Open Source and Online Platforms in STEM Education

Nilay Muslu-Komurcu, Hasan Zuhtu Okulu

Mugla Sitki Kocman University, Türkiye

Chapter Highlights

The following highlights outline the role, structure, and classroom applications of open-source and online platforms in supporting accessible, scalable, and innovative STEM education.

- Defining Open-Source and Online Platforms – Clear distinctions and shared features, emphasizing openness, scalability, and adaptability.
- Open-source and online platforms in STEM education – Importance and significance of open-source and online platforms in STEM education
- Selected Platforms – In-depth discussion of TeachEngineering, NASA STEM Engagement, STEM Learning, and Scientix MOOCs, complemented by PhET, Code.org, and OpenSciEd.
- Practical Applications – Classroom vignettes illustrating how teachers use platforms to overcome barriers in time, pedagogy, assessment, curriculum integration, and professional development.

To Cite This Chapter:

Muslu-Komurcu, N., & Okulu, H. Z. (2025). Open source and online platforms in STEM education. In M. T. Hebebci (Ed.), *Innovative Practices in STEM Education: Emerging Technologies, Pedagogies and Learning Models* (175-200). ISRES Publishing

Introduction

In recent years, our understanding of education has undergone significant changes in response to global challenges such as climate change and rapid population growth. These forces have given rise to shifting societal needs, compelling education systems to adapt. This rethinking emphasizes not only broader accessibility but also equity. In other words, it ensures that learning opportunities are disseminated fairly and reach those most affected by these challenges. As a result, inclusivity and accessibility have become central to modern educational approaches (Navas-Bonilla et al., 2025). Technologies such as open sources, digital learning tools, and online platforms have played a key role in shaping how education reaches learners (Mexhuani, 2025). STEM education is no exception to this transformation.

STEM education centers on the science, technology, engineering, and mathematics and the integration of these disciplines into real-life contexts (Kelley & Knowles, 2016). This approach aims not only to provide students with scientific knowledge but also to foster the development of interdisciplinary thinking skills (Awad, 2023). In STEM education, engineering occupies a special position, as it not only represents a single discipline but also integrates the others through the engineering design process (English et al., 2017). Thus, mathematics, science, technology, and engineering are not treated as separate domains but rather as an integrated structure aimed at solving real-world problems (Couso & Simmaro, 2020). This integrated approach underscores the need for STEM education to be accessible to a wider audience. Open-source tools and online platforms serve as essential vehicles for linking real-world problem solving with equitable learning opportunities. These tools play a significant role in the development and dissemination of STEM education. They make learning materials more accessible, enable collaboration among teachers and students, and facilitate the rapid sharing of innovative practices (Sanabria-Z. et al., 2024).

Open Source and Online Platforms in Education

Education has transcended the traditional boundaries of the classroom. While knowledge has long been accessible through books and libraries, today learners can even complete entire courses at a distance. Over time, online platforms advanced from static repositories of resources into dynamic ecosystems that promote collaboration, personalization, and assessment (Liu & Yu, 2023). Importantly, these developments paved the way for open-source online platforms, where educational resources and tools are freely accessible to anyone with an internet connection. While distance education laid the groundwork for separating learning from physical classrooms, the early 2000s marked a new stage with the emergence of the Open Educational Resources (OER) movement (Mishra, 2017). The OER philosophy gradually shaped the evolution of online platforms. Whereas traditional distance education mainly relied on institutionally controlled distribution, OER initiatives promoted openness, collaboration, and adaptation across institutional and national boundaries (Li & Wong, 2021; Mishra, 2017). It also led to an important cultural shift: learners were no longer passive recipients of content, but became co-creators by adapting and redistributing materials. This understanding of openness influenced the development of cMOOCs, which emphasized networking, collaboration, and learner autonomy through a connectivist pedagogy. In contrast, xMOOCs are characterized by educator-led instruction and large-scale content delivery, as seen in early platforms like Coursera and edX (Stracke et al., 2019).

To better understand the platforms for STEM education, it is essential to clarify two key terms: open-source platform and online platform. These concepts are sometimes used interchangeably, but they have distinct meanings in the literature. The term open-source platform originates from software development, where open-source refers to making the source code freely available for use, modification, and redistribution (Oussous et al., 2023). In educational contexts, this translates into platforms that not only provide resources but also allow educators to adapt tools to specific pedagogical needs. By contrast, an online platform refers broadly to any web-based environment where learning materials are hosted, distributed, and experienced. Stracke et al. (2019) define online platforms in education through the example of MOOCs, which extend university courses to massive global audiences. Online platforms may be proprietary or open-access, and they can operate on a small or large scale. Their defining feature is that they enable learners and educators to connect through digital environments. In doing so, they often help overcome geographical and temporal boundaries. Open-source platforms emphasize adaptability, freedom to modify, and community-driven development, while online platforms prioritize delivery, scalability, and access (Josué et al., 2023). Openness in education encompasses both technical openness (e.g., open-source code) and content openness (e.g., freely licensed materials), while also serving as a pedagogical value aligned with democratization of knowledge and social justice in education (Sousa et al., 2023). Recognizing these multiple dimensions of openness is essential for understanding how platforms operate within STEM education.

Open-Source and Online Platforms for STEM Education

STEM education has undergone substantial transformations, driven by the dual forces of digital innovation and the need for inclusive, high-quality learning opportunities (Chu, 2025). Online and open-source platforms have emerged as central tools for extending access to STEM disciplines, fostering collaboration, and promoting interdisciplinary problem-solving. These platforms not only deliver content but also provide environments where learners can practice critical thinking, engage in inquiry-based activities, and interact with real-world problems (Dao et al., 2025). STEM education, by its very nature, requires the integration of multiple disciplines. Yet for teachers, achieving pedagogically meaningful integration is not always feasible, as teacher preparation is typically rooted in specialization within a single discipline. Even so, a teacher without formal engineering education and with limited experience in the engineering design process can still implement high-quality STEM activities. Such implementation is facilitated through access to activities provided by open-source and online platforms. These activities may include classroom applications, worksheets, and assessment practices. Moreover, by building on these experiences, teachers may design their own STEM activities, fostering a sustainable approach to STEM education. Nevertheless, it is crucial that teachers have access to appropriate resources. Therefore, in this section, we illustrate how to identify such resources by introducing a set of six criteria used to guide the selection of example technological platforms.

