1. Citation

Author(s): Sascha Mahlke. **Year:** 2008. **Title:** User Experience of Interaction with Technical Systems. **Institution:** Technische Universität Berlin.

2. Study Aim & Context

• **Main Goal:** To present an approach to user experience (UX) of interaction with technical systems that makes theoretical, methodological, and empirical contributions to overcome the shortcomings of existing approaches.

• **Focus:**

◦ **Interface design & UX:** Introduces a framework that includes instrumental and non-instrumental qualities.

◦ **Emotional reactions:** Proposes a multi-component approach to emotional user reactions including subjective feelings, physiological reactions, and motor expressions.

• **Field:** Human-Computer Interaction (HCI), User-Centered Design (UCD), and Psychology.

3. Core Research Problem & Purpose

The research addresses the shift in interactive system use from purely professional tools to integral parts of everyday life. Traditional design focused on **instrumental aspects** (usefulness and usability). Mahlke argues that to be successful, development must take the **entire user experience** into account, including non-instrumental qualities like aesthetics and symbolic aspects, as well as emotional reactions.

4. Methodology

Aspect	Details
Research Type	Quantitative and Experimental (Three empirical studies).
Target Learners	University students and staff (Adults, ages 17–54).
Tool Used	Portable audio players (MuVo², Zen Micro, etc.) and computer-based simulations.
Data Collected	Task performance (completion rates/time), questionnaires (SUMI, SAM, SUS), and physiological data (EDA, EMG, heart rate).

Evaluation Metrics	Perceived usability, visual aesthetics, symbolic quality, valence/arousal of emotions, and overall judgment.
Study Setting	Laboratory (UseLab at the Center of Human-Machine-Systems).

5. Intervention / Design Features

• **Key Design Elements:**

◦ **Visual/aesthetic elements:** Variations in symmetry, color combination, and shape of device bodies.

◦ **Interaction/UX patterns:** Variations in menu design (icons vs. text), navigation aids (scrollbars), and dialogue structure.

◦ **Contextual Variation:** Comparison between **goal-mode** (task-oriented) and **action-mode** (exploratory) usage.

• **Implementation:** These features were implemented across physical audio players and high-fidelity screen simulations to test how specific property changes influenced UX components.

6. Outcomes & Findings

• **Independence of Perceptions:** Instrumental (usability) and non-instrumental (aesthetics) qualities are perceived independently.

• **Determinants of Emotion:** Emotional reactions are determined by both types of quality perceptions.

• **Overall Judgment:** All three components (instrumental, non-instrumental, and emotional) influence the final judgment of a system.

• **Impact of Usability:** High usability leads to faster task completion and more positive emotional valence.

• **Cultural Influence:** Cultural background (Canadian vs. German) significantly affects the perception of visual aesthetics and subjective feelings.

7. Comparative Designs or Approaches

The study compared variations of systems with **high vs. low usability** and **high vs. low aesthetics**. Findings showed that **usability (instrumental quality) has a higher effect on the emotional experience** of interaction than non-instrumental quality perceptions. However, aesthetics contribute significantly to overall judgment, particularly in exploratory "action-mode" settings.

8. Pedagogical / Cognitive Implications

• **Cognitive Appraisals:** The research utilizes Scherer's model of cognitive appraisals (novelty, goal relevance, etc.) to explain how users evaluate a system's impact on their well-being.

• **Usage Modes:** It suggests that cognitive focus shifts depending on whether a user is in "goal-mode" (where usability is the primary predictor of satisfaction) or "action-mode" (where aesthetics and exploration play a larger role).

9. Design & UX Implications

• **Separation of Concerns:** Designers should address usability and aesthetics as distinct goals.

• **Predicting Overall Ratings:** To achieve a positive overall rating, a system must provide at least a moderate level of both usability and aesthetic appeal.

• **Culture-Centered Design:** Visual aesthetics must be tailored to different cultural backgrounds as perceptions of "good design" vary.

10. Practical Takeaways for a Game (e.g., "Auri's Journey")

• **Actionable Insights:**

1. **Prioritize Usability for Tasks:** Ensure the core mechanics (moving Auri, interacting with items) are highly usable to prevent negative emotional reactions during challenging levels.

2. **Use Aesthetics to Drive Evaluation:** While usability is key for performance, invest in high-quality visual aesthetics to boost the player's overall rating of the game.

