicted and spoofed by external actors.

By including a specially crafted *x-middleware-subrequest* header in an HTTP request, an attacker could cause the Next.js runtime to skip its middleware execution phase entirely, bypassing authentication, authorisation, and any security policy checks implemented at that layer. The affected versions included all Next.js releases prior to 12.3.5 (for the 12.x branch), 13.5.9 (for 13.x), 14.2.25 (for 14.x), and 15.2.3 (for 15.x). The production deployment of HydroTeach used a version within the affected range.

The potential consequences of successful exploitation are significant: attackers could gain unauthorised access to protected routes and administrative interfaces, bypass Content Security Policy headers, cause cache poisoning, or trigger denial-of-service conditions. The ease of exploitation — requiring only the addition of a single HTTP header to a request — and the vulnerability's high CVSS score of 9.1 categorise it as a critical risk.

Upon confirming the affected version, the development team implemented immediate remediation. The patch implemented by the Next.js maintainers addressed the vulnerability through two mechanisms: stripping all externally supplied instances of the internal header before they could reach the middleware execution layer, and validating the header value against a randomly generated hexadecimal string to ensure only legitimate internal requests pass through.

In parallel with addressing the immediate vulnerability, the team conducted a broader review of the technology stack, which ultimately contributed to the decision to migrate from Next.js to SvelteKit, thereby eliminating the affected framework entirely from the production environment. The incident demonstrated the critical importance of dependency version management in self-hosted web applications, and the value of infrastructure monitoring: without Grafana and the hosting provider's own monitoring, the exploitation may have persisted undetected for a significantly longer period.

1.4.5.8 SvelteKit Migration

The migration from Next.js to SvelteKit was not solely a reactive response to the security incident; consideration of SvelteKit as an alternative had been underway prior to the CVE discovery. The incident accelerated a decision that was already being discussed. SvelteKit is an open-source, full-stack web framework built on Svelte, which compiles component code to highly optimised vanilla JavaScript at build time, resulting in minimal runtime overhead and faster page loads compared to React-based frameworks. The migration offered several advantages: elimination of the compromised framework, reduction in bundle size, improved server-side rendering performance, and a simpler deployment model. The SvelteKit application was containerised using Docker and integrated into the existing CI/CD pipeline without significant changes to the deployment workflow.

1.4.6 Content Strategy

The content of HydroTeach is developed collaboratively across the partner institutions, with each school contributing materials according to its area of expertise as defined in WP2 and WP5 of the grant application. NTI Gävle is responsible for content on how to build hydroponic systems and how to use IT in hydroponic monitoring. NTI Lund is responsible for the IT and sensor-based content. RTS leads the overall coordination of teaching materials and the practical guidelines sections. Yuverta produces the system definition content and light and temperature material. Fraisoro contributes material on growing substrates.

The content is structured across five activity areas within WP2: an introduction to hydroponic cultivation systems in a sustainable future (A1), definitions of the different hydroponic systems including aquaponics, bioponics, hydroponics, and aeroponics (A2), European examples of hydroponic cultivation systems presented via film (A3), presentations of hydroponic companies in Europe (A4), and comprehensive theory and practical guidelines covering plant nutrients, light and temperature, irrigation, growing materials, system construction, and IT monitoring (A5).

All content is produced in English as the working language, with planned translations into Danish, Swedish, Dutch, Spanish, and Basque to ensure accessibility for students across all partner countries. The grant application acknowledges that "many VET school students may find it difficult to use English as a working language," particularly students with fewer opportunities, making multilingual content a formal project obligation.

At the time of writing, content production is ongoing. The site has been deployed in a prototype state with initial content, and further material is being developed and will be added progressively as each work package activity is completed through to the project's conclusion in February 2027.

1.4.7 Learning Methods

The pedagogical design of HydroTeach is grounded in a multi-modal learning approach. The project presentation identifies planned features including videos, a blog/guides section, a Kahoot-style competitive system, a quiz-based learning system, teaching tools for teachers including results overviews, and downloadable documents and handbooks. Rather than relying on a single instructional method, the platform integrates several evidence-based strategies to accommodate different learning styles and to maximise engagement and retention among secondary school students.

1.4.7.1 Interactive Learning

Interactive learning is a pedagogical approach that requires active engagement from the learner rather than passive consumption of information. On HydroTeach, interactive elements are planned to include embedded exercises, self-check questions, and navigable diagrams that require the user to make decisions or inputs in order to progress. The survey data collected from potential users in April 2025 revealed that interactive learning games were among the most frequently requested content formats, with the majority of respondents selecting 'Interactive learning (games, etc.)' as a preferred presentation format. This strong user demand validates the inclusion of interactivity as a core feature of the platform.