To examine the role of open-source and online platforms in STEM education, it was first necessary to identify exemplary cases of best practices at the global level. These platforms illustrate effective integration of digital tools into teaching and learning. At the same time, they demonstrate potential relevance for diverse educational contexts. To ensure coherence and consistency in the analysis, several criteria were applied in the selection process.

- **Alignment with STEM curricula and standards:** Platforms were selected if they offered resources covering the core STEM subjects, with particular emphasis on facilitating learner interaction. Alignment with established curriculum frameworks ensures that resources can be directly integrated into classroom practice.
- **Free or low-barrier access:** Accessibility is a defining feature of open-source and online platforms. The selected platforms offer their core resources at no cost, thereby reducing barriers for both

teachers and students. This was considered essential to support equitable access across regions with varying levels of educational infrastructure.

- **Pedagogical richness:** Platforms were evaluated based on the degree to which they provide interactive, hands-on, and authentic learning opportunities. Resources that go beyond static text such as simulations, multimedia materials, maker challenges, and project-based activities were prioritized.
- **Support for educators:** Effective adoption of platforms depends on teacher readiness and scaffolding. For this reason, platforms offering professional development, communities of practice, instructional guides, or teacher-focused resources were included. These supports enable teachers to integrate materials into their classrooms more effectively.
- **Global relevance and adaptability:** While the platforms under review were developed in specific national contexts (e.g., United States or United Kingdom), they were selected for their potential to be adapted for international use. Their global reach, flexible structures, and emphasis on fundamental STEM practices make them valuable beyond their original contexts.
- **Evidence of impact and credibility:** Finally, preference was given to platforms with demonstrated effectiveness, credibility, or institutional backing. This includes evidence from usage statistics, evaluations, or recognition by established educational organizations, ensuring that the platforms examined are not only theoretically promising but also practically impactful.

Based on these criteria, four platforms were selected for detailed examination: TeachEngineering, NASA STEM Engagement, STEM Learning (UK), and Scientix MOOCs. Collectively, these platforms represent curriculum support, real-world STEM applications, and professional development opportunities. To broaden the perspective, shorter descriptions of other widely used platforms such as PhET, Code.org, and OpenSciEd will also be included. Although PhET, Code.org, and OpenSciEd met the selection criteria, they were categorized as supplementary platforms. This is because, rather than providing complete STEM lesson plans, they offer educational materials such as simulations and coding activities that can be integrated into STEM lessons. Table 1 presents a comparative overview of these platforms based on key selection criteria, including curriculum alignment, accessibility, pedagogical richness, educator support, global relevance and adaptability, and evidence of impact and credibility.

Table 1. Comparative Analysis of Selected STEM Education Platforms Based on Key Evaluation Criteria

Criteria	TeachEngineering	NASA STEM Engagement	STEM Learning (UK)	Scientix MOOCs	Supplementary Platforms (PhET, Code.org, OpenSciEd)
Curriculum alignment	Next Generation Science Standards (NGSS)-aligned lessons in science and engineering; easy to adapt to other national standards.	Resources linked to U.S. STEM education frameworks-strong focus on space/earth science.	Directly linked to UK National Curriculum in STEM subjects.	Covers STEM-related Professional Development (PD) courses (e.g., citizen science, nature-based solutions); adaptable to general STEM education, though less tied to K–12 curricula.	PhET simulations aligned with science/math; Code.org aligned with Computer Science standards; OpenSciEd aligned with NGSS.
Accessibility	Fully free and open access.	Freely available globally via NASA portal.	Many resources free; some professional development requires fees.	Mostly free MOOCs accessible globally through the Scientix platform.	PhET and Code.org free; OpenSciEd curriculum free.
Pedagogical richness	Hands-on, inquiry-based engineering design challenges. Example: Renewable energy project.	Inquiry- and challenge-based learning with multimedia. Example: NASA Student Challenge on Mars habitats.	Inquiry-based experiments and real-world contexts. Example: Renewable energy lesson pack.	Offers MOOCs on inquiry-based, real-world topics (e.g., citizen science, sustainability).	PhET: interactive simulations; Code.org: Hour of Code activities; OpenSciEd: inquiry-based science units.
Educator support	Teacher guides, rubrics, and background information etc..	Lesson plans, webinars, and educator workshops etc.	Strong Continuing Professional Development, STEM Ambassadors, and online communities.	Explicitly designed for teacher professional development; strong PD focus, resources, and networking.	PhET provides teaching tips; Code.org offers curricula + PD; OpenSciEd provides teacher guides.

Global relevance and adaptability	Open-ended design challenges adaptable worldwide.	Universal appeal of space science; adaptable to international classrooms.	Materials tailored for the UK but adaptable internationally; PD less accessible globally.	Pan-European initiative, globally relevant topics; adaptable internationally but with some EU focus.	PhET widely translated); Code.org global adoption; OpenSciEd adaptable but U.S.-centric.
Evidence of impact and credibility	NSF-supported, widely adopted in U.S. K–12.	Backed by NASA with extensive outreach evaluation.	Government-funded, university- and industry-backed, evaluation studies available.	Backed by European Schoolnet; credible network, though limited published impact studies specific to MOOCs.	PhET validated in research; Code.org widely studied; OpenSciEd backed by major foundations.

As seen in Table 1, the platforms examined in this section illustrate the breadth and diversity of open-source and online tools currently available for STEM education. They meet comprehensive criteria: they align with curricula, provide free or low-barrier access, emphasize interactivity, and offer professional support for educators. Each demonstrates how digital platforms can serve not only as repositories of knowledge but also as ecosystems that connect teachers, students, and communities of practice. At the same time, supplementary platforms such as PhET, Code.org, and OpenSciEd highlight the specialized contributions of narrower initiatives that focus on simulations, computer science, or open science curricula. Taken together, these platforms show how a wide range of digital resources can support STEM learning at different scales and for different purposes. To explore these dynamics in greater detail, the following subsections examine the platforms individually, showcasing how each contributes STEM education.