3. **Support Exploratory Modes:** Design the game to provide high "action-mode" satisfaction where players can enjoy the visuals and symbolic qualities without immediate goal pressure.

11. Strengths & Novel Contributions

• **Integrative Framework:** Successfully combines fragmented UX approaches into one model.

• **Methodological Breadth:** Uses a combination of subjective questionnaires and objective physiological measures.

• **Contextual Analysis:** One of the few studies to empirically test the moderating role of usage modes and culture on UX.

12. Limitations & Research Gaps

• **Duration:** The studies focused on short-term interactions (episodes), leaving a gap in understanding UX over long-term usage (weeks/months).

• **Scope:** The application area was limited to consumer electronics (audio players/phones); generalizability to other complex systems (like educational games) requires further testing.

• **Complexity of Emotions:** Specific "enthusiastic" or high-arousal positive emotions were difficult to induce in a lab setting.

13. Key Quotes / Definitions

• **UX Definition:** "User experience takes an entirely user-oriented perspective on human-technology interaction. The user’s perspective on the quality of the interaction is the ultimate criterion".

• **Core Finding:** "Instrumental and non-instrumental qualities are perceived independently".

14. Tags / Keywords

["UX_design", "usability", "aesthetics", "emotional_user_reactions", "HCI", "goal-mode", "action-mode", "cultural_differences"]

15. Relevance Score & Applicability (1–5)

Category	Rating
Relevance to cognitive/learning focus	3
Relevance to UX/design focus	5
Applicability to game development	4
Novelty for thesis	4

16. Notes for Thesis Synthesis

Mahlke (2008) establishes that user experience is a multi-dimensional construct where **usability (instrumental)** and **aesthetics (non-instrumental)** function as independent predictors of a user's **emotional reaction** and **overall judgment**. This suggests that for interactive systems, high performance is necessary but insufficient; the emotional quality of the experience, moderated by culture and usage mode, is what ultimately determines a system's success.

1. Citation

Author(s): Kristian Kiili, Sara de Freitas, Sylvester Arnab, & Timo Lainema. **Year:** 2012. **Title:** The Design Principles for Flow Experience in Educational Games. **Journal/Conference:** Procedia Computer Science, 15, 78–91.

2. Study Aim & Context

• **Main Goal:** To present a **flow framework** that describes the building blocks of flow experience to help design appealing and effective educational games for formal and informal learning.

• **Focus:**

◦ **Motivation & flow** in educational games.

◦ **Game-based learning / constructivist learning.**

◦ **Interface design & UX** (specifically playability and fluent interaction).

• **Field:** Game-based learning, instructional design, and human-computer interaction.

3. Core Research Problem & Purpose

The research addresses the challenge of **balancing gameplay and learning objectives**. Designers often struggle to translate the benefits of entertainment games into educational contexts without losing educational effectiveness. The study aims to improve **cognitive engagement** and **intrinsic motivation** by using flow theory to ensure players remain absorbed in the learning task.

4. Methodology

Aspect	Details
Research Type	Quantitative and Experimental (Case study).
Target Learners	University students (Economics, Finance, Marketing, etc.).
Game/Tool Used	**RealGame**, a collaborative business simulation game.
Data Collected	9-item flow questionnaire (6-point Likert scale) and game performance metrics (turnover, profit).
Evaluation Metrics	Flow dimensions (challenge, goals, feedback, playability, etc.) and learning/performance outcomes.

Study Setting Classroom/Lab environment (five exercise groups).

5. Intervention / Design Features

• **Key Design Elements:**

◦ **Flow Antecedents:** Clear goals, immediate/cognitive feedback, sense of control, challenge, and playability.

◦ **Playability:** Designing controls to be **transparent** so users focus on higher-order cognition rather than the interface.

◦ **Cognitive Feedback:** Provided through virtual agents or in-game avatars to stimulate reflection.

• **Implementation:** These features were implemented in a business simulation where challenges were adjusted (via clock speed) to match student skill levels.

6. Outcomes & Findings

• **High Flow Levels:** Students experienced a high level of flow (Mean = 4.60).

• **Strongest Dimensions: Sense of control, clear goals, and challenge-skill balance** scored the highest among participants.

• **Performance Correlation:** Flow experience significantly correlated with game performance, specifically **turnover ($r = .29$)** and **profit ($r = .33$)**.

• **User Influence:** The ability to influence game events and other players was identified as a major factor in enhancing the flow experience.

