

Designing Digital Game Based Learning in Early Childhood Teacher Education Using the ADDIE Model

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Abstract

Teacher education programs increasingly need to prepare preservice teachers to make pedagogically sound decisions about digital technology rather than simply operate digital tools. This study examined an ADDIE-guided redesign of an Educational Technology for Early Childhood course for preservice early childhood teachers at Universitas Mataram, Indonesia. The development process included curriculum analysis, redesign of the Semester Learning Plan (RPS), expert review by 10 lecturers, implementation across 16 course meetings, and evaluation of seven student-developed digital game prototypes. Eight randomly selected students rated each prototype on originality, innovation, aesthetics, functionality, relevance, and perceived impact using a five-point scale. Expert feedback prompted revisions to learning-outcome alignment, assessment, technology ethics and safety, learning resources, and interactive learning activities. Six prototypes were rated in the study's good range and one in the adequate range. Product-level means ranged from 3.65 to 4.38, with an overall mean of 3.97/5. Functionality received the highest cross-product dimension mean (4.16), whereas aesthetics was the lowest (3.75). The findings show that a curriculum-embedded design project can provide observable evidence of preservice teachers' capacity to apply technological and pedagogical knowledge in authentic product development. Because the study did not include a pretest-posttest competence measure or comparison group, the findings indicate demonstrated design performance rather than causal improvement in competence.

1 Introduction

Digital transformation has intensified expectations that teacher education programs prepare graduates to make principled decisions about technology rather than merely operate digital tools. A recent systematic review found that preservice teachers often demonstrate stronger basic digital skills than advanced pedagogical integration, ethical awareness, and critical decision-making [1]. In early childhood education, this challenge is especially consequential because digital technology must be reconciled with play, developmental appropriateness, accessibility, child safety, and adult mediation. Studies using the technological pedagogical content knowledge (TPACK) perspective similarly show that effective technology integration depends on the interaction among technological, pedagogical, and content knowledge and on the institutional context in which teachers work [2, 3].

Digital game-based learning (DGBL) provides a useful context for developing this integrated professional knowledge. Designing an educational game requires decisions about learning goals, task structures, feedback, interaction, visual communication, and user experience. Reviews and meta-analytic studies suggest that digital games can support motivation and learning when game mechanics are coherently connected to educational purposes [4–6]. At the same time, preservice teachers may express positive attitudes toward games while reporting limited preparation and uncertainty about how game-based approaches should be integrated into instruction [7].

For this reason, teacher education research has increasingly moved beyond asking preservice teachers to use or play digital games and has examined what happens when they design game-based learning

experiences themselves. Design activities can make pedagogical reasoning visible because preservice teachers must translate curriculum goals into interactive tasks, decide how feedback should operate, and connect technological choices to the needs of learners [8–11]. In early childhood education, this design work must also account for the distinctive developmental and relational conditions of young children's learning [12].

The present study was conducted in the Early Childhood Education Study Program at Universitas Mataram, Indonesia, within the Educational Technology for Early Childhood course. The development work centered on a Semester Learning Plan (Rencana Pembelajaran Semester, RPS) and a culminating project in which preservice teachers developed online educational games for early childhood learning. The source project originally treated successful product development as evidence of improved student competence. However, the available dataset contains no standardized pretest, posttest, or comparison group. Accordingly, this article adopts a more conservative analytic position: prototype quality is interpreted as evidence of demonstrated design performance after participation in the redesigned course, not as proof of causal competence gains.

Two research questions guided the study: (1) How did expert review shape the redesign of the game-based Educational Technology for Early Childhood course? and (2) What quality profile was demonstrated by the digital educational game prototypes produced following implementation of the redesigned course?

2 Methods

2.1 Research design

The study used a research-and-development approach organized through the ADDIE sequence of Analysis, Design, Development, Implementation, and Evaluation. ADDIE functioned as an instructional-development structure rather than as an experimental design. This positioning is consistent with design and developmental approaches in digital game-based learning, which emphasize iterative alignment among learning goals, design decisions, implementation, and evaluation [13]. The development objects were the revised RPS for the Educational Technology for Early Childhood course and the digital game prototypes produced during its implementation. The study workflow is summarized in Fig. 1.