Research in educational technology confirms that active engagement with content improves both comprehension and retention compared to passive reading. Interactive features also provide immediate feedback, which is a key principle of effective instructional design: learners benefit from knowing whether their responses are correct while the material is still fresh, creating a direct link between action and outcome.

1.4.7.2 Practical Learning

One of the primary goals of HydroTeach is to promote a practical learning experience through the construction of physical hydroponic systems. The EUPiH2 grant application explicitly describes this goal, stating that teaching materials will include “how to build your own hydroponic system” with guidelines, diagrams, and films enabling students to construct systems independently. NTI Gymnasiet Lund is specifically tasked with producing the IT monitoring content, while NTI Gävle is responsible for the system construction guides.

The practical learning approach is grounded in the principle of learning-by-doing, which is among the most empirically supported methods in educational research. Practical tasks give students the opportunity to fail, iterate, and improve, developing problem-solving skills and a deeper understanding of the subject matter than theoretical instruction alone can provide. Survey respondents confirmed this expectation, with one noting that the site should be “both informational so that everyone can build their own hydroponic system at home step by step” and accessible enough “to even teach children with it.”

1.4.7.3 Theoretical Learning

Theoretical content forms the foundational layer of the HydroTeach curriculum. Students are introduced to the scientific principles underlying hydroponics, including plant biology, nutrient chemistry, and the mechanics of different system types. The EUPiH2 grant application describes the theoretical content as covering “plant growth and nutrients, water, light and growing materials,” with a strong emphasis on STEM competences in chemistry, physics, mathematics, and information technology.

The survey data confirmed demand for theoretical depth alongside accessibility: one respondent specifically called for content that “critically examines the claim that hydroponics systems are sustainable systems — they can be, under very specific circumstances.” This reflects a mature pedagogical expectation: students benefit not only from enthusiastic promotion of hydroponics but from honest, evidence-based analysis of its limitations and conditions for success.

1.4.7.4 Competitive Learning

The competitive learning method planned for HydroTeach is conceptually analogous to Kahoot, a widely used educational quiz platform. As identified in the project presentation materials, a Kahoot-style system is among the planned features of the platform. In a competitive learning scenario, two or more students engage in a knowledge challenge in which speed and accuracy are rewarded: the faster a student provides a correct answer, the more points they accumulate.

This format activates the brain’s reward system through the release of dopamine. Neuroscientific research demonstrates that dopamine is released not at the moment of receiving a reward, but in the anticipatory moment immediately before the outcome is revealed — precisely the psychological state induced by a timed competitive quiz. Research on the mesolimbic reward pathway shows that this anticipatory release can facilitate memory consolidation by triggering dopamine release in the hippocampus, which is the brain region most directly involved in the encoding of new memories. Studies have found that gamification mechanisms rooted in these neurochemical principles can improve learning retention rates by up to 80% compared with traditional instruction methods.

However, competitive formats must be implemented thoughtfully. Research indicates that leaderboards can lower motivation for students who consistently appear near the bottom of rankings, and that rotating team-based formats, progress-based tracking, and periodic resets help maintain motivational benefits across the full student cohort.

1.4.7.5 Repetitive Learning

Repetitive learning is a well-established pedagogical strategy based on the principle that information is more reliably encoded into long-term memory through repeated exposure over time. On HydroTeach, repetitive learning is supported by the modular structure of the content, which allows students and teachers to revisit specific topics as required. The platform's quiz and self-assessment features will also support repetition, enabling students to retake exercises to reinforce knowledge that was not fully consolidated during the initial attempt.

This approach is consistent with the psychological concept of spaced repetition, supported by findings that gamification elements such as short modules and micro-challenges minimise the effort required to re-engage with material, and that each small success provides a dopamine reinforcement that builds momentum and consistency over time.

1.4.7.6 Quiz-Based Learning

Quiz-based learning is used on HydroTeach both as a formative assessment tool and as a standalone learning activity. The project presentation identifies a quiz learning system as a distinct planned feature, separate from the competitive Kahoot-style system, targeting individual self-assessment.

From a neuroscientific perspective, the act of attempting to retrieve information — even when the retrieval is unsuccessful — strengthens the memory trace associated with that information, a phenomenon known as the testing effect. Research confirms that extrinsic rewards trigger dopamine release, which causes positive emotions and fosters the storage of newly learned information into long-term memory. Dopamine release each time a student responds correctly to a quiz item reinforces the behaviour and motivates continued engagement.

Medical education research further confirms that badges and quiz-based reward elements allow instructors to provide feedback on failure without imposing punitive consequences, supporting a low-stakes but motivating assessment environment. This is directly relevant to the HydroTeach context, in which many students may be encountering hydroponics for the first time and may require encouragement rather than pressure.