7. Comparative Designs or Approaches

The study proposes replacing the traditional flow dimension of "action-awareness merging" with **"playability"** in educational contexts. This is because learning requires **conscious, active knowledge construction** rather than the spontaneous, automatic behavior often found in pure entertainment games.

8. Pedagogical / Cognitive Implications

• **Constructivist Learning:** The framework supports active and aware decision-making by the player.

• **Zone of Proximal Development:** The authors extend the flow model by incorporating Vygotsky's theory, suggesting that **guidance or collaboration** can help players move from anxiety/boredom back into the flow state.

• **Cognitive Load:** Fluent interaction (high playability) minimizes the cognitive resources spent on the interface, leaving more for the learning task.

9. Design & UX Implications

• **Transparent Controls:** Interface design must be intuitive enough that it becomes "invisible" to the player.

• **Immediate Feedback:** To prevent distraction, the game must inform the player of the effects of their actions immediately.

• **Balanced Challenge:** Games should adapt to the player’s skill level; if the challenge is too high, it leads to anxiety; if too low, it leads to boredom.

10. Practical Takeaways for “Auri’s Journey”

1. **Establish Clear Sub-goals:** Divide the main game goal into smaller, manageable sub-goals to maintain a sense of success.

2. **Optimize Playability:** Ensure the controls for Auri are transparent so the player focuses on the puzzles, not the buttons.

3. **Adaptive Challenge:** Implement mechanics that adjust difficulty based on the player’s performance to keep them in the **"flow channel."**

4. **In-Game Feedback:** Use an avatar or guide to provide **cognitive feedback** that helps the player reflect on their strategies.

11. Strengths & Novel Contributions

• **The Flow Framework:** It provides a specific model for designers to map game mechanics to flow dimensions.

• **Playability as Antecedent:** Recognizing that "automaticity" is not always desirable in learning, making "playability" a unique contribution to UX in educational games.

12. Limitations & Research Gaps

• **Context Specificity:** The results were based on a business simulation; other genres (like adventure or puzzle games) might yield different results.

• **Manual Adjustment:** In the study, the challenge level (clock speed) was sometimes adjusted by an operator, which might be difficult to automate in all games.

• **Long-term Effects:** The study does not address how flow is maintained over very long periods of gameplay.

13. Key Quotes / Definitions

• **On UX:** "User experience should be considered from physical, sensual, cognitive, emotional, and aesthetic perspectives."

• **On Flow:** "Flow describes a state of complete absorption or engagement in an activity and refers to the optimal experience."

• **On Playability:** "The aim of the user interface design of games is to support the shift from cognitive interaction to fluent interaction."

14. Tags / Keywords

["flow_theory", "educational_games", "playability", "cognitive_engagement", "feedback", "constructivist_learning", "UX_design"]

15. Relevance Score & Applicability

Category	Rating (1-5)
Relevance to cognitive/learning focus	5
Relevance to UX/design focus	4
Applicability to Auri’s Journey	5
Novelty for thesis	4

16. Notes for Thesis Synthesis

Kiili et al. (2012) demonstrate that **flow is a critical predictor of performance** in educational games, with dimensions like clear goals and sense of control being paramount. Their model emphasizes that **"playability"**—the reduction of interface-related cognitive load—is essential for allowing players to focus on the actual learning content, effectively bridging the gap between entertainment and education.

1. Citation

Author(s): Zehui Zhan, Luyao He, Yao Tong, Xinya Liang, Shihao Guo, & Xixin Lan. **Year:** 2022. **Title:** The effectiveness of gamification in programming education: Evidence from a meta-analysis. **Journal/Conference:** *Computers and Education: Artificial Intelligence*, Volume 3, 100096.

2. Study Aim & Context

• **Main Goal:** To construct a systematic framework and examine the effect of gamification on programming education through a meta-analysis of 21 empirical studies.

• **Focus:**

◦ **Learning psychology & cognitive engagement:** Examining thinking skills and cognitive load.

◦ **Motivation & flow:** Identifying the impact on student motivation.

◦ **Game-based learning:** Investigating various game types (puzzle, role-playing, etc.).

◦ **Gamification & reward systems:** Analyzing gamification as a competitive mechanism or teaching tool.

• **Field:** Educational Technology, Artificial Intelligence, and Instructional Design.