2.2 Setting and course context

The study was conducted in the Early Childhood Education Study Program, Faculty of Teacher Training and Education, Universitas Mataram, Indonesia, during the 2024 academic year. The redesigned course was implemented with third-semester preservice teachers across 16 meetings. The intended course outcome was that students would be able to design, create, and apply online games as educational technology for early childhood learning. The course therefore combined conceptual study with a product-development task rather than treating technology as a stand-alone technical skill.

2.3 Analysis, design, and expert review

During the analysis stage, the research team reviewed the curriculum, program learning outcomes, course learning outcomes, learning materials, assessment strategy, learning resources, and student needs. These findings informed a redesigned RPS that aligned weekly learning activities, assessment, and a project-based digital game task with the course learning outcomes.

An initial RPS draft was then reviewed by 10 lecturers with expertise in instructional planning and early childhood education. Their feedback was organized into four broad areas: format and structure; content and substance; language and writing; and additional curricular considerations. The review generated substantive revisions, including clearer alignment among program outcomes, course outcomes, and sub-outcomes; stronger attention to critical thinking and problem solving; inclusion of technology ethics and safety for young children; updated learning resources; more explicit assessment criteria; and more interactive learning activities.

2.4 Implementation and prototype development

The revised RPS was implemented across the 16-meeting course. The first half of the semester addressed foundational concepts in educational technology, the development of educational technology, and analysis of technology use in early childhood learning. Following the mid-semester examination, students moved into a design-and-development phase. At the end of the course, seven digital game prototypes were presented: Counting Object 1–10, Labelled Diagram, Crossword Puzzle, Spinning Wheel, Match Up, Unjumble, and Counting Object.

2.5 Prototype evaluation and data analysis

Eight students were randomly selected as evaluators. Each prototype was rated on six dimensions: originality, innovation, aesthetics, functionality, relevance, and perceived impact. Ratings used a five-point scale. Consistent with the source study, mean scores were categorized as poor (1.00–2.33), adequate (2.34–3.66), or good (3.67–5.00). Descriptive analysis was used to calculate product-level and dimension-level mean scores.

During reconstruction of the article, the reported totals were checked against the item-level values available in the institutional research report. Where a narrative statement and the item-derived mean differed, the arithmetic mean and the consolidated summary were used. This affected the reported total for Unjumble, for which the six item means yield approximately 4.06. No inferential test was added because the original dataset and design do not support causal or population-level inference.

2.6 Ethics and consent

The study involved student-generated digital products, peer ratings, and lecturer review within an educational research-and-development activity at Universitas Mataram. The research protocol entitled "Development of Game-Based Learning Tools to Improve the Competence of Early Childhood Education Students" was reviewed and approved by the Human Research Ethics Committee of the Faculty of

Teacher Training and Education, Universitas Mataram, under Ethical Approval No. 2263/UN18.FS/BP3MF.OT/2024. All procedures involving human participants were conducted in accordance with the ethical requirements of the approving committee, relevant institutional guidelines and regulations of Universitas Mataram, and the ethical principles of the Declaration of Helsinki. Informed consent to participate was obtained from all student participants and lecturer reviewers before participation and before their responses or evaluations were used for research purposes. Participation was voluntary, and confidentiality and anonymity of participant information were maintained throughout data collection, analysis, and reporting.

3 Results

Expert review and implementation produced two complementary outcomes: a more explicitly aligned course design and a set of digital game prototypes that made students' technology-integration performance observable.

3.1 Expert-informed redesign of the RPS

Expert review led to changes that went beyond formatting. Reviewers requested clearer mapping among program learning outcomes, course learning outcomes, and sub-outcomes; updated references and learning resources; stronger assessment criteria; and a more transparent relationship between weekly activities and intended outcomes. They also recommended adding technology ethics and safety for young children and broadening the course's attention to emerging educational technologies. Table 1 summarizes the principal revisions.

Table 1
Expert-review recommendations and resulting design emphasis

Review area	Key recommendation	Resulting design emphasis
Format and structure	Standardize document formatting and visual presentation	Improved usability and transparency
Learning outcomes	Strengthen alignment among program outcomes, course outcomes, and sub-outcomes; add critical thinking/problem solving	Clearer constructive alignment
Content	Add technology ethics and safety; update technology topics and references	Broader professional and ethical framing
Assessment	Clarify criteria and diversify assessment through projects, presentations, and portfolios	More authentic evidence of learning
Learning activities	Increase interactive activities, case work, simulation, and project-based learning	Stronger connection between concepts and practice
Media and resources	Specify relevant digital applications, websites, and software	More concrete technology integration

These changes repositioned the RPS from a schedule of topics into a more explicit instructional design document. In particular, assessment and project work were linked more directly to the course outcome requiring students to design and apply digital educational technology.

