From Planning to Practice: LEARN-Kit for Flexible STEM Workshop Delivery

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ABSTRACT

STEM workshops in schools are increasingly used to complement formal education, yet educators often struggle to adapt content to diverse learner needs and constraints, such as varying age groups, prior knowledge, group sizes, and limited time. Existing resources rarely offer structured guidance for tailoring activities under these conditions, leading to inconsistent quality and high preparation effort. There is a need for flexible, scalable solutions that support educators in designing and delivering effective, context-sensitive, and inclusive workshops.
This paper introduces **LEARN-Kit,** which addresses this gap through a modular system of categorized unplugged and digital activities. Drawing on principles of modularity, microlearning, and learning object theory, the toolkit enables rapid assembly of tailored workshop formats. Ready-to-use materials—slides, summaries, and planning aids—support consistent implementation with minimal onboarding. Since its development, LEARN-Kit has been applied in 29 workshops across different educational contexts, reaching over 750 children. Field experiences highlight strengths in adaptability, accessibility, and educator readiness, while also pointing to challenges in managing time and transitions.

1 INTRODUCTION

It is important to deliver engaging computer science (CS) workshops for school groups to foster interest and confidence in STEM early. These workshops vary in group size, grade level, available time, and prior knowledge, creating challenges for planning and

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implementation. Existing platforms, such as CS Unplugged[1], ScratchEd[2], and Code.org[3], offer a variety of teaching resources but often lack structured navigation and filtering options tailored to classroom constraints. The limited availability of well-organized, easily adaptable resources complicates effective CS instruction at the primary level (Aguar et al., 2017).

Early exposure to CS fosters curiosity, builds confidence and strengthens problem-solving and computational thinking skills (Lamprou & Repenning, 2018; Yune Tran, 2018). However, many young children still perceive CS as difficult or unengaging, often due to teaching formats that do not align with their needs or classroom constraints (Papadakis & Kalogiannakis, 2019).

Research also highlights that existing programming resources show a shortage of incorporating a gender perspective, particularly at the primary and early secondary level when girls form early ideas about their abilities and future careers (Torres-Torres et al., 2019). A lack of inclusive, gender-sensitive materials can reduce their long-term engagement and reinforce existing gender gaps in STEM (Tarpley, 2020).

To address this, we developed **LEARN-Kit**, a modular and flexible approach for learning and education that enables educators to assemble tailored workshops quickly and efficiently. The kit is guided by five core principles: **L**earning, **E**ngagement, **A**ctivities, **R**eusability, and **N**eeds, which reflect its structured yet adaptable and intentionally inclusive design. It supports workshop planning under varying conditions and offers activities that reduce barriers and broaden participation across diverse learning contexts.

This paper contributes to the discourse on modularity in education and outlines key challenges in outreach contexts. It introduces LEARN-Kit with a focus on adaptability to different needs and educational contexts. The discussion includes an examination and reflection of its implementation in field tests with school groups and concludes with insights and directions for future improvements.

2 CONCEPTUAL FOUNDATIONS AND PRACTICAL DEMANDS

Framing LEARN-Kit within the broader educational discourse, the upcoming discussion introduces key terminology and examines the practical challenges that shape the need for flexible and adaptable formats.

2.1 Key Concepts and Framing

LEARN-Kit builds on the idea of using small, reusable, and instructional components comparable instead of fixed teaching curricula. Learning institutions can adapt these components based on the target group, available time, materials, and number of participants and educators. This flexibility is particularly relevant when class compositions and conditions vary widely.

The concept of modularity in education dates back to 19th-century curriculum reforms at Harvard University (Bell & and Wade, 1993) and today refers to autonomous learning units linked to specific competencies (Mazrekaj & De Witte, 2020). IEEE defines

[1] https://www.csunplugged.org/en/
[2] https://scratched.gse.harvard.edu/index.html
[3] https://code.org/

learning objects as any digital or non-digital entity used in technology-supported learning ("IEEE Standard for Learning Object Metadata," 2020), and standards such as Learning Object Metadata (LOM) provide formal structures for organizing them (Bärenfänger, 2012). LEARN-Kit's short and focused activities align with the microlearning principles, which emphasize brief, skill-oriented learning to meet immediate needs (Zhang & West, 2020). This makes them suitable for informal learning formats such as summer schools and project days (Taylor & Hung, 2022).