3. Core Research Problem & Purpose

Programming is often considered a difficult subject due to **abstract concepts** and **obscure logic**, leading to low student motivation. While gamification is proposed as a solution, academic consensus is divided on whether it truly improves engagement and knowledge retention or simply adds a non-relevant burden to working memory. This study aims to quantify its effectiveness on **academic achievement, cognitive load, motivation, and thinking skills**.

4. Methodology

Aspect	Details
Research Type	Quantitative Meta-analysis.
Target Learners	K-12 and Higher Education (University students).
Game/Tool Used	Various gamified platforms/types: Reasoning strategy, Puzzle, Role-playing, and Robot games.
Data Collected	71 effect sizes derived from 21 empirical studies (2010–2020).

Evaluation Metrics	Standardized Mean Difference (SMD/Hedges' g) for learning outcomes and cognitive load.
Study Setting	Formal educational environments (classroom/lab).

5. Intervention / Design Features

• **Key Design Elements:**

◦ **Gamification mechanics:** Points, badges, leaderboards, and competitive mechanisms.

◦ **Game Genres:** Puzzle games for observation/logic, reasoning strategy games for deduction, and role-playing for problem-solving.

◦ **Pedagogical Agents:** Implementation of virtual agents, physical robots, or real-person agents to support learning.

• **Implementation:** Gamification was applied either as a **teaching tool**, a **student work** (creating games), or a **competitive mechanism**.

6. Outcomes & Findings

• **Overall Effectiveness:** Gamification has a significant positive effect on programming education (SMD = 0.63).

• **Primary Drivers:** It has the largest impact on **motivation (SMD = 0.77)** and **academic achievement (SMD = 0.75)**.

• **Cognitive Load:** Gamification slightly **increased cognitive load (SMD = 0.23)**, suggesting that game elements can sometimes distract from the core learning content if not managed well.

• **Genre Success: Reasoning strategy games** were most effective for academic achievement, while **puzzle games** were most effective for motivation.

• **Application Mode:** Using gamification as a **competitive mechanism** had the greatest impact on thinking skills and motivation.

7. Comparative Designs or Approaches

• **Programming Types:** Gamification was significantly more effective for **text-based programming** than for graphical programming.

• **Pedagogical Agents:** The presence of a **virtual agent** (SMD = 1.26) showed a higher impact on achievement than no agent, though this was based on a smaller sample of studies.

• **Schooling Levels:** Gamification showed a higher impact on academic achievement and motivation in **higher education** compared to K-12.

8. Pedagogical / Cognitive Implications

• **Scaffolding & ZPD:** The findings support the need for guidance according to the **Zone of Proximal Development**; without proper instructional design, gamification can become a burden on memory.

• **Intrinsic vs. Extrinsic:** The source warns that rewards (extrinsic) can sometimes make students feel manipulated, reducing their **intrinsic motivation**.

9. Design & UX Implications

• **Strategic Genre Use:** Use **puzzle games** at the beginning of a curriculum to trigger interest, followed by **reasoning strategy games** to deepen learning.

• **Managing Complexity:** Because programming is complex, designers must ensure the interface and game rules do not add **extraneous cognitive load**.

• **Competitive Mechanics:** Implementing leaderboards or competitive challenges can be a powerful tool to boost thinking skills.

10. Practical Takeaways for "Auri's Journey"

1. **Prioritize Puzzle Elements:** Use puzzle-based mechanics to keep player motivation high during the introductory levels.

2. **Include a Virtual Guide:** Integrate a virtual pedagogical agent (a mentor character) to provide scaffolding, as this is linked to significantly higher achievement.

3. **Manage Cognitive Load:** Carefully design the introduction of new mechanics so the "gamified" parts of Auri's journey don't overwhelm the actual "learning" parts.

4. **Use Competition for Skills:** If the game includes logic-based challenges, incorporate a competitive element (like a timer or ranking) to enhance thinking skills.

11. Strengths & Novel Contributions

• **Granular Analysis:** It is the first meta-analysis to examine specific subgroups like programming type, game type, and the role of pedagogical agents.

• **Systematic Evidence:** Provides clear quantitative evidence (effect sizes) for the benefits of gamification beyond simple qualitative claims.

12. Limitations & Research Gaps

• **Sample Size:** Only 21 studies met the rigorous inclusion criteria.

• **Immersion Gaps:** There is a lack of research on high-immersion environments like the **metaverse** in programming education.

• **Subgroup Scarcity:** Some categories, like robot games or virtual agents, had very few studies for comparison.