3.2 Digital game prototypes

Following implementation of the revised RPS, students produced seven online educational game prototypes. The development task required students to move from learning about technology to making decisions about content representation, interaction, visual design, functionality, and relevance to early childhood learning. Table 2 presents the product-level evaluation results.

Table 2
Product-level evaluation of the seven digital game prototypes

No.	Prototype	Mean score (1–5)	Category
1	Counting Object 1–10	3.85	Good
2	Labelled Diagram	3.69	Good
3	Crossword Puzzle	4.38	Good
4	Spinning Wheel	3.65	Adequate
5	Match Up	4.17	Good
6	Unjumble	4.06	Good
7	Counting Object	4.00	Good
Overall mean		3.97	Good

Six of the seven prototypes were rated within the study's good range, while Spinning Wheel was rated adequate. Crossword Puzzle received the highest mean score (4.38), followed by Match Up (4.17), Unjumble (4.06), Counting Object (4.00), Counting Object 1–10 (3.85), Labelled Diagram (3.69), and Spinning Wheel (3.65). The mean of the seven product-level totals was 3.97 out of 5. The product-level score pattern is shown in Fig. 2.

3.3 Dimension-level quality profile

Table 3
Mean ratings across the seven prototypes by
evaluation dimension

Evaluation dimension	Mean score (1–5)
Functionality	4.16
Relevance	4.00
Perceived impact	3.98
Originality	3.97
Innovation	3.97
Aesthetics	3.75

Dimension-level aggregation adds detail to the product totals. Functionality had the highest mean across the seven prototypes (4.16), followed by relevance (4.00), perceived impact (3.98), originality (3.97), innovation (3.97), and aesthetics (3.75) (Table 3). The relatively strong functionality result indicates that students were generally able to make their prototypes operate as intended. Aesthetics was the weakest dimension overall, and originality also varied noticeably between products. These patterns identify specific areas for future instructional support, particularly visual communication, child-centered interface design, creative ideation, accessibility, and iterative playtesting. The dimension-level profile is visualized in Fig. 3.

4 Discussion

The central contribution of this study is not a claim that digital games automatically improve preservice teacher competence. Rather, the findings show how a curriculum-embedded design process can make technological-pedagogical performance visible. This interpretation is consistent with research showing that preservice teachers can develop professionally relevant understandings when they move beyond discussing technology integration and engage in the design of game-based learning experiences [8–11]. Design tasks externalize professional reasoning: students must decide what children are expected to learn, how interaction will support that learning, what feedback a game should provide, and how the digital product will fit within a wider pedagogical sequence.

The expert-review findings also align with a TPACK-oriented view of technology integration. In early childhood education, technological skill alone is insufficient; appropriate practice depends on the fit among technology, pedagogy, content, learners, and context [2, 3]. The RPS revisions strengthened these connections by clarifying the relationship among outcomes, learning activities, assessment, digital resources, and the developmental context of early childhood education. The inclusion of ethics and safety was particularly important because professional digital competence includes decisions about privacy, developmentally appropriate use, accessibility, and adult mediation, not only technical proficiency [1, 2].

The prototype ratings provide a second insight. An overall mean of 3.97 indicates that the assignment generally resulted in products meeting the study's quality criteria, but the range from 3.65 to 4.38 shows meaningful variation in design quality. A completion-only assessment would have obscured this variation. Rubric-based evaluation made it possible to identify which aspects of design were comparatively strong and which required further development. Functionality was the strongest dimension, while aesthetics was the weakest. This suggests that novice designers may achieve basic operational and curricular relevance before developing more sophisticated visual and user-experience design.

The study extends the literature on game design in preservice teacher education by focusing specifically on early childhood education. Previous studies have reported that game-design activities can support technology-integration knowledge, professional confidence, and reflective pedagogical decision-making, although outcomes are not necessarily uniform across all competencies [8–11]. The present findings reinforce the importance of matching claims to measured outcomes. Here, prototype scores are a direct outcome; broader claims about competence development require stronger designs with baseline measures, repeated assessment, or comparison groups.

For teacher education practice, the findings support a development sequence in which preservice teachers analyze curriculum and child-learning goals, examine examples of digital games, design and build prototypes, receive formative feedback, test products, and revise their designs. Future iterations should add authentic child-user testing under appropriate ethical oversight, accessibility checks, documentation of design decisions, and structured reflection linking each technological choice to a pedagogical rationale. Such additions would transform a product-oriented assignment into a more complete professional learning cycle.