TeachEngineering

TeachEngineering is a free, open-access digital library developed through collaborations among U.S. universities with support from the National Science Foundation (NSF). It offers more than 1,900 standards-aligned lessons and activities that emphasize engineering design and inquiry learning. All resources are mapped to the NGSS, ensuring pedagogical rigor. Although these resources are designed for U.S. classrooms, the activities are adaptable to international contexts. The platform provides detailed teacher guides, rubrics, and background information, making it a practical tool for classroom use. Its credibility is underscored by NSF funding and wide adoption in K–12 STEM education. TeachEngineering is available at: https://www.teachengineering.org. Figure 1 illustrates the TeachEngineering digital library interface, where educators can browse, standards-aligned lessons, activities, and units by grade level, curriculum type, or subject area.

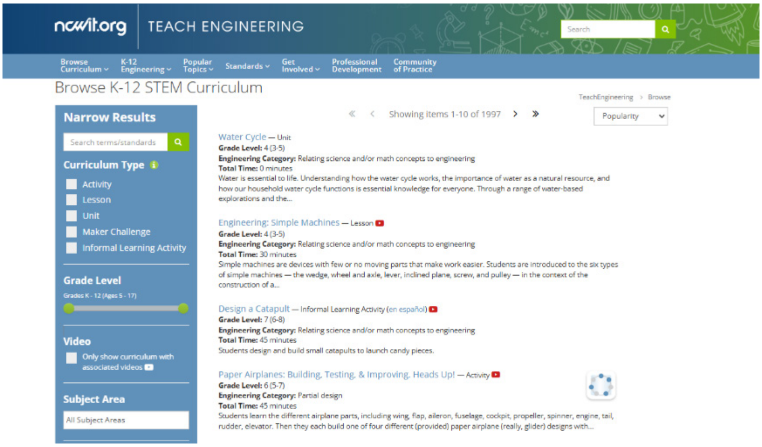

Figure 1. TeachEngineering Interface with Searchable K–12 Stem Resources

NASA STEM Engagement

NASA STEM Engagement provides authentic, mission-based resources that connect students to space exploration, climate science, and robotics. Through simulations, multimedia materials, and inquiry-driven challenges, it fosters curiosity and links classroom learning to real-world scientific endeavors. This platform is particularly significant because it emphasizes examples related to space, climate change, and sustainability, which can foster students' creativity and influence their perspectives on potential future careers. Such an emphasis aligns with the broader objectives of STEM education, as it seeks not only to develop disciplinary knowledge but also to cultivate innovative thinking and awareness of diverse professional pathways. The platform is freely available worldwide and is backed by the authority of NASA, which adds significant credibility. However, its close alignment with U.S. standards and the need for advanced teacher expertise in some areas may limit straightforward adoption internationally. It is accessible via the official website: https://www.nasa.gov/learning-resources/stem-engagement/. Figure 2 shows the NASA STEM Engagement interface, which presents program elements, highlights, and opportunities that connect students with NASA's people, content, and facilities.

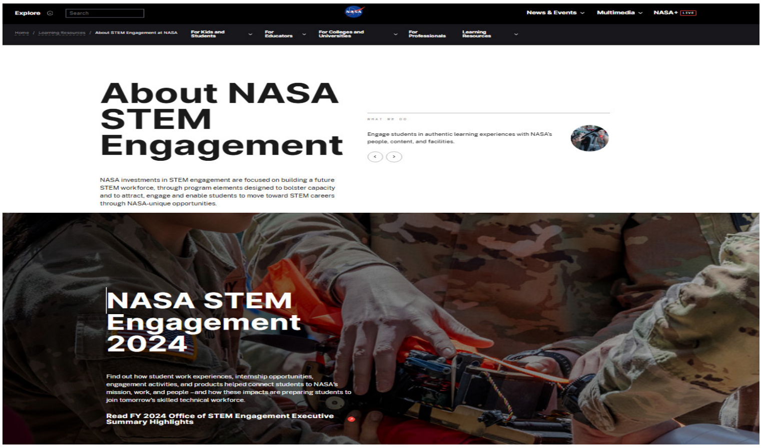

Figure 2. NASA STEM Engagement Platform Interface

STEM Learning

STEM Learning is the largest provider of STEM education support in the UK, offering curriculum-linked teaching resources, professional development opportunities, and access to the STEM Ambassador program. Its strengths lie in its dual focus on classroom practice and teacher professional growth, supported by government and industry partnerships. While many resources are free, some professional development opportunities require payment, and most content is tailored to the UK curriculum. Nevertheless, its adaptable structure and strong emphasis on teacher support make it a valuable resource internationally. It can be accessed at https://www.stem.org.uk/. Figure 3 illustrates the STEM Learning interface, highlighting its focus on professional development and classroom resources.