13. Key Quotes / Definitions

• **On Motivation:** "Gamification has the largest effect on students' motivation, followed by academic achievement".

• **On Cognitive Load:** "Gamification slightly increased students' cognitive load... if not guiding properly, it might cause additional cognitive load for students".

14. Tags / Keywords

["gamification", "programming_education", "motivation", "academic_achievement", "cognitive_load", "meta-analysis", "thinking_skills"].

15. Relevance Score & Applicability

Category	Rating (1-5)
Relevance to cognitive/learning focus	5
Relevance to UX/design focus	4
Applicability to Auri's Journey	5
Novelty for thesis	4

16. Notes for Thesis Synthesis

Zhan et al. (2022) provide meta-analytic evidence that gamification is a moderately effective tool (SMD = 0.63) for improving programming education, particularly in boosting **motivation** and **academic achievement**. However, they highlight a critical trade-off: gamified elements can increase **cognitive load**, necessitating the use of **pedagogical agents** and structured **scaffolding** to ensure that game mechanics facilitate rather than hinder the learning of abstract concepts.

1. Citation

Author(s): Yang Gui, Zhihui Cai, Yajiao Yang, Lingyuan Kong, Xitao Fan, and Robert H. Tai. **Year:** 2023. **Title:** Effectiveness of digital educational game and game design in STEM learning: a meta-analytic review. **Journal/Conference:** *International Journal of STEM Education*, 10:36.

2. Study Aim & Context

• **Main Goal:** To investigate the general effect of digital game-based learning (DGBL) over traditional STEM learning and to assess the enhancement effect of adding specific game-design elements over "base" game versions.

• **Focus:**

 ◦ **Learning psychology & cognitive engagement:** Measured through STEM knowledge and cognitive skills.

 ◦ **Game-based learning:** Analyzed across various subjects (Science, Math, Engineering, Computer).

 ◦ **Interface design & UX:** Examined through game mechanics and levels of realism.

• **Field:** STEM Education, Instructional Design, and Educational Psychology.

3. Core Research Problem & Purpose

The study addresses the **inconsistency in empirical evidence** regarding the efficacy of DGBL in STEM education. It seeks to resolve whether digital games are superior to traditional instruction and, crucially, **what specific game design elements (learning vs. gaming mechanisms)** actually contribute to better learning outcomes and higher-order thinking skills.

4. Methodology

Aspect	Details
Research Type	Quantitative Meta-analysis (including 123 studies and 217 effect sizes).
Target Learners	Pre-school/Primary to College/University students.
Game/Tool Used	Various digital games (Puzzle, Role-playing, Simulation, Strategy, Action, Adventure, Construction).
Data Collected	Hedges’ g (effect sizes) derived from sample sizes, means, and standard deviations.

Evaluation Metrics	STEM academic achievement (knowledge gains and cognitive skills).
Study Setting	Various (Classroom, Lab, and experimental/quasi-experimental settings).

5. Intervention / Design Features

• **Key Design Elements:**

◦ **Game Types:** Comparison of genres such as strategy, puzzle, and role-playing.

◦ **Game Mechanisms:** Divided into **learning mechanisms** (e.g., feedback, self-explanation, pedagogical agents) and **gaming mechanisms** (e.g., points, leaderboards).

◦ **Level of Realism:** Variations from schematic (lines/text) to photorealistic environments.

• **Implementation:** Conducted via two meta-analyses: one comparing DGBL to non-game instruction and another comparing base games to versions enhanced with added mechanics.

6. Outcomes & Findings

• **General Efficacy:** DGBL has a medium to large positive effect on STEM learning compared to traditional methods (**g = 0.624**).

• **Cognitive Skills vs. Knowledge:** DGBL is significantly more effective at promoting **cognitive skills (g = 0.91)** than it is for basic knowledge acquisition (g = 0.538).

• **Design Element Effectiveness:** Added elements for **content learning (g = 0.432)** were significantly more effective than elements added purely for the **gaming experience (g = 0.175)**.

• **Genre Success: Strategy games** showed the largest average effect size (g = 1.841) for STEM learning environments.

7. Comparative Designs or Approaches

The meta-analysis explicitly compared "Media Comparison Research" (games vs. traditional) and "Value-Added Research" (base game vs. enhanced game). It found that while games are generally effective, **learning-related enhancements** provide more value than aesthetic or reward-based ones, as excessive gaming mechanics can distract from the learning task.