LEARN-Kit uses modular design principles, learning object reusability, and microlearning. It does not adhere to a formal standard or technical implementation. Instead, it adopts the ideas pragmatically to provide a flexible toolkit designed for diverse educational scenarios.

2.2 Challenges and Contextual Factors

Expanding on the conceptual framing, the following overview addresses four key challenges in designing effective educational workshops, namely rapid change, learner diversity, the balance between effectiveness and reusability, and logistical flexibility.

The continuous evolution of content, tools, and workshop requirements complicates planning. Educators face difficulties in keeping pace with changing pedagogies and rapid developments in CS (Blikstein & Moghadam, 2018). Educational workshops are often not part of a fixed program and must be planned on short notice. Under these conditions, creating entirely new content requires restructuring entire workshops. A modular approach addresses these issues by allowing educators to revise or replace individual components without disrupting the overall structure (Barua & Lockee, 2024).

Learner diversity presents a challenge, both within and across workshops, as participants differ in prior knowledge, learning preferences, and experience (Pavlov et al., 2023). Misaligned activities reduce motivation and learning outcomes and may unintentionally reinforce stereotypes or lead to exclusion (Yang & and Bers, 2024). Modular content enables educators to adjust materials effectively to group-specific needs, supporting appropriate levels of challenge and accessibility (Barua & Lockee, 2024). When aligned with learners' abilities, well-structured and interactive activities further improve engagement and satisfaction (Metz et al., 2018).

Balancing pedagogical effectiveness with reusability requires that modular content functions across diverse settings without losing contextual relevance. While high reusability can reduce effort, it risks limiting educational depth (Bärenfänger, 2012). Research shows that theme-based, context-aware approaches support deeper engagement without sacrificing adaptability (Brotman & Moore, 2008). Bärenfänger argues that effective learning objects must be self-contained and pedagogically meaningful and balancing these demands remains a core design challenge (Bärenfänger, 2012).

Modularity also increases flexibility in program delivery, which is essential for educational settings involving repeated visits, varying topics, and shifting schedules. These conditions require adaptable formats and consistent quality, even when educators rotate, or resources change (Metz et al., 2018). Barua and Lockee emphasize the importance of pedagogical openness and content flexibility, which helps to ensure that learning remains accessible and adaptable regardless of who facilitates the workshop.

A modular design supports this by allowing educators to co-create or choose appropriate content without being involved in the entire program development (Barua & Lockee, 2024).

3 LEARN-KIT

As a flexible alternative to rigid, pre-defined curricula, LEARN-Kit enables educators to assemble unplugged and digital activities tailored to each learner group. This ensures alignment with available time, group size, prior knowledge, and further specifications while fostering engagement. The kit's foundation is a structured classification that assigns each activity key characteristics such as CS topics, grade level, prior knowledge, group size, and available time. This allows activities to remain self-contained yet easily combinable, and adaptable to various planning constraints.

Supporting tools complement the structured activity collection to facilitate efficient preparation and flexible implementation. Each activity contains short instructional slides of key concepts, background information, or instructions. These slides are assembled into cohesive slides according to the activity sequence flow, ensuring clarity and consistency. Activity summaries and overview tables help educators quickly grasp the purpose and understand the core aspects of each activity. This is particularly valuable in settings with rotating educators or limited preparation time.

3.1 Adaptability to Different Needs

LEARN-Kit supports adaptation to diverse learner needs through predefined structures and categorized activities. Each activity includes an overview table specifying key characteristics, illustrated in Table 1, and options to adjust complexity and modify duration. Some activities additionally support a gradual approach, starting with simpler tasks and expanding as needed to match learner abilities or available time.