2. Result

2.1 Synthesis

The principal outcome of the project at the time of writing is the successful development and deployment of the HydroTeach website in a production-ready state. The platform is hosted on the Karabro VPS, is publicly accessible, and has been reviewed and positively received by the Steering Group at the May 2025 meeting. The technology stack — SvelteKit, Docker, Traefik, and Cloudflare — is fully operational, and the CI/CD pipeline via GitHub Actions ensures that future updates can be deployed efficiently and safely.

The design process produced approximately five major redesigns in Figma over the development period, reflecting the iterative refinement that characterises professional web development. User research was conducted through a structured survey of approximately 25 respondents from partner schools, whose input directly shaped the platform's content format strategy, navigation structure, and feature prioritisation. Formal Steering Group feedback was collected in May 2025 and resulted in documented improvement actions including content labelling changes, the introduction of partner school profiles, and a more clearly defined teacher-facing section.

The modular website architecture developed is capable of hosting multiple content types (theoretical articles, practical guides, interactive elements, and quiz-based activities) and is configurable to accommodate the educational contexts of different partner institutions. This directly addresses the first research question regarding the feasibility of a modular and configurable digital learning system. The grant application's WP4 objectives describe the intended outcome as "a user friendly and easy accessible webpage as a digital tool box" with a "clear and user-friendly interface that is easy to navigate," accessible to people of all backgrounds and abilities.

The learning methods integrated into the platform represent a comprehensive multi-modal approach grounded in educational research. The design of each method was informed by evidence from learning science and neuroscience, as detailed in Section 1.4.7. Interactive features, quizzes, and a competitive system are planned for implementation as the content development phase of the project progresses through 2026.

At the time of writing, formal user testing and structured assessment of student learning outcomes have not yet been conducted. The platform is deployed and operational, but data collection from student and teacher users is planned as a subsequent phase of the project. Matomo analytics has not yet been deployed; this represents a pending infrastructure task. The absence of empirical usage data is acknowledged as a limitation of the current evaluation.

3. Discussion

3.1 Result Discussion

The deployment of HydroTeach represents a meaningful achievement within the constraints of the project. The team successfully navigated the complexity of a multi-national collaboration involving five institutions across four countries, each with different languages, institutional structures, and pedagogical traditions. The grant application acknowledges these challenges explicitly, noting that "coordination and collaboration" in the content-producing activities require particular care because "each country has different time of year with holidays and exams where it's not possible to meet or work."

The security incident involving CVE-2025-29927 was a significant and instructive event. The speed with which the vulnerability was identified — within approximately 24 hours of the first production deployment — reflects positively on the monitoring infrastructure that had been put in place. The incident also had a productive outcome in that it prompted the migration to SvelteKit, which is a more appropriate framework for a project of this scale and resulted in a leaner, more performant production environment.

The user research process represents a genuine methodological strength of the project. The April 2025 survey, while relatively small in scale (approximately 25 respondents), captured authentic expectations from the target audience across multiple countries. The finding that the overwhelming majority of respondents wanted interactive, video-rich, and visually driven content — rather than text-heavy pages — directly validates the multi-modal design philosophy of the platform.

The Steering Group feedback process also demonstrated that the project's governance structure is functioning as intended. The grant application commits to biannual website review meetings "every October and May" throughout the project duration, and the May 2025 session produced concrete, actionable feedback that was documented and acted upon. Partner responses were encouragingly enthusiastic, with one partner stating: "Do not be afraid to leave something to view before you feel it is ready. It is part of a development process. Everyone are impressed with your job and skills."

3.2 Conclusion

HydroTeach demonstrates that it is feasible to develop a modular, configurable educational platform within the context of a transnational school partnership, using open-source technologies and a constrained budget. The platform integrates multiple evidence-based learning methods, a technically sound infrastructure, and has been successfully deployed to a production environment and received by an international Steering Group.

The four research questions posed at the outset of the project have been addressed to varying degrees. The feasibility of a modular learning system has been demonstrated through the deployment of the platform and its capacity to host multiple content types and serve multiple institutional partners. The selection of learning methods has been informed by research in educational neuroscience and learning science. The UI/UX design decisions have been grounded in established principles for educational technology interfaces and validated through user surveys and Steering Group feedback. The question of which specific design elements most effectively capture user attention, and the broader question of learning effectiveness, will require empirical data from user studies to be answered definitively.

The project's longer-term trajectory is defined by the Erasmus+ project timeline: content development continues through to February 2027, and NTI Gymnasiet Lund is committed to maintaining the website for three years beyond that date. As stated in the grant application, "the students in Sweden who attend the webcourse at NTI will three years after the project ends continuously work with the digital toolbox."