8. Pedagogical / Cognitive Implications

• **Situated Learning:** Digital games create a virtual "community of practice" where learners construct knowledge through interaction.

• **Cognitive Theory of DGBL:** Effectiveness stems from mechanisms that **minimize irrelevant cognitive processing** and encourage generative processing.

• **Higher-Order Thinking:** The study reinforces the idea that DGBL is particularly suited for developing 21st-century skills like problem-solving and critical thinking.

9. Design & UX Implications

• **Focus on Learning Mechanics:** Designers should prioritize "cognitive apprenticeships" like **pedagogical agents and adaptive feedback** rather than just leaderboard systems.

• **Realism is Secondary:** The **level of realism** (cartoon-like vs. photorealistic) did not significantly impact learning outcomes, suggesting designers can focus budget on mechanics rather than high-end graphics.

• **Complexity Management:** Game rules must support the learning content directly to avoid over-burdening the player's limited cognitive processing capacity.

10. Practical Takeaways for Our Game ("Auri's Journey")

1. **Prioritize Strategy Mechanics:** Incorporate elements requiring tactics and long-term planning, as **strategy games** are the most effective for STEM-related cognition.

2. **Embed Learning Aids:** Directly integrate **pedagogical agents or self-explanation prompts** into Auri's Journey to provide cognitive scaffolding.

3. **Target Higher-Order Skills:** Design challenges that focus on **problem-solving and creative thinking** rather than rote memorization, as this is where digital games offer the greatest advantage.

4. **Balance Feedback:** Ensure feedback is **related to the learning content** (e.g., explaining why a puzzle solution worked) rather than just awarding points.

11. Strengths & Novel Contributions

• **Three-Level Model:** Used a cutting-edge statistical model to avoid biases from non-independent data.

• **Comprehensive Scope:** Unlike previous subject-specific reviews, this meta-analysis integrates the entire STEM field and distinguishes between knowledge and cognitive skill outcomes.

12. Limitations & Research Gaps

• **Outcome Variety:** Primarily focused on cognitive outcomes; **motivation and emotion** were not quantitatively synthesized.

• **Specific Mechanics:** Did not isolate the effects of individual mechanics like narrative or collaboration.

• **Cultural Factors:** Did not account for how **sociocultural differences** might affect game effectiveness.

13. Key Quotes / Definitions

• "The game-design elements added for content learning were more effective than those added for gaming experience".

• "STEM digital games were more effective for developing cognitive skills than for facilitating knowledge acquisition".

• "Strategy games could be more effective in the STEM learning environment than other types of games".

14. Tags / Keywords

["STEM_education", "meta-analysis", "cognitive_skills", "game_design", "strategy_games", "learning_mechanisms", "DGBL", "academic_achievement"]

15. Relevance Score & Applicability

Category	Rating (1-5)
Relevance to cognitive/learning focus	5
Relevance to UX/design focus	4
Applicability to Auri's Journey	5
Novelty for thesis	4

16. Notes for Thesis Synthesis

Gui et al. (2023) establish through a comprehensive meta-analysis that DGBL offers a significant advantage in STEM education, particularly for developing **higher-order cognitive skills ($g = 0.91$)** over simple knowledge acquisition. Their findings suggest a shift in design priority: for a game to be educationally effective, developers must focus on **integrating learning-focused mechanics** (such as adaptive feedback and cognitive apprenticeships) rather than relying on purely entertainment-driven gamification.

Analogy for Understanding: Designing an educational game like "Auri's Journey" is like **building a high-performance bicycle**: the "gaming mechanics" (points/badges) are like the paint and stickers—they make it look cool—but the "learning mechanisms" (feedback/scaffolding) are the gears and pedals. While the stickers might get someone on the bike, it is the gears and pedals that actually help them climb the mountain of knowledge.

1. Citation

Author(s): Anissa All, Elena Patricia Nuñez Castellar, & Jan Van Looy. **Year:** 2014. **Title:** Measuring Effectiveness in Digital Game-Based Learning: A Methodological Review. **Journal/Conference:** *International Journal of Serious Games*, Volume 1, Issue 2, pages 3–21.

2. Study Aim & Context

• **Main Goal:** To map the current research methods used for **effectiveness research in digital game-based learning (DGBL)** and take a first step toward a **standardized procedure** for assessment.

• **Focus:**

◦ **Learning psychology & cognitive engagement:** Specifically focusing on knowledge transfer (cognitive learning outcomes).