Several limitations constrain interpretation. First, the source report does not state the full course enrollment, so the proportion of students represented by the eight evaluators cannot be established. Second, the evaluators were peers rather than independent experts or child users, which may have introduced familiarity or leniency effects. Third, the study relied on descriptive ratings and did not report inter-rater reliability. Fourth, there was no pre-course baseline, post-course competence measure, or comparison group. Fifth, the games were evaluated as prototypes rather than through direct measurement of learning outcomes among young children. These limitations mean that the study demonstrates the quality of produced artifacts and the feasibility of the course design, but not causal improvement in competence or child learning.

5 Conclusion

An ADDIE-guided redesign of an early childhood educational technology course enabled preservice teachers to move from conceptual study to the production of seven digital game prototypes. Expert review strengthened the alignment of learning outcomes, activities, assessment, learning resources, and technology ethics and safety. Six prototypes were rated in the study's good range, and the overall

product-level mean was 3.97/5. Functionality was the strongest cross-product dimension, while aesthetics was the weakest. These findings provide evidence of demonstrated digital game-design performance after implementation of the redesigned course; they do not, by themselves, establish causal improvement in competence. Future research should incorporate baseline and post-intervention measures, independent expert evaluation, child-user testing, accessibility and ethical design criteria, and stronger reliability evidence. Within these limits, the study offers a practical model for embedding authentic digital design work into early childhood teacher education.

Declarations

Ethical approval

This study was reviewed and approved by the Human Research Ethics Committee of the Faculty of Teacher Training and Education, Universitas Mataram, under Ethical Approval No. 2263/UN18.FS/BP3MF.OT/2024. The approved research protocol was entitled "Development of Game-Based Learning Tools to Improve the Competence of Early Childhood Education Students". All procedures involving human participants were conducted in accordance with the ethical requirements of the approving committee, relevant institutional guidelines and regulations of Universitas Mataram, and the ethical principles of the Declaration of Helsinki.

Consent to participate

Informed consent to participate was obtained from all student participants and lecturer reviewers before their participation and before their responses or evaluations were used for research purposes. Participation was voluntary, and participants were informed of the purpose and procedures of the study. Confidentiality and anonymity of participant information were maintained throughout data collection, analysis, and reporting.

Consent to publish

Not applicable. The manuscript contains only aggregated and non-identifiable data and does not include any information, images, or other material that could identify individual participants.

Competing interests

The authors declare no competing interests.

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Author Contribution

M.A.M.H. contributed to conceptualization, methodology, formal analysis, interpretation of the findings, visualization, and writing of the original manuscript, and coordinated the revision and final preparation of the manuscript. B.N.A. contributed to conceptualization, research design, investigation, development of the instructional framework and Semester Learning Plan (RPS), data collection, validation, and review and editing of the manuscript. I.M.S.A. contributed to investigation, instructional and educational game design, validation, interpretation of the findings, and review and editing of the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for the work.

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Data Availability

The supporting data comprise the aggregated prototype-rating results and the revised Semester Learning Plan (RPS) documented in the institutional research report. These materials are not deposited in a public repository and are available from the corresponding author upon reasonable request.

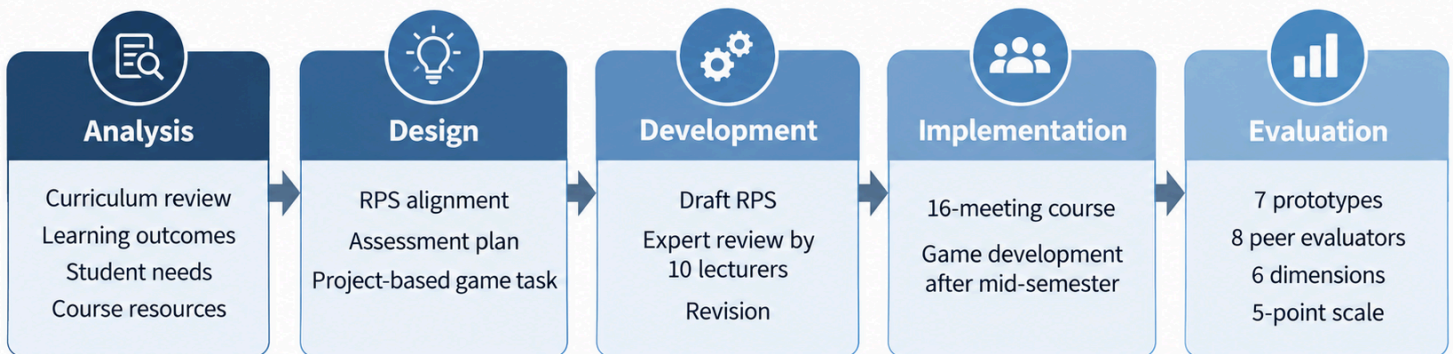
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Figures