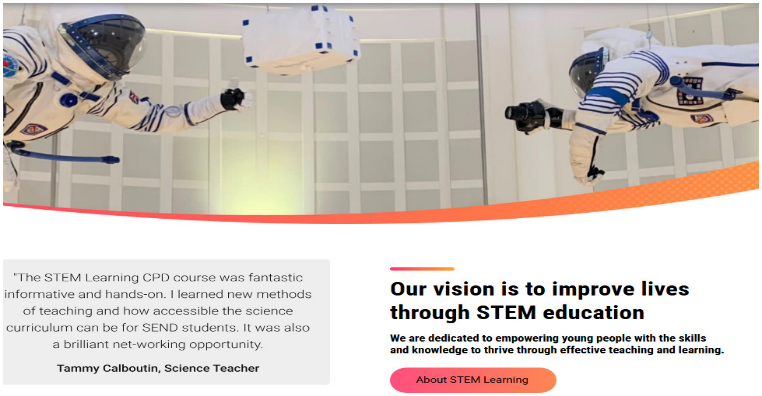

Figure 3. STEM Learning Platform Interface

Scientix MOOCs

Scientix, coordinated by European Schoolnet, supports STEM education across Europe by providing teachers with professional development opportunities through MOOCs. These courses cover contemporary topics such as citizen science, sustainability, and nature-based solutions, helping teachers expand their pedagogical approaches while also enriching their STEM perspective. In addition to supporting classroom strategies, they emphasize science content, technology integration, and activity design, often requiring teachers to create lesson activities that explicitly highlight STEM connections. The platform's global accessibility and European credibility strengthen its appeal, though the MOOCs are often more focused on teacher training than direct K–12 student instruction. Moreover, rather than focusing solely on teacher training, the courses also prioritize community building by fostering communication among teachers and supporting the development of a broader STEM teacher community. Additionally, some content reflects European contexts and may require adaptation elsewhere. The official platform is hosted at https://www.scientix.eu/resources/pd-resources/moocs. Figure 4 illustrates the Scientix MOOCs interface, showcasing courses on citizen science, sustainability, and teacher professional development.

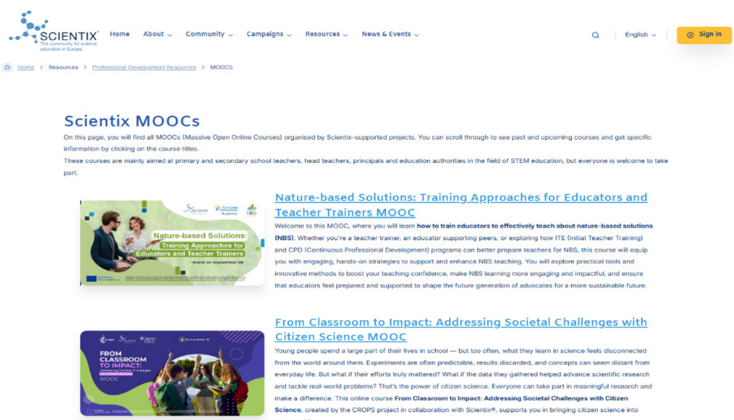

Figure 4. Scientix MOOCs Platform Interface

Supplementary Platforms

The primary platforms selected for in-depth discussion are TeachEngineering, NASA STEM Engagement, and STEM Learning and Scientix MOOCs. These platforms are distinguished by their breadth, strong institutional support, and comprehensive approach to STEM education. Nevertheless, other widely used platforms also play an important role in shaping the global landscape. These platforms are considered here as supplementary cases, as they typically focus on more specialized aspects of STEM learning rather than providing the broad curriculum integration or professional development opportunities of the main four. Nevertheless, their popularity and educational value make them important for a holistic view.

PhET Interactive Simulations

Developed by the University of Colorado Boulder, PhET offers free interactive simulations in physics, chemistry, biology, earth sciences, and mathematics. The simulations are designed to make abstract concepts more concrete by enabling students to manipulate variables and observe outcomes in real time. PhET has been widely adopted internationally and translated into multiple languages, making it highly accessible. Its main limitation is that it focuses primarily on simulations rather than providing full curriculum support, teacher professional development, or assessment tools. The platform can be accessed at https://phet.colorado.edu. Figure 5 shows the PhET Interactive Simulations platform, which provides free, inquiry-based digital tools to support science and math learning worldwide.

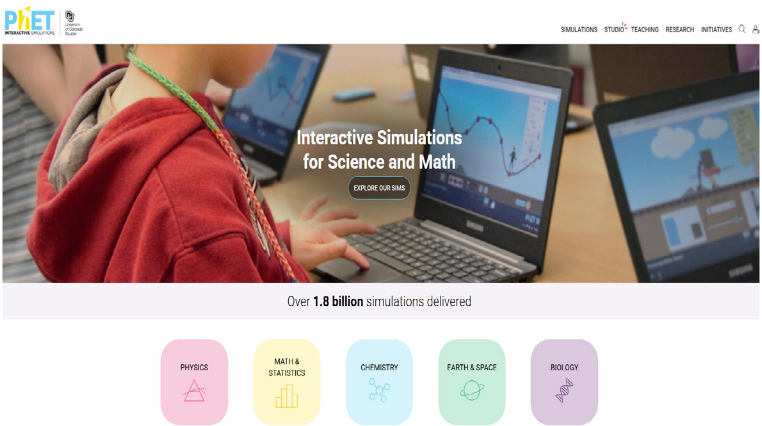

Figure 5. PhET Interactive Simulations Platform Interface

Code.org.

A nonprofit initiative, Code.org provides free resources to promote computer science education, with an emphasis on programming, computational thinking, and equity of access. Its materials are designed for K–12 students and include engaging activities such as the "Hour of Code," which introduces millions of learners worldwide to coding. While

Code.org has had a major impact on global awareness of computer science, it is somewhat narrower in scope compared to broader STEM platforms, focusing heavily on computing rather than the full STEM spectrum. The platform is available at https://code.org. Figure 6 illustrates the Code.org platform, which offers accessible computer science learning pathways for students, educators, parents, and schools.

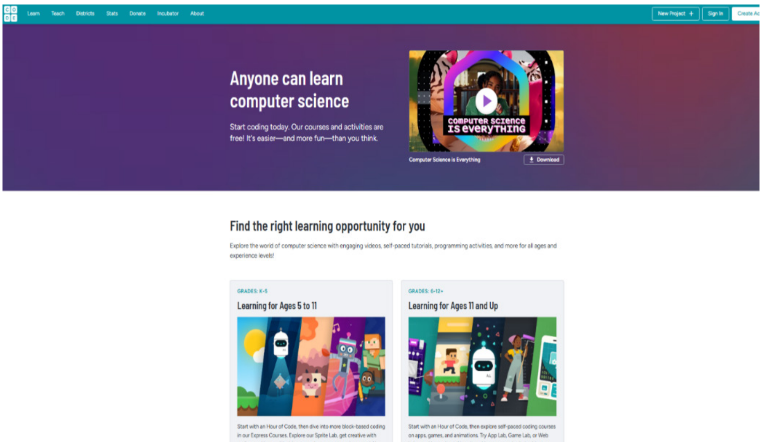

Figure 6. Code.org Platform Interface

OpenSciEd.