Table 1. Overview table of activity characteristics for "Bubble Sort"

Activity Name: Bubble Sort		
Characteristic	**Details**	**Comment**
Grade level	Grades 5 – 9	Higher grades are welcome, but usually may feel disengaged
Estimated Time	10 - 20 minutes	-
Number of participants	2 - 4 groups of 4 - 8 participants	Number of groups should equal the number of educators
Number of educators	2 - 4	Should equal the desired number of groups
Materials	Optional: Sorting categories (paper)	Pupils can draw categories or come up with their own
Prior knowledge	-	-
Resources	<Link to slides>	Exclude Page 7 - 9 for Grade 5 and 6
Cognitive vs. Creative Focus	Embodied and procedural	Combines algorithmic thinking with physical activity and social interaction
Notes and Considerations	It is a movement-based activity and works well after extended periods of sitting	

In addition to modifying individual activities, educators can reorganize the activity sequence by rearranging or substituting single activities to better align with time constraints and learner groups. This flexibility removes the need to design new workshops from scratch and allows educators to focus on effective delivery.
Adaptability is particularly valuable when working with several classes of the same grade level, where educational tracks differ. In these cases, educators modify activities while maintaining a consistent structure and thematic focus. This ensures consistent

engagement and comparable learning experiences across groups, while still addressing the specific needs and abilities of each class.

LEARN-Kit supports inclusion through open-ended and thematically neutral activities. It avoids stereotypical or technical framing. Instead, it promotes storytelling, creativity, and engagement with everyday contexts that offer relevant and relatable learning experiences. All activities involve pair or group work to support collaboration. This format creates opportunities for learners to share responsibilities across genders and encourages them to value each other's ideas and abilities.

3.2 Adaptability to Different Educational Institutions

The structure of LEARN-Kit enables straightforward integration into different schools and universities, STEM initiatives, after-school programs, or informal learning formats such as summer schools and project days. Learning institutions can adopt the LEARN-Kit by using the provided templates for existing activity overview tables or expand it with new activities accordingly. The kit supports frequently changing educators by providing materials that require minimal preparation and activity summaries. All instructional slides are self-explanatory and include concise, easy-to-follow notes. This format allows new educators to quickly familiarize themselves with the content and deliver workshops effectively and confidently.

One barrier to the immediate implementation is that some activities require physical materials. Learning institutions intending to use these activities must acquire the necessary resources. However, LEARN-Kit already includes a broad selection of activities that only require printed, or preferably laminated, materials. These provide a practical and low-barrier starting point for institutions looking to adopt LEARN-Kit. Institutions can build on this foundation by developing additional activities that reflect their specific subject areas or institutional focus.

4 APPLYING AND ADAPTING THE LEARN-KIT

LEARN-Kit originated within the TUM LearnLabs initiative at the Technical University of Munich. TUM LearnLabs develops tools and resources that introduce young children to CS concepts at an early age. The initiative aims to foster interest, confidence, and a sense of belonging in STEM, particularly among girls who often have limited exposure to these fields. Since its development, we used LEARN-Kit in 29 workshops with diverse student groups across school types, grade levels, and formats, reaching over 750 children. Each workshop focused on creating inclusive and gender-sensitive learning environments**.** A summary of these implementations is provided in Table 2.

Table 2. List of school visits within TUM LearnLabs with LEARN-Kit

Frequency	Secondary Level	School Type	Learner group size (Average)	Format
8x	Lower	Grammar School (1x) Secondary School (7x)	29	School Visit
9x	Middle	Grammar School (5x) Secondary School (4x)	28	School Visit
7x	Upper	Grammar School	22	School Visit
2x	Lower and Middle	Mixed	30	STEM Taster Day
2x	Upper	Grammar School	30	Trial Course
1x	Upper	Grammar School	26	Summer School

TUM LearnLabs invites school classes from grade 2 onward to explore CS through engaging, interactive, age-appropriate workshops. These tailored workshops ensure that participants encounter neither excessive difficulty nor insufficient challenge. Fig. 1 illustrates three exemplary activities, Caesar Cipher, Towers of Hanoi, and Binary Bracelets, that we conducted as part of the workshops and integrated into the LEARN-Kit. TUM LearnLabs continuously expands its activities to cover with multiple needs and interests of different learner groups. LEARN-Kit emerged from this commitment to improve adaptability and instructional quality. The following sections present its practical application and reflect on strengths, challenges, and areas for improvement.