Instructional Development and Evaluation Sequence



Course redesign translated conceptual learning into observable digital-game design performance.

Figure 1

ADDIE-guided development and evaluation workflow used in the study

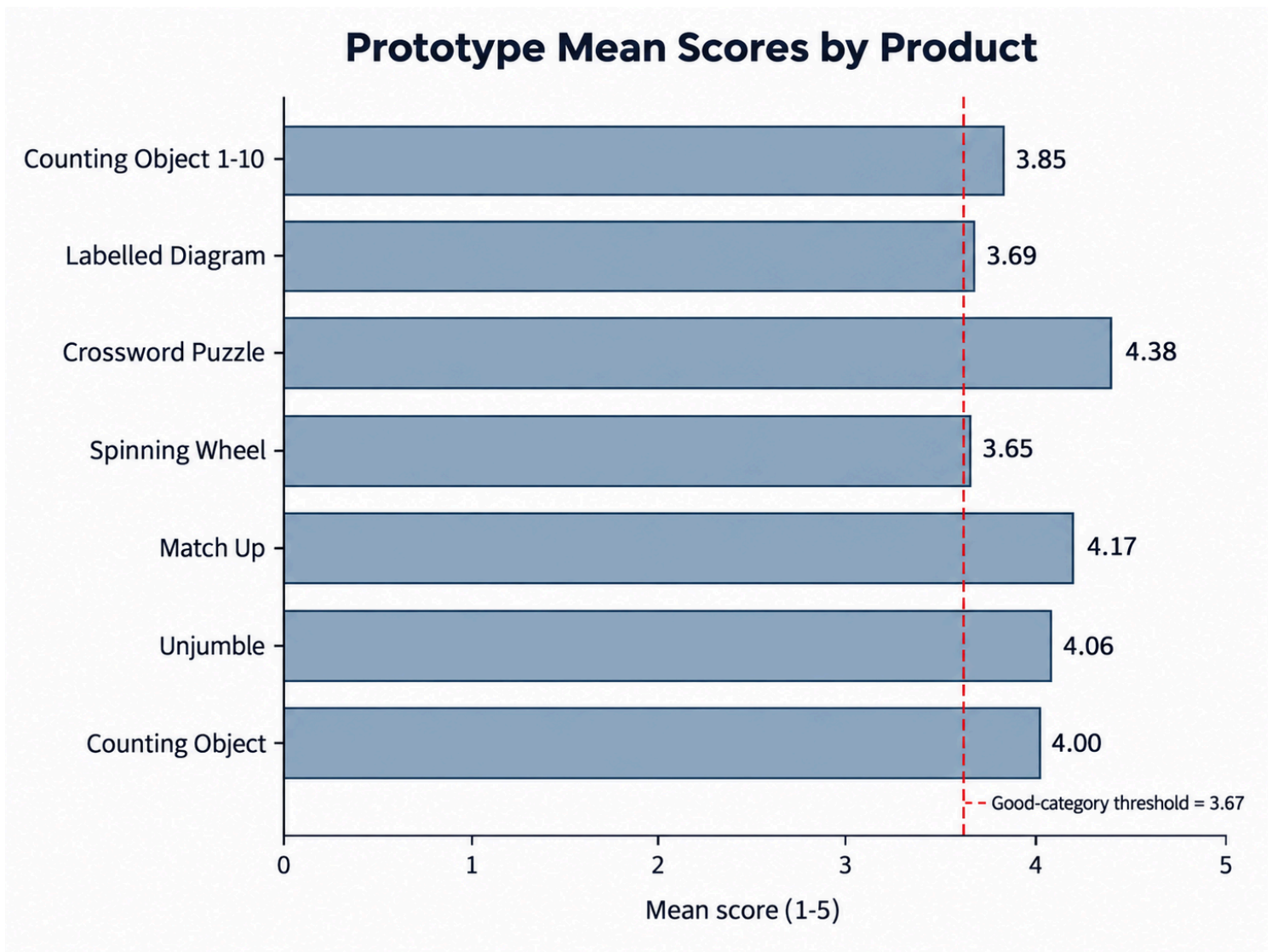


Figure 2

Mean quality scores of the seven student-developed digital game prototypes

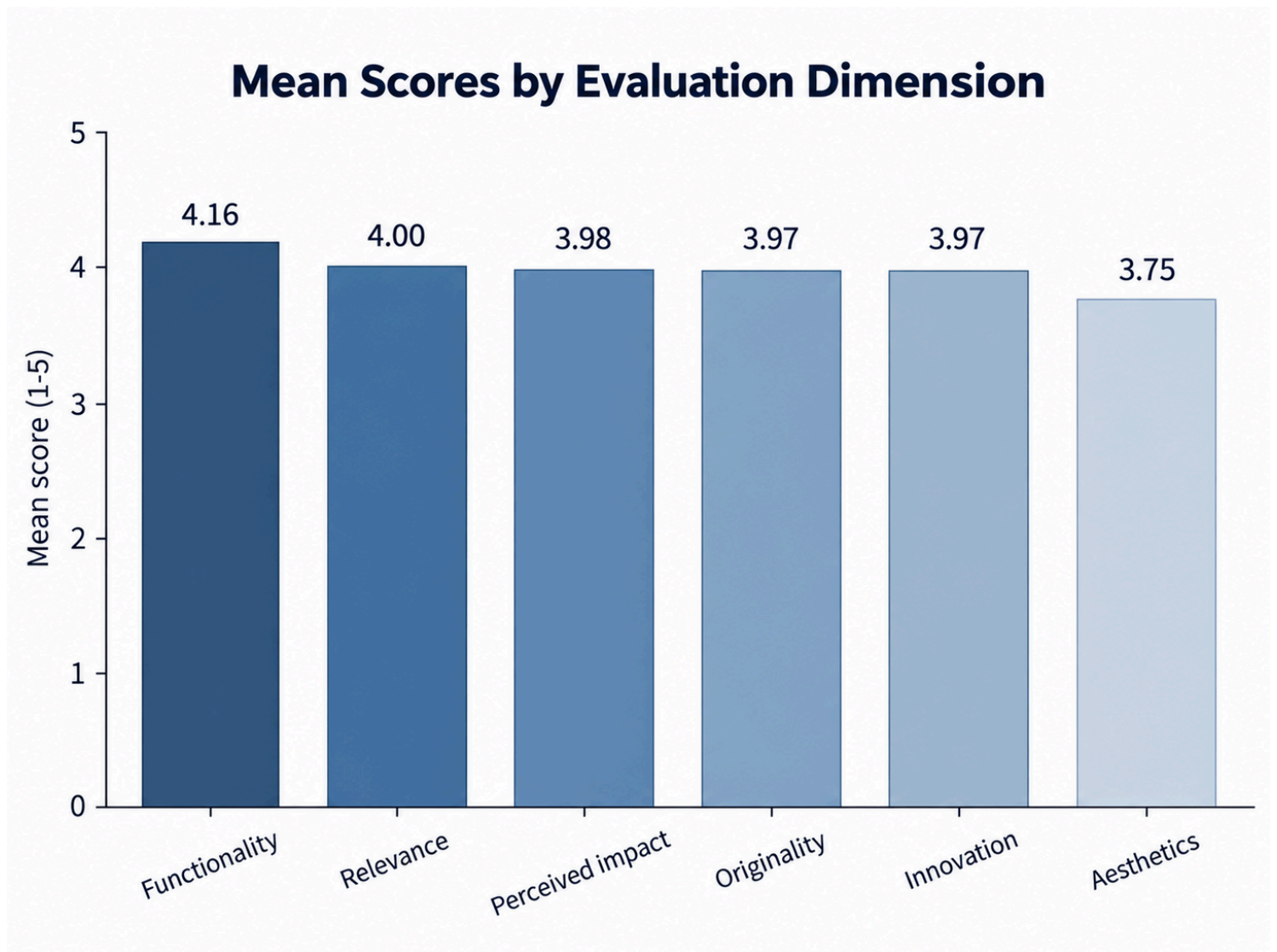


Figure 3

Mean ratings across the six prototype-evaluation dimensions