OpenSciEd is an open educational resource initiative that develops free, high-quality, NGSS-aligned science curriculum units for middle and high school students. Its strength lies in providing carefully structured, inquiry-based units that teachers can implement directly in classrooms. However, its resources are currently limited in subject coverage (primarily science) and require adaptation for non-U.S. curricula. While highly valuable, its narrower disciplinary and grade-level scope distinguishes it from more comprehensive platforms like STEM Learning or TeachEngineering. Further information is available at https://www.openscied.org. Figure 7 illustrates the OpenSciEd platform, which provides free, NGSS-aligned science curriculum units designed to support inquiry-based learning.

In summary, these platforms illustrate the diversity of the open-source and online STEM education ecosystem. PhET contributes powerful tools for interactive conceptual understanding, Code.org expands access to computer science, and OpenSciEd provides structured, open science units. Although they are more limited in scope compared to the primary platforms discussed earlier, their wide adoption and demonstrated impact make them essential complements to the larger ecosystem of STEM education platforms.

Figure 7. OpenSciEd Platform Interface

Overcoming STEM Teaching Barriers with Digital Platforms

Open sources and online platforms offer significant advantages in terms of accessibility, adaptability, and alignment with curricular standards. Their structured and openly accessible resources enable teachers to implement STEM activities more effectively without the need to design every component from scratch. Because of these features, such platforms hold strong potential for addressing key barriers identified in the literature. Among the most frequently reported are time and workload constraints, pedagogical and assessment challenges, limited opportunities for teacher professional development, and difficulties with curriculum integration (Estapa & Tank, 2017; Huang et al., 2022). In the following sections, selected vignettes illustrate how open-source and online STEM platforms can help mitigate these challenges through classroom-ready resources, scaffolding tools, and professional support mechanisms.

Vignette 1: Overcoming Time and Intensity Challenges with TeachEngineering

Ms. Adali, a middle school science teacher, knew that designing a full engineering challenge would take days or even weeks. Such a challenge would need to include materials, instructions, standards alignment, and assessments. With limited class hours and a packed syllabus, the task seemed daunting. One afternoon, she opened the TeachEngineering curriculum library and filtered for "Maker Challenges" and "Activities" requiring up to six hours of class time. She found a ready-made project titled "Clean Enough to Drink: Making Devices to Filter Dirty Water."

The lesson was designed for grades 3–5 and lasted six hours, divided into eight 45-minute periods. The estimated cost was about $5 per group. Teachers received extensive support materials, including background information, objectives, worksheets, rubrics, assessment suggestions, and extension ideas. Instead of designing all of these from scratch, Ms. Adali quickly adapted the activity to her class schedule and available supplies.

When she ran the activity, students enthusiastically designed, tested, and iterated their own water filtration prototypes using everyday materials such as plastic bottles, sand, and cloth. Because the heavy preparation had already been done, Ms. Adali could focus on facilitating inquiry, guiding discussion, and connecting student work to core science and engineering standards. What would once have been a multi-day planning burden became a smooth, efficient, and highly engaging engineering unit.

How TeachEngineering Helps Address Time & Workload Constraints

The TeachEngineering curriculum library demonstrates how open-source platforms can directly address the challenge of time and intensity in STEM education. Teachers can filter by grade level, activity type, time required, engineering category, and standards alignment to quickly identify activities that fit their instructional context. Because lessons are scaffolded with step-by-step procedures, detailed teacher guides, materials lists, time estimates, assessments, and extension ideas, teachers save hours of planning time.

This structure allows educators to select activities that align with their available class periods and adapt them without starting from scratch. The inclusion of low-cost, accessible materials reduces logistical barriers, while built-in standards alignment ensures curricular relevance. By providing high-quality, classroom-ready resources, TeachEngineering allows teachers to integrate hands-on STEM experiences efficiently, turning what might feel like an overwhelming preparation task into an achievable and rewarding teaching experience.

Challenges and Solutions Linked to the Vignette

The case of Ms. Adali highlights how time and workload are central barriers for teachers who want to integrate meaningful STEM activities.

While TeachEngineering reduces preparation demands through ready-to-use, scaffolded lessons, several challenges remain. Equity and accessibility can still pose obstacles. Even low-cost activities, such as the water filtration challenge, assume that teachers can obtain basic materials and have access to the internet to download resources. In under-resourced schools, these assumptions may not always hold. A possible solution is for teachers to take advantage of TeachEngineering's detailed materials lists to plan well in advance, substitute with locally available items, and share resources collaboratively with colleagues. Offline availability of PDFs also ensures that teachers can still use the resources without a constant internet connection.

Teacher readiness is another challenge. Although the lesson includes rubrics and guides, some teachers may feel uncertain about facilitating open-ended design activities. To address this, platforms like TeachEngineering recommend starting with shorter, simpler activities, gradually building confidence before attempting multi-day challenges. Pairing teachers through professional learning communities or using MOOCs such as those offered by Scientix can also strengthen support. By recognizing these challenges, teachers can overcome barriers of time and intensity. Platform features such as downloadable resources, flexible material substitutions, step-by-step scaffolds, and opportunities for collaboration also make STEM experiences more accessible and equitable for students.

Tips for Teachers: Managing Time and Workload with TeachEngineering

- Start with ready-to-use activities. Use the platform's filters (e.g., grade level, activity type, estimated time) to select projects that fit your available class hours.
- Plan materials flexibly. The detailed supply lists can be adapted using low-cost or locally available alternatives, making activities more feasible in resource-constrained settings.
- Download and save resources offline. PDFs, guides, and worksheets can be stored for later use, reducing reliance on constant internet access.
- Build confidence gradually. Begin with shorter activities to gain comfort with facilitating open-ended tasks before attempting multi-day design challenges.
- Leverage professional networks. Share adaptations and classroom experiences with colleagues or online communities (e.g., Scientix, teacher forums) to exchange strategies and reduce preparation burden.

