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Strengthening Teachers' Digital Competence through Training in Developing Educational Game-Based Learning Media at a Madrasah Tsanawiyah

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Abstract. Access to digital devices does not by itself enable teachers to produce digital learning resources. This community service program trained 12 Madrasah Tsanawiyah teachers to design educational games with Kodu Game Lab, a visual programming environment that requires no prior coding experience. The program followed seven participatory stages: needs identification, concept strengthening, demonstration, hands-on development, mentoring, product evaluation, and reflection. Its design drew on the DigCompEdu and TPACK frameworks and on established features of effective professional development. Learning was assessed with a knowledge test administered before and after the training. The group mean rose from 65 to 88, a gain of 23 points (35.38%), corresponding to an aggregate normalized gain of 0.657, which falls in the medium range. Participants also produced initial game prototypes. Because only group means were available and there was no comparison group, the result is preliminary evidence of improved knowledge rather than proof of broader digital competence. Follow-up programs should collect individual scores, rate prototypes with a validated rubric, and examine classroom use and student outcomes.

Keywords: Digital Competence, Educational Games, Kodu Game Lab, Teacher Professional Development, Community Service

1 Introduction

Digital technology has changed how teachers plan, deliver, and assess learning, and the competence to use it well is now part of the professional profile expected of every teacher. The European Framework for the Digital Competence of Educators (DigCompEdu) describes this competence across six areas: professional engagement, digital resources, teaching and learning, assessment, empowering learners, and facilitating learners' digital competence [1]. Within this framework, the ability to create and modify digital resources, rather than only to select them, is treated as a distinct and more advanced competence [1], [2]. Self-assessment studies built on the framework show that many teachers rate themselves as users of digital resources but far fewer as creators [3], and international surveys consistently list information and communication technology for teaching among the areas in which teachers report the greatest need for professional development [4].

Access to devices and connectivity does not translate automatically into meaningful technology use. Research on technology integration has long shown that teachers' knowledge, confidence, pedagogical beliefs, and school culture shape whether and how technology enters the classroom [5]–[8]. The Technological Pedagogical Content Knowledge (TPACK) framework explains why: effective integration requires teachers to combine knowledge of a technology with knowledge of pedagogy and subject content, so training that teaches only how to operate an application leaves the most important connection unmade [9]. Syntheses of teacher education research recommend that teachers learn technology through authentic design tasks, role models, collaboration, and feedback on their own products [10].

Educational games are a demanding but promising test of this design capacity. Meta-analyses report that digital game-based learning improves cognitive, metacognitive, and motivational outcomes in school, provided that the game is designed around clear learning goals [11]–[13]. Reviews also show that the benefits depend on the integration of game mechanics with content, feedback, and an appropriate level of challenge [14]–[16], and that gamification alone produces smaller and less consistent effects [17]. Teachers' willingness to use games is influenced by their expectations of value and by their confidence in handling the technology [18], and professional development that addresses these perceptions can change teachers' attitudes and self-efficacy regarding game-based learning [19]. Asking teachers to design games themselves adds a further benefit: the

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design process forces them to translate content into rules, goals, and feedback, which strengthens the pedagogical reasoning described by TPACK [20], [21].

Kodu Game Lab offers a low-threshold entry into such design. Developed by Microsoft Research, it allows users to build three-dimensional game worlds by attaching visual "When–Do" rules to characters and objects, without writing textual code [22], [23]. Studies with learners show that this rule-based environment can express core programming concepts such as conditionals, events, and sequencing [24], and that users' reasoning while building Kodu programs can be analyzed systematically [25]. These features make the tool suitable for teachers with little or no programming background.

At the partner Madrasah Tsanawiyah, the problem identified with the school was not a lack of access to technology or an inability to operate common applications. It was teachers' limited experience in turning subject matter into interactive digital learning products, together with a need for practical guidance that connects learning objectives, content, game elements, and technology. This community service program was designed to address that gap. It aimed (1) to strengthen teachers' knowledge of educational game design and their basic ability to build a game prototype in Kodu Game Lab, and (2) to examine the change in participants' test performance before and after the training. The program's contribution lies in combining a competence framework (DigCompEdu), a knowledge framework (TPACK), and features of effective professional development in a single, short, product-oriented training model for madrasah teachers.