Fig. 1. Exemplary activities of LEARN-Kit during a workshop (from left to right: Caesar Cipher, Towers of Hanoi, Binary Bracelets)

4.1 Workshop Planning Process

TUM LearnLabs hosts workshops for visiting school classes. These workshops are not part of a fixed program and cannot be booked through a standardized system. Except for a few special formats, schools or individual classes request visits directly. The designated contact person (e.g., teacher) provides core specifications, including the date and duration of the visit, the grade level, and the number of participants. For specialized school types or upper secondary classes, the TUM LearnLabs educators also gather additional details, such as special requests for subject focus or topics of interest to be addressed during the workshop. Fig. 2 illustrates the overall process.

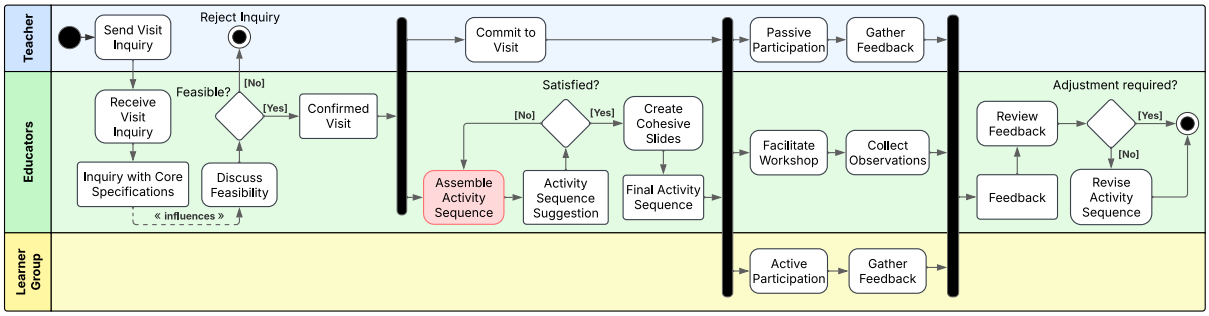

Fig. 2. The overall process of workshop planning with LEARN-Kit

Based on the input, the educators assemble an activity sequence suggestion using LEARN-Kit, as depicted in Fig. 3. Within the reviewing workflow, educators ensure that the selected activities collectively meet all relevant conditions. In addition to fulfilling core specifications such as total duration and group size, the planning process incorporates pedagogical and logistical considerations. This means scheduling cognitively demanding activities or material-intensive activities before the break, while creative or reflective tasks are placed toward the end. If needed, educators revise and iterate the activity selection. Once all conditions are met, the preliminary activity sequence is confirmed and passed on as an activity sequence suggestion.

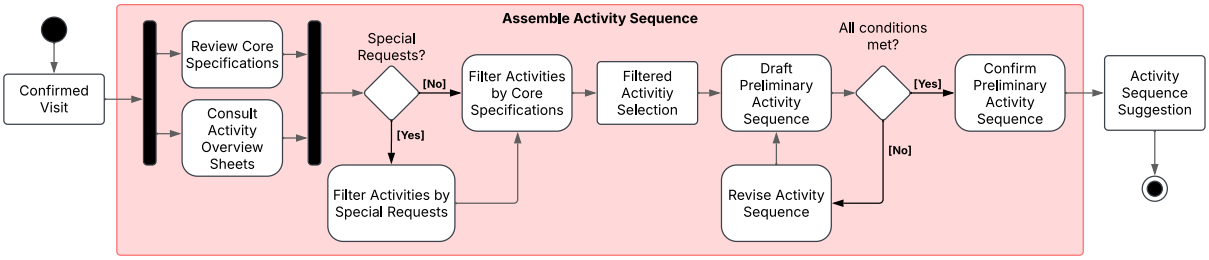

Fig. 3. Activity diagram for assembling an activity sequence with LEARN-Kit

After confirmation, educators compile the relevant instructional slides into cohesive slides. This results in the final activity sequence and ensures that all materials are prepared for the visit. During the workshop, educators facilitate the activity sequence and observe learner engagement and participation. After the workshop, they gather informal feedback from both teachers and the learner group. Educators reflect on the activity flow, suitability, and group response. Based on this feedback, they review whether adjustments are necessary and revise the activity sequence accordingly to improve future implementations.