These strategies allow teachers to enjoy the benefits of open-source platforms like TeachEngineering while addressing challenges of limited time, heavy workloads, and equity in access.

Vignette 2: Navigating Pedagogical and Assessment Challenges with Mission to the Moon

Mr. Evans, a primary science teacher, was excited about introducing STEM activities to his Year 5 students. He believed in the value of problem-based and inquiry-driven learning but often found it difficult to design activities that balanced excitement with clear learning outcomes. More importantly, he struggled with assessing not just "what" students learned but how they collaborated, generated ideas, and solved problems. Traditional quizzes or short-answer questions felt inadequate for capturing these dimensions. Traditional quizzes could measure facts, but they could not capture how students brainstormed, tested prototypes, or defended their decisions. Preparing both the activity and assessment tools often took so much time that Mr. Evans hesitated to attempt it at all. One afternoon, he discovered the Mission to the Moon resource on the STEM Learning platform. The collection provided a set of ready-mades, real-world challenges linked to space exploration—such as designing lunar landers, testing materials that could withstand extreme lunar conditions, and building simple rovers from recycled items. What immediately caught Mr. Evans's attention was the structure: each activity came with curricular links, background notes, and clearly defined student roles like astronomer, engineer, and geologist. This structure meant he could set up an inquiry-based project without having to invent everything from scratch.

He chose the activity where students had to build and test their own lunar lander models. The guidance included step-by-step instructions, suggested materials, prompts for group discussion, and learning objectives. Instead of drafting new rubrics, Mr. Evans adapted the provided outcomes into a simple checklist: Did students share ideas? Did they test and refine their designs? Could they explain why their final model worked (or didn't) using scientific reasoning? When he ran the activity, students immediately engaged with the problem. Some groups debated how to balance weight and stability, while others argued about the best materials to absorb impact. There were moments of failure—rockets that tipped over or landers that collapsed—but students quickly went back to redesigning and retesting. As he observed, Mr. Evans realized he was finally able to focus on how students collaborated and thought critically rather than spending his energy on logistics. By the end of the project, he had evidence of both content knowledge and key

STEM competencies like teamwork, creativity, and problem-solving. What once seemed like an overwhelming pedagogical and assessment challenge became a manageable and rewarding classroom experience. By the end of the unit, Mr. Evans felt more confident about integrating problem-based approaches into his teaching. The resource didn't eliminate every challenge, but it gave him a scaffold to evaluate creativity and teamwork alongside scientific understanding.

STEM Learning Helps Address Pedagogical and Assessment Challenges

The Mission to the Moon resource demonstrates how online platforms can ease the burden of implementing problem-based, project-based, and inquiry-driven learning. By offering scaffolded activities with clear objectives, background notes, group roles, and suggested assessment strategies, it reduces both planning and evaluation challenges. Teachers can shift their attention from designing every detail to facilitating and observing learning. The structured format also ensures that assessment goes beyond content recall. Students' collaboration, creativity, and critical thinking are made visible through group roles, iterative design processes, and opportunities for reflection. Teachers, in turn, can adapt provided rubrics or checklists to capture these higher-order skills more systematically.

Challenges and Solutions Linked to the Vignette

Even with strong resources such as Mission to the Moon, teachers may still encounter difficulties when implementing problem-based and inquiry-driven lessons. One common challenge is equity and participation. In group settings, certain students often dominate while others remain passive, which can undermine the collaborative intent of the activity. A practical solution is to rotate roles—such as astronomer, engineer, or geologist—so that all students experience leadership, technical, and reflective tasks. Another issue is the subjectivity of assessment. Measuring collaboration, creativity, and critical thinking can feel inconsistent, especially for teachers used to traditional tests. To address this, teachers can adapt the suggested learning outcomes included in the resource into simple observation checklists. This makes assessment more systematic and transparent while still capturing higher-order skills.

Time pressure also poses a significant obstacle. Inquiry-based projects often take longer than standard lessons, which can discourage teachers from using them. One solution is to adapt activities by focusing on the most critical stages, such as design and testing, rather than attempting to complete every step of the project. This allows teachers to preserve the spirit of inquiry within realistic time constraints. Finally, confidence in facilitation remains an important concern. Teachers without strong backgrounds in engineering or space science may feel uncertain about guiding these kinds of projects. In such cases, the background notes and teacher guides provided by Mission to the Moon can help fill knowledge gaps and provide reassurance, enabling teachers to focus on facilitation rather than content expertise.

Tips for Teachers: Managing Pedagogy and Assessment with STEM Learning

- Use structured group roles (astronomer, engineer, geologist) to make collaboration both visible and assessable.
- Adapt provided rubrics into observation checklists rather than creating assessment tools from scratch.
- Rotate responsibilities so all students practice creativity, leadership, and technical thinking.
- Break down large projects into smaller steps if time is limited.
- Ask reflective questions (e.g., *"What did your team change in your design, and why?")* to capture critical and creative thinking in real time.

Vignette 3: Feeling Behind in Digital & Pedagogical Tools

Ms. Jordan, a secondary school teacher, often felt she was falling behind. New digital tools, interdisciplinary approaches, and project-based pedagogies were being discussed at conferences and in staff meetings, but she had never received formal training on how to use them. While she was confident in teaching science content, she struggled to design lessons that connected her subject to mathematics, technology, or engineering, and she worried that her students saw STEM as too "academic" and disconnected from real life. What she needed was structured, high-quality professional development that could help her bridge these gaps without overwhelming her already busy schedule. One day she discovered STEM Is Everywhere! MOOC, a course hosted on the European Schoolnet Academy through the Scientix initiative. The course promised to guide teachers in integrating real-world problems into their STEM lessons. Its modules ranged from "Real-world problems for STEM subjects" to "Interdisciplinary STEM teaching with real-world problems," and participants were required to design and submit a real-world STEM lesson plan as a final assignment. For Ms. Jordan, this structure was transformative: she was not just reading about pedagogy, she was applying it directly to her own classroom. By the end of the course, she had designed a unit where her students investigated air quality around the school, analyzed the data, and proposed engineering solutions. In the peer-review process, she reviewed others' lesson plans and received feedback on her own. Through this exchange, she built confidence and gained insight into multiple approaches to similar challenges.