2 Method

2.1 Program Design

The program used a participatory community service approach in which the university team and the partner madrasah jointly identified needs, planned the activity, and reviewed its results [26]. Its design followed five features that research associates with effective professional development: a focus on content, active learning, coherence with teachers' work, sufficient duration, and collective participation [27], [28]. It also followed the recommendation that teachers learn technology by designing and receiving feedback on their own products [10], [29], [30]. The program consisted of seven stages (Figure 1). Needs identification established participants' initial knowledge and experience. Concept strengthening introduced educational games and their alignment with learning objectives. A demonstration presented the Kodu Game Lab interface, objects, worlds, and rule editor. During hands-on development, participants built simple prototypes, and facilitators provided individual mentoring throughout. Product evaluation reviewed each prototype for its relevance to the intended objective and its basic functionality, and a closing reflection discussed lessons learned and plans for classroom use.

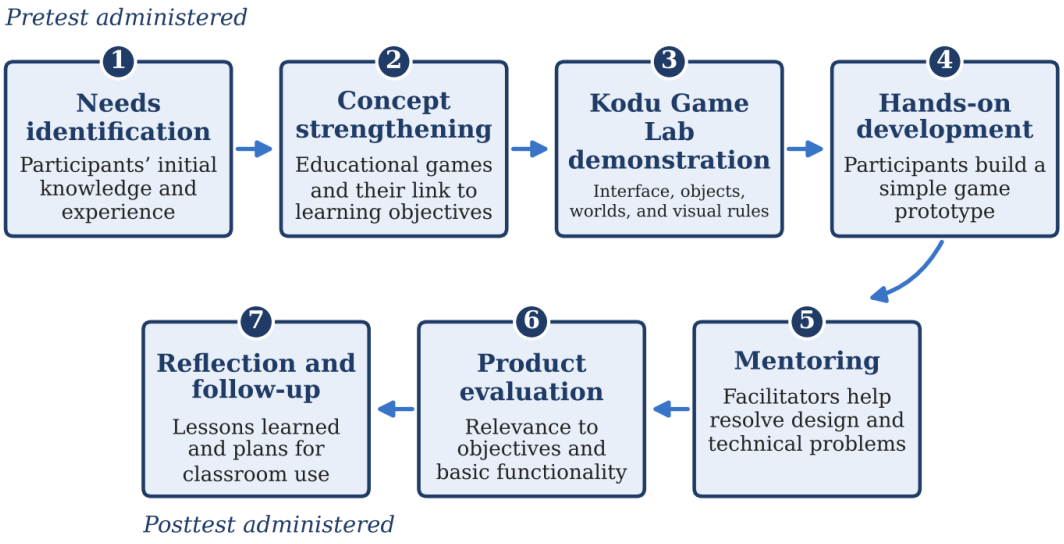


Figure 1. Implementation stages of the educational game development training.

The training was held at the partner Madrasah Tsanawiyah on June 4, 2026, for a total of 8 contact hours.

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2.2 Participants

Twelve teachers from the partner Madrasah Tsanawiyah took part. They were selected purposively based on their active teaching duties and the need, identified with the school, to strengthen their capacity to develop digital learning media. Participants differed in prior digital experience, and all took part in every stage of the training.

2.3 Training Materials

The materials were sequenced from concepts to production (Table 1) so that each practical step built on a conceptual one. The design stage asked participants to start from a learning objective and only then choose game elements, following the principle that the instructional goal, not the technology, should drive game design [12], [16].

Table 1. Structure of the training materials.

No.	Component	Main content
1	Digital learning media	Characteristics and functions of digital learning media
2	Educational games	Concepts, characteristics, and pedagogical principles
3	Learning design	Alignment of learning objectives with game activities
4	Kodu Game Lab	Interface, objects, worlds, and visual When–Do rules
5	Game development	Designing characters, rules, challenges, and interactions
6	Product evaluation	Relevance to objectives, functionality, and learning potential
7	Reflection	Review of the learning experience and follow-up plans

2.4 Data Collection and Analysis

Learning was assessed with a knowledge test on digital learning media and educational game development, administered before and after the training. Learning was assessed using a 15-item instrument combining written questions and practical assessment, administered before and after the training. The instrument was developed by the training team to assess participants' knowledge of digital learning media and their basic skills in educational game development using Kodu Game Lab. The written component assessed participants' understanding of the training materials, while the practical component assessed their application of the knowledge and skills introduced during the training. The instrument was developed specifically for this activity and was not subjected to formal validation; therefore, the results should be interpreted as an activity-specific assessment of participants' learning rather than as measurements from a formally validated instrument. The evaluation corresponds to the second level, participants' learning, of Guskey's five-level model for evaluating professional development [31]. The data available for analysis were the group mean scores. Change was summarized as the absolute difference, the relative increase P in (1), and Hake's normalized gain ⟨g⟩ in (2), which expresses the observed gain as a share of the maximum possible gain [32]:

$$P = (Posttest - Pretest) / Pretest \times 100\% \quad (1)$$

$$\langle g \rangle = (Posttest - Pretest) / (100 - Pretest) \quad (2)$$

Following Hake's classification, $\langle g \rangle \geq 0.7$ is high, $0.3 \leq \langle g \rangle < 0.7$ is medium, and $\langle g \rangle < 0.3$ is low [32]. Because only aggregate means were available, ⟨g⟩ was computed at the group level, and no inferential test, effect size, or individual gain could be calculated. Single-group pretest–posttest designs are also open to threats such as testing effects and regression to the mean [33]; the results are therefore reported descriptively.

3 Results and Discussion

3.1 Implementation of the Training

All seven stages were carried out as planned. Needs identification showed that participants differed in their prior experience of producing digital media, which was why the program combined group instruction with individual mentoring. In the concept stage, facilitators contrasted media that only present information with media that require learners to act, make decisions, and receive feedback. The demonstration then introduced the Kodu interface, terrain and object tools, and the When–Do rule editor, which allowed participants to create interactions without writing code [23].

Hands-on development was the central activity. Each participant started from a learning objective in his or her own subject and translated it into game elements following the sequence shown in Figure 2: subject content, game concept, characters and world, rules and challenges, and feedback. Participants who encountered technical

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difficulties received direct assistance from the facilitators during practice, so that problems were resolved while participants were still working. During product evaluation, participants presented their prototypes and discussed whether each game element served the stated objective. Participants completed initial prototypes, which remained simple because of the limited training time. Figure 3 documents the activity.

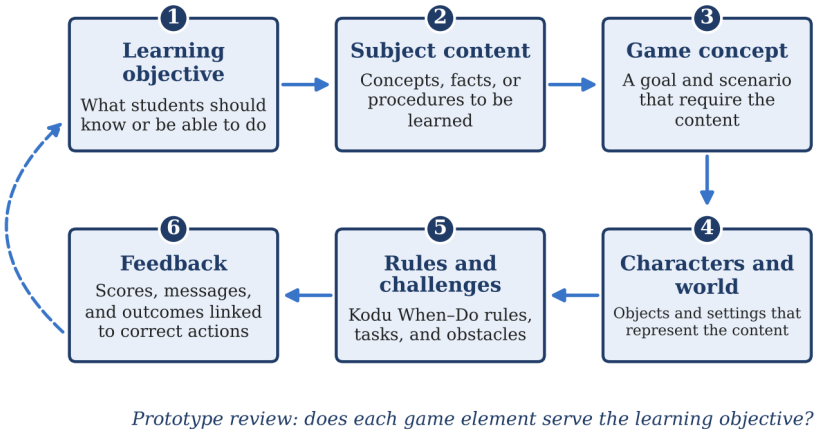


Figure 2. Steps used to transform subject content into an educational game prototype in Kodu Game Lab.



Figure 3. Documentation of the training activities at the partner Madrasah Tsanawiyah.

3.2 Change in Test Performance

Table 2 summarizes the test results. The group mean increased from 65 on the pretest to 88 on the posttest, an absolute gain of 23 points and a relative increase of 35.38%. Applying (2), $\langle g \rangle = (88 - 65)/(100 - 65) = 0.657$, which falls in the medium range of Hake's classification [32]. In other words, participants closed about two-thirds of the gap between their initial mean score and the maximum possible score.

Table 2. Pretest and posttest results (n = 12, group means).

Indicator	Pretest	Posttest	Change
Mean score (0–100)	65	88	+23
Relative increase, P	–	–	35.38%
Normalized gain, ⟨g⟩	–	–	0.657 (medium)

These figures describe group means only. Without individual scores, it is not possible to tell whether all participants improved, whether some participants gained much more than others, or how large the effect is relative to the variability of scores. The posttest also measured knowledge rather than performance, so the score gain cannot be read as direct evidence of improved practical skill in Kodu Game Lab. Table 3 therefore maps the available evidence to Guskey's levels and identifies what remains to be measured [27], [31].

Table 3. Evidence available at each level of professional development evaluation.