4.2 Lessons Learned

Feedback gathered after each school visit confirmed the key strengths of the kit and guided ongoing refinement. Teachers valued the low-threshold, engaging introduction to CS, describing it as “student-friendly” and praising the hands-on approach that made complex content accessible. Others highlighted the lasting impact and inclusive atmosphere, noting that “learners stayed engaged the entire time, which is particularly noteworthy given today’s reduced attention spans shaped by social media.”

The educators’ reflections revealed that the modular structure enabled flexible adaptation to group-specific needs, while the classification system facilitated topic selection based on age and prior knowledge. The low-preparation format allowed new educators to lead workshops confidently. Most activities successfully encouraged active participation. Continuous updates to the materials helped maintain consistent quality.

The reflections also identified areas for improvement. Educators occasionally misjudged timing and failed to plan transitions and breaks effectively, which disrupted the overall pacing. At times they overlooked team size recommendations for activities, resulting in sequential activities with identical group structures and reduced variation. In early versions, programming-based activities lacked reliability and supporting materials such as cheat sheets, limiting learners' ability to engage independently.

Clearer activity descriptions and supporting materials can improve workshop planning and delivery in this regard. Indicating ideal group sizes helps educators structure activity sequences more effectively. Scheduling breaks and ensuring that materials are ready to teach or include clear introductions will further strengthen workshop quality.

5 INSIGHTS, IMPACT, AND NEXT STEPS

LEARN-Kit responds to a recurring difficulty in education by enabling the delivery of engaging and appropriately challenging workshops under variable conditions. Grounded in microlearning and learning object theory, its modular design supports educators in creating effective activity sequences for diverse learner groups. Structured classified activities enable flexible adaptation to specifications such as group

size, prior knowledge, and available time. The implementation at TUM LearnLabs demonstrates that the kit simplifies educator onboarding while maintaining consistent quality and promotes learner engagement even with limited preparation time. LEARN-Kit lowers entry barriers for both educators and learners and promotes inclusive and motivating learning environments.

> **Key Insight: Flexibility & Engagement:** LEARN-Kit enables flexible, engaging workshops and lowers entry barriers for both educators and learners.

Beyond its original context, LEARN-Kit offers a transferable and scalable structure for broader educational use. It supports tailored workshops without requiring specialized infrastructure or extensive preparation time. Learning institutions can adapt LEARN-Kit to their own contexts and needs and expand it by integrating new activities. Its open-ended, thematically neutral, and collaborative activities promote inclusion and make it suitable for diverse learner groups. LEARN-Kit adapts well in classrooms, afternoon-school programs, and extracurricular initiatives and serves as a practical model to enhance flexibility and responsiveness.

> **Impact: Transferability, Scalability & Inclusion:** The modular design scales across settings without requiring special infrastructure. Activities support diverse learner groups through open-ended, collaborative tasks.

The field test revealed opportunities for refinement. Planned improvements include expanding the number of activities, supporting selection through an analogue matrix or a digital recommendation system, and integrating pedagogical categories, such as Bloom's taxonomy, to provide further guidance. A broader evaluation across diverse learning institutions and learner groups will assess LEARN-Kit's transferability, usability, and learning impact in varied educational and diverse settings. Plans include making it publicly accessible and suitable for independent use to support a wide range of learning initiatives that value adaptability, quality, and learner engagement.

> **Next Steps: Refinement & Expansion:** Expand activity options, support guided selection, and evaluate broader impact.

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