◦ **Motivation:** Examining motivation as a necessary prerequisite and secondary outcome.

◦ **Field:** Instructional Design, Educational Research, and Game Studies.

3. Core Research Problem & Purpose

The research addresses the **lack of sound empirical evidence** regarding DGBL effectiveness caused by inconsistent outcome measures, varying data collection methods, and difficult-to-interpret results. The study seeks to identify **confounding variables**—such as instructor influence and practice effects—that currently invalidate many effectiveness claims.

4. Methodology

Aspect	Details
Research Type	**Systematic Literature Review** using the **Cochrane method** and quantitative content analysis.
Target Learners	**Children (65%)**, teenagers (24%), and young adults/university students (12%).
Game/Tool Used	25 peer-reviewed studies (2000–2012) that used digital games for **cognitive learning outcomes** with a pre-post control group design.
Data Collected	Coding of dimensions: participants, interventions, methods, and outcome measures.
Evaluation Metrics	Accuracy (test scores/student achievement), time on task, self-efficacy, and **motivation**.
Study Setting	Mostly **formal contexts** (64%, e.g., schools during hours).

5. Intervention / Design Features

• **Key Design Elements:**

◦ **Gameplay Composition:** Individual play (associated with better performance), cooperative play, and competition.

◦ **Program Embedment:** Games were either **stand-alone (28%)** or embedded in larger programs (48%).

◦ **Support Elements:** Use of introductions, training sessions, extra reading materials, and **debriefing sessions**.

• **Implementation:** These features were reviewed based on how they were integrated into the educational intervention, noting that **instructor presence** (supervision vs. guidance) was reported in 56% of cases.

6. Outcomes & Findings

• **Methodological Diversity:** Comparison across studies is problematic due to the wide variety in control group activities and statistical techniques.

• **Confounding Factors:** Positive DGBL effects are often **overestimated** because of added elements like extra reading or extra interaction time that the control group did not receive.

• **Motivation Types:** Two distinct types were found: **motivation toward the intervention** (situational enjoyment) and **motivation toward the content** (learning outcome).

• **Gameplay Performance:** One reviewed study indicated that **individual gameplay leads to significantly better performance** than other compositions.

7. Comparative Designs or Approaches

The source notes that effectiveness interpretation depends heavily on the **control group activity**. It highlights that comparing DGBL to a "no-intervention" control group is problematic for justifying investment; instead, games should be compared to **viable, less expensive alternatives** using similar instructional techniques.

8. Pedagogical / Cognitive Implications

• **Multidimensional Learning:** DGBL primarily targets cognitive outcomes but often results in **affective secondary outcomes** (e.g., improved attitude toward a subject).

• **Intrinsic vs. Extrinsic Motivation:** While games are inherently motivating, in DGBL, students are often **extrinsically motivated** (e.g., playing for credits), and higher levels of **autonomy** in this extrinsic motivation lead to better learning quality.

9. Design & UX Implications

• **Transparent Interaction:** Medium and content are connected; the characteristics of the game medium influence the learning outcome.

• **In-Game Assessment:** The use of **"stealth assessment"** is noted as a way to dynamically measure progress without interrupting the user experience.

• **Avoiding Distraction:** Design must ensure that gaming mechanics do not become **confounds** that make it impossible to tell if the game or the surrounding materials caused the learning.

10. Practical Takeaways for Our Game ("Auri's Journey")

1. **Isolate the Game Effect:** Ensure that Auri’s Journey can stand alone as a learning tool without requiring external "required reading" to be effective.

2. **Measure Two-Tiered Motivation:** Evaluate both the **enjoyment of the interface** (UX) and the resulting **interest in the learning topic** (Auri's world/subject).

3. **Balance Gameplay Modes:** Since **individual play** may boost performance but cooperation is common, consider offering a focused individual mode for core learning segments.

4. **Use Parallel Testing:** When testing Auri’s Journey, use **parallel versions** of tests (different questions, same difficulty) for pre- and post-tests to minimize **practice effects**.

11. Strengths & Novel Contributions

• **Systematic Mapping:** Provides the first comprehensive mapping of DGBL research methods to identify why evidence remains "inconclusive".

• **Confounds Identification:** Systematically categorizes the types of confounds (instructor, intervention elements, test effects) that plague the field.

12. Limitations & Research Gaps

• **Narrow Focus:** Limited only to digital games for **cognitive learning outcomes**.

• **Coding Bias:** Selection and coding were conducted by a **single researcher**.