3.3 Discussion of Methodology

The methodology employed combined technical development practices (agile iteration, CI/CD, containerisation) with pedagogical design principles and user-centred design methods. This interdisciplinary approach was both a strength and a challenge: it required team members to operate across technical, creative, and academic domains simultaneously.

The iterative design process, supported by prototyping in Figma and multiple feedback cycles including formal Steering Group reviews and a broad user survey, was effective in producing a coherent and progressively improving interface. The approximately five major redesigns and 25 site rewrites reflect a thorough commitment to iteration, which is characteristic of professional-grade product development.

The infrastructure methodology was generally sound. The use of Docker and CI/CD pipelines provided reproducibility and deployment efficiency. The security incident, while disruptive, was managed effectively and led to improvements in the overall stack. The manual server setup approach, while not providing the automated reproducibility of a configuration management tool such as Ansible, was appropriate for a project of this scale given the team's available time and resources.

The user research methodology could be strengthened in future iterations. The April 2025 survey, while valuable, was conducted at a single point in time before the prototype was publicly available. Future research phases should include post-deployment usability testing with representative users from each partner country, which would provide empirical data to answer research questions 3 and 4 more definitively.

3.4 Source Evaluation

The sources used in this thesis span the Erasmus+ grant application and formal project documentation, user survey data collected from real respondents, Steering Group meeting notes, peer-reviewed academic publications, technical security advisories, and industry research on UI/UX and learning science.

The Erasmus+ grant application (KA220-VET-AAFE5AC7) is the most authoritative primary source used, providing the formal project context, partner information, work package structures, budget allocations, and stated objectives against which the website's development can be evaluated. The user survey data and Steering Group feedback documents are primary empirical sources produced specifically within the context of this project, lending them strong relevance and authenticity.

Peer-reviewed sources from journals including Frontiers in Education, the Journal of Cognitive Sciences and Human Development, and Cogent Education provide a robust empirical foundation for the claims made regarding learning methods and gamification. Technical sources, including CVE advisories from the National Vulnerability Database and security analyses from organisations such as Datadog Security Labs, Akamai, and Zscaler, are authoritative references for the infrastructure and security sections. While these security sources are not peer-reviewed, they are published by recognised organisations in the cybersecurity field and are consistent with each other and with the official CVE record.

3.5 Subjective Evaluation

3.5.1 Chaspian Stoltz Johannesson

[To be completed by the author.]

3.5.2 Timo Hirsch Mörk

[To be completed by the author.]

3.5.3 Johann Albrecht

[To be completed by the author.]

3.5.4 Alexander Wollmér

[To be completed by the author.]

3.5.5 Ulrika Assarehn

[To be completed by the author.]

3.5.6 Mats Wahlberg

[To be completed by the author.]

3.6 Objective Evaluation

3.6.1 The Server

The server infrastructure performed reliably following the resolution of the CVE-2025-29927 security incident and the subsequent migration to SvelteKit. The combination of Traefik as a reverse proxy, Docker for containerisation, and Cloudflare for DNS management and DDoS protection provides a resilient and maintainable architecture. The observability stack (Grafana) enabled rapid detection of the security anomaly and provides ongoing visibility into server health. The fixed-cost model with Karabro ensures budgetary predictability for the remainder of the project and is consistent with the €240/year hosting cost estimated in the WP4 budget.

3.7 Sources of Error

- Unclear communication from the Steering Group regarding requirements and deliverables at the outset of the project, making it difficult to prioritise development tasks and align expectations across partner institutions.
- The Steering Group's requirements were not fully defined at the outset of the project, leading to scope changes during development. This is reflected in the project's own documentation, which acknowledges the challenge of coordinating across organisations with different academic calendars and internal processes.
- Documentation received from certain partner institutions contained terminology without clear operational definitions. Terms such as 'Digital Toolbox' and 'Work Packages' were used extensively before their scope and deliverables were formally agreed upon, creating ambiguity in planning.
- Challenges in cross-institutional collaboration, particularly in establishing shared timelines and agreeing on deliverable formats with all five partner schools across four countries.
- The 30-month duration of the Erasmus+ project introduces risks related to staff turnover, institutional continuity, and the evolving technical landscape over the project lifecycle.
- The security incident involving CVE-2025-29927 introduced an unplanned interruption to the development timeline and required a full framework migration, affecting the project schedule.
- The absence of Matomo deployment at the time of writing means that no quantitative visitor data is yet available to evaluate the platform's reach, which limits the completeness of the Results section.

4. Source Declaration

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