Scientix Helps Address Professional Development Gaps

STEM Is Everywhere! MOOC directly addresses one of the biggest challenges in STEM education: the lack of continuous, high-quality professional development for teachers. Rather than leaving educators to navigate new tools and approaches alone, the course provides a guided pathway with concrete resources, activities, and examples. By focusing on real-world problems, the course helps teachers link STEM to everyday contexts, making lessons both more engaging for students and more feasible for teachers to implement. Importantly, the course also builds a professional learning community. Through peer reviews, discussion forums, and social media groups like #STEMIsEverywhereMOOC, teachers can share experiences, best practices, and resources. This collaboration helps teachers stay current with evolving practices while also reducing the sense of isolation that often accompanies professional growth.

Challenges and Solutions Linked to the Vignette

Even with such structured opportunities, challenges remain. The most pressing is time: teachers already face heavy workloads, and dedicating hours to a MOOC can feel unrealistic. Breaking the course into smaller, weekly goals can make the learning process manageable. One way to do this is by completing one module at a time. Another challenge is contextual adaptation. While the course provides rich examples, they may not always align perfectly with a teacher's local curriculum or resources. Teachers like Ms. Jordan could benefit from localizing activities, such as using nearby environmental data rather than relying on European case studies. The peer-review system supports this adaptation by exposing teachers to diverse strategies and contexts. Finally, there is the issue of sustainability. A single MOOC may inspire change, but without continued support, teachers risk reverting to old practices. For this reason, Scientix encourages teachers to join broader professional networks, attend follow-up courses, and even work toward becoming Scientix ambassadors, ensuring that the professional development continues beyond one course.

Tips for Teachers: Making the Most of MOOCs for Professional Growth

- Treat MOOC modules as bite-sized learning chunks — dedicate short time slots (e.g. 1 module per week) instead of trying to complete everything at once.
- Design the required lesson plan around a real issue in your local context so the effort directly benefits your classroom.
- Engage fully in peer reviews to gain diverse perspectives and constructive feedback. Create peer learning groups (with colleagues or online MOOC participants) to discuss readings, co-plan lessons, and adapt ideas collaboratively.
- After completing a module, try one small classroom experiment (e.g. use one strategy or tool) rather than attempting an entire unit at once.
- Adapt and localize MOOC examples to match your students' realities, curriculum, and available resources.
- Archive resources and stay connected with the MOOC community to extend professional learning beyond the course itself.

Vignette 4: Facing Curriculum Integration Challenges

Mr. Rivera, a high school science teacher, was eager to design a project that connected physics principles with real-world engineering applications. However, since his background training was primarily in biology, he felt uncertain about guiding students through engineering design tasks. While searching for help, he discovered several platforms that offered structured entry points into interdisciplinary teaching. On TeachEngineering, he found ready-made lessons where engineering design was embedded within physics and environmental science contexts, including activities on renewable energy systems. These resources gave him a clear framework for integrating engineering into his science classes.

Turning to NASA STEM Engagement, Mr. Rivera used multimedia simulations and space-related challenges to highlight the role of technology in scientific discovery. This helped him bring authentic technology integration into his lessons without needing to develop resources from scratch. At the same time, STEM Learning provided him with teacher guides on interdisciplinary STEM pedagogy. Even though he wasn't trained in mathematics instruction, the platform's guidance helped him understand how to frame cross-disciplinary projects and assess student learning.

To support conceptual understanding, he used PhET simulations to demonstrate physics concepts interactively, lowering the barrier for integrating mathematic ideas. Finally, through Scientix, Mr. Rivera connected with other European educators who had already experimented with interdisciplinary projects, gaining concrete strategies for adapting resources to his local context. By combining these platforms, Mr. Rivera realized he didn't need to be an expert in every STEM discipline to design integrated lessons. Instead, he could rely on open source and online platforms to provide the scaffolding and professional guidance he lacked in his formal training.

Tips for Teachers: Overcoming Curriculum Integration Challenges

- Use structured resources (e.g., TeachEngineering lesson plans, NASA STEM engagements modules) to embed engineering and technology naturally into science or math classes.
- Start small with simulations (e.g., PhET) to introduce cross-disciplinary concepts in an accessible way before moving into larger projects.
- Seek professional development through platforms like STEM Learning, which offer CPD resources on interdisciplinary teaching.
- Join teacher communities (e.g., Scientix) to learn how others integrate multiple STEM disciplines and adapt materials across national contexts.
- Blend resources strategically. Combining different platforms can reduce the burden of designing everything alone and provide balance between content, pedagogy, and practical implementation.

These approaches ensure that teachers with expertise in one discipline can still design meaningful interdisciplinary STEM experiences by leveraging the strengths of multiple platforms.

Taken together, open-source and online platforms are enriching STEM education by extending accessibility, fostering collaboration, and supporting interdisciplinary problem-solving (Navas-Bonilla et al., 2025; Sanabria-Z. et al., 2024). Their capacity to align with curricula, provide adaptable resources, and offer professional development enables teachers to address barriers such as curriculum integration, assessment, and workload (Estapa & Tank, 2017; Huang et al., 2022). At the same time, the broader evolution of openness in education—from OER initiatives to MOOCs—has reinforced the pedagogical value of adaptability, equity, and democratization of knowledge (Mishra, 2017; Sousa et al., 2023). While challenges of contextual adaptation and teacher readiness remain, the platforms examined here illustrate how digital ecosystems can transform STEM instruction into a more inclusive, efficient, and globally relevant practice (Chu, 2025; Dao et al., 2025).