Level	Evidence from this program	Status and next step
1. Participants' reactions	Informal comments during reflection	Not measured systematically; use a short satisfaction survey
2. Participants' learning	Group mean test scores rose from 65 to 88; participants completed initial prototypes	Partly established; add individual scores and a prototype scoring rubric
3. Organizational support	Training held in the madrasah's computer laboratory	Not evaluated; document school support for follow-up
4. Use of new knowledge	Plans for classroom use discussed during reflection	Not yet observed; follow up with classroom observation
5. Student learning outcomes	None	Not yet measured; compare classes that use and do not use the games

3.3 Discussion

The increase in mean scores is consistent with research showing that professional development focused on specific content and built around active learning produces measurable gains in teacher knowledge [27], [28], [30]. The medium normalized gain is comparable in category to the gains Hake reported for interactive-engagement courses, although the two settings differ in content, instrument, and length, and the values should not be compared numerically [32]. The most plausible mechanism is the hands-on design task. Building a prototype required participants to make many small decisions about how content becomes a goal, a rule, or a piece of feedback, and these decisions are the TPACK connections that demonstration alone rarely produces [9], [20]. This interpretation agrees with experiential learning theory, in which concrete experience and reflection on it drive understanding [34]–[36], and with evidence that making games, not only playing them, supports learning [21].

The program also illustrates why mentoring matters in technology training. Teachers with different levels of prior experience meet different obstacles, and unresolved technical problems reduce confidence, one of the main barriers to technology integration [5], [6]. Immediate help during practice kept participants working on design questions rather than on troubleshooting. Kodu Game Lab supported this goal because its visual rules lowered the technical threshold [22], [24]. The same simplicity, however, limits how far the resulting games can go, and teachers who wish to build richer games may later need tools with more expressive power.

The findings should be interpreted within clear limits. The program measured knowledge at the group level, had no comparison group, and did not score the prototypes systematically, so the results do not establish improvement across the competence areas of DigCompEdu [1], [3]. Nor do they show that the games improve students' learning; the meta-analytic evidence for game-based learning concerns well-designed games used in instruction [11]–[13], and the prototypes produced here have not yet been validated or used with students. Changes in teachers' beliefs and confidence, which strongly predict sustained technology use [7], [8], were not measured either. Single-group pretest–posttest results can also be inflated by familiarity with the test [33].

These limits suggest a sequence for follow-up programs. Individual pretest and posttest scores should be recorded to allow paired tests and effect sizes. Prototypes should be scored with a rubric covering alignment with objectives, functionality, and feedback quality, and DigCompEdu self-assessment could be added before and after the training [3]. Mentoring should continue after the workshop, since effective professional development is sustained rather than one-off [29], [30]. Finally, refined games should be implemented in classrooms, with student engagement and achievement compared against regular instruction.

3.4 Supporting and Constraining Factors

Three factors supported the program: its practical orientation, which kept participants actively engaged; direct mentoring, which resolved technical difficulties during practice; and the accessible design of Kodu Game Lab. Three factors constrained it: differences in participants' prior digital experience, which led to different working speeds; limited training time, which kept the products at the prototype stage; and evaluation data limited to group means.

4 Conclusion

This community service program trained 12 Madrasah Tsanawiyah teachers to design educational games with Kodu Game Lab through seven participatory stages that combined concept strengthening, demonstration, hands-on development, mentoring, product evaluation, and reflection. The group mean test score rose from 65 to 88, a relative increase of 35.38% and a normalized gain of 0.657 in the medium range, and participants produced initial game prototypes. These results provide preliminary evidence that short, product-oriented training with mentoring can improve teachers' knowledge of educational game development and give them first-hand experience as producers, not only users, of digital learning media. Because the evaluation relied on group means and a single group, the program does not yet demonstrate gains across the full range of digital competence or any effect on students. Future programs should collect individual data, validate the games with a scoring rubric, provide sustained mentoring, and test the games in classrooms.

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Conflict of Interest

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Author Contributions

L.E.: Conceptualization, Methodology, Project Administration, Writing – Original Draft. M.N.H.: Investigation, Resources. S.D.: Investigation, Formal Analysis. H.A.: Investigation, Visualization. F.A.: Validation, Writing – Review & Editing. P.D.: Investigation, Data Curation. All authors have read and approved the final version of the manuscript.

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Artificial Intelligence (AI) Use Statement

During the preparation of this manuscript, the authors used Claude (Anthropic) for language editing, structural revision, and assistance in locating and formatting references. All AI-assisted output was reviewed, verified, and revised by the authors. The authors take full responsibility for the accuracy, integrity, originality, and final content of the manuscript.

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