• **Missing Data:** Many studies failed to report critical info like **gameplay composition** or how **test similarity** was assessed.

13. Key Quotes / Definitions

• **Effectiveness:** "Acquisition of knowledge and skills as a result of the implementation of a game as an instructional medium".

• **Motivation:** "Motivation is a necessary prerequisite to ensure that learners actually learn something".

14. Tags / Keywords

["DGBL_effectiveness", "methodological_review", "cognitive_learning", "motivation", "confounding_variables", "pre-post_design", "instructional_design"]

15. Relevance Score & Applicability

Category	Rating (1–5)
Relevance to cognitive/learning focus	5

Relevance to UX/design focus

Applicability to Auri's Journey

Novelty for thesis

16. notes for thesis synthesis

All et al. (2024) argue that the current evidence for DGBL effectiveness is weakened by suboptimal research designs and confounding variables. They emphasize that for a game to be truly proven effective, researchers must account for instructor influence and ensure that the control group receives an equivalent instructional intervention minus the game element.

1.Citation

Author(s): H W Prabawa, H Sutarno, J Kusnendar, & F Rahmah. Year: 2018. Title: Learning basic programming using CLIS through gamification. Journal/Conference: Journal of Physics:

Conference Series (4th International Seminar of Mathematics, Science and Computer Science Education). **Volume/Pages:** 1013, 012099.

2. Study Aim & Context

• **Main Goal:** To develop and test gamified learning media integrated with the **Children Learning in Science (CLIS)** model to increase student excitement and understanding of basic programming.

• **Focus:**

◦ **Learning psychology & cognitive engagement:** Focuses on shifting students from memorization to conceptual understanding.

◦ **Motivation & flow:** Aims to overcome boredom caused by monotonous learning processes.

◦ **Game-based learning / constructivist learning:** Utilizes the CLIS model, which is rooted in constructivism.

◦ **Gamification & reward systems:** Uses points, levels, and rewards.

• **Field:** Computer Science Education, Instructional Design, and Educational Technology.

3. Core Research Problem & Purpose

The study addresses the **difficulty of understanding programming concepts**, which is identified as a major hurdle for vocational students. Traditional learning is often **monotonous** and lacks varied media, leading to students memorizing vocabulary without comprehending real meanings. The research aims to **boost motivation** and **conceptual understanding** through interactive, aesthetic, and structured gamification.

4. Methodology

Aspect	Details
Research Type	Quantitative with **One Group Pre-test and Post-test** design.
Target Learners	Vocational school students majoring in Computer and Network Engineering (*N*=31).
Game/Tool Used	Multimedia gamification learning media based on the CLIS model.
Data Collected	Ability tests (pre/post), observation instruments (TPACK), and satisfaction questionnaires.

Evaluation Metrics	**Gain Index** (Hake's calculation), ANOVA for group differences, and student satisfaction percentages.
Study Setting	Vocational school classroom in Bandung, Indonesia; 4 meetings over one week.

5. Intervention / Design Features

• **Key Design Elements:**

◦ **CLIS Stages:** Introduction, Orientation, Idea, Rearrangement of ideas, Application, and Review.

◦ **Gamification Mechanics:** Point systems, leveling, finish-line goals, and reward systems.

◦ **Visual/Aesthetic Elements:** Nature-themed themes (green for grass, brown for soil, blue for clouds) to create harmony.

◦ **Cognitive Scaffolding: Non-player characters (NPCs)** that guide students and help solve challenges.

• **Implementation:** Students move characters through different stages corresponding to CLIS steps, collecting coins and solving branching algorithm problems.

6. Outcomes & Findings

• **Learning Improvement:** Statistical tests (ANOVA) showed significant differences in understanding after the intervention.

• **Group Performance (Gain Index):**

◦ **Upper Group:** 0.76 (High enhancement).

◦ **Middle Group:** 0.61 (Average enhancement).

◦ **Lower Group:** 0.44 (Average enhancement).

• **Response & Satisfaction:** 90% of students considered the media an effective alternative for learning. There was a **positive correlation (0.61)** between student satisfaction and their gain scores.

• **Behavioral Observations:** Some students in the "lower group" still struggled with focus, particularly during video-based segments.

7. Comparative Designs or Approaches

The study compared outcomes across **three ability groups** (upper, middle, and lower). While all groups improved, the **upper group** showed the most significant development. The study suggests that gamification