References

Awad, N. (2023). Exploring STEM integration: Assessing the effectiveness of an interdisciplinary informal program in fostering students' performance and inspiration. *Research in Science & Technological Education, 41*(2), 675–699. https://doi.org/10.1080/02635143.2021.1931832

Chu, Y. (2025). Revolutionizing STEM education through emerging technologies. *American Journal of STEM Education: Issues and Perspectives, 10*, 71–80. https://doi.org/10.32674/bkw4ty40

Couso, D., & Simmaro, C. (2020). STEM education through the epistemological lens: Unveiling the challenge of STEM transdisciplinarity. In C. C. Johnson, M. J. Mohr-Schroeder, & T. J. Moore (Eds.), *Handbook of research in STEM education* (pp. 17–28). Routledge.

Dao, V.-P., Nguyen, T.-L., Bui, V.-H., & Nguyen, M.-D. (2025). Developing a digital platform ecosystem for distance learning and STEM education. *Journal of Information Systems Engineering and Management, 10*(38), 218–226. https://doi.org/10.52783/jisem.v10i38s.6842

English, L. D., King, D., & Smeed, J. (2017). Advancing integrated STEM learning through engineering design: Sixth-grade students' design and construction of earthquake resistant buildings. *The Journal of Educational Research, 110*(3), 255–271. https://doi.org/10.1080/00220671.2016.1264053

Estapa, A. T., & Tank, K. M. (2017). Supporting integrated STEM in the elementary classroom: A professional development approach centered on an engineering design challenge. *International Journal of STEM Education, 4*(6). https://doi.org/10.1186/s40594-017-0058-3

Huang, B., Jong, M. S.-Y., Tu, Y.-F., Hwang, G.-J., Chai, C. S., & Jiang, M. Y.-C. (2022). Trends and exemplary practices of STEM teacher professional development programs in K-12 contexts: A systematic review of empirical studies. *Computers & Education, 189*, 104577. https://doi.org/10.1016/j.compedu.2022.104577

Josué, A., Bedoya-Flores, M. C., Mosquera-Quiñonez, E. F., Mesías-Simisterra, Á. E., & Bautista-Sánchez, J. V. (2023). Educational platforms: Digital tools for the teaching-learning process in education. Ibero-American J*ournal of Education & Society Research, 3*(1), 259–263. https://doi.org/10.56183/iberoeds.v3i1.626

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education*. International Journal of STEM Education, 3*(1), 1–11. https://doi.org/10.1186/s40594-016-0046-z

Li, K. C., & Wong, B. T. M. (2021). A review of the use of open educational resources: The benefits, challenges and good practices in higher education. *International Journal of Innovation and Learning, 30*(3), 279–298. https://doi.org/10.1504/IJIL.2021.118599

Liu, M., & Yu, D. (2023). Towards intelligent e-learning systems. *Education and Information Technologies, 28*, 7845–7876. https://doi.org/10.1007/s10639-022-11479-6

Mexhuani, B. (2025). Adopting digital tools in higher education: Opportunities, challenges and theoretical insights. *European Journal of Education, 60*(1), Article e12819. https://doi.org/10.1111/ejed.12819

Mishra, S. (2017). Open educational resources: Removing barriers from within. *Distance Education, 38*(3), 369–380. https://doi.org/10.1080/01587919.2017.1369350

Navas-Bonilla, C., Guerra-Arango, J. A., Oviedo-Guado, D. A., & Murillo-Noriega, D. E. (2025). Inclusive education through technology: A systematic review of types, tools and characteristics. *Frontiers in Education*, *10*. https://doi.org/10.3389/feduc.2025.1527851

Oussous, A., Menyani, I., Srifi, M., Lahcen, A. A., Kheraz, S., & Benjelloun, F.-Z. (2023). An evaluation of open source adaptive learning solutions. *Information, 14*(2), Article 57. https://doi.org/10.3390/info14020057

Sanabria-Z., J., Alfaro-Ponce, B., González-Pérez, L. I., & Ramírez-Montoya, M. S. (2024). Reusable educational resources for developing complex thinking on open platforms. *Education and Information Technologies, 29*, 1173–1199. https://doi.org/10.1007/s10639-023-12316-0

Sousa, L., Pedro, L., & Santos, C. (2023). A systematic review of systematic reviews on open educational resources: An analysis of the legal and technical openness. *International Review of Research in Open and Distributed Learning, 24*(3), 18–33. https://doi.org/10.19173/irrodl.v24i3.7196

Stracke, C. M., Downes, S., Conole, G., Burgos, D., & Nascimbeni, F. (2019). Are MOOCs Open Educational Resources? A literature review on history, definitions and typologies of OER and MOOCs. *Open Praxis, 11*(4), 331–341. https://doi.org/10.5944/openpraxis.11.4.1010

About the Authors

Nilay Muslu-Komurcu is an Assistant Professor of Science Education at Mugla Sitki Koçman University, Türkiye. She holds a bachelor's degree in Physics Education from Dokuz Eylul University and earned both her master's and Ph.D. degrees in Science Education from the University of Missouri-Columbia, USA. Her scholarly expertise includes classroom assessment practices, particularly formative assessment, as well as science teacher professional development. She also specializes in educational technology integration, focusing on generative AI and digital feedback applications in K–12 settings. Dr. Muslu-Komurcu has published extensively in national and international peer-reviewed journals indexed in SSCI, SCIE, and Scopus. She teaches undergraduate courses such as Formative Assessment in Classrooms, Social Media and Web 2.0 Tools in Education, and Physics Education.

✉ *nilaymuslu@mu.edu.tr*
0000-0002-7429-5142

Hasan Zuhtu Okulu earned his Ph.D. in Science Education and currently serves as an Associate Professor at the Department of Science Education, Faculty of Education, Mugla Sitki Koçman University, Türkiye. His scholarly interests center around STEM education, astronomy education, instructional design, and the pedagogical integration of emerging technologies including generative AI, and virtual reality. Dr. Okulu has published extensively in peer-reviewed SSCI/SCIE-indexed journals and actively participates in both national and international research projects funded by organizations such as TUBİTAK and the European Union. His work explores how technology-supported environments can foster interdisciplinary and design-based learning experiences across K–12 education.

✉ *hasanokulu@mu.edu.tr*
0000-0002-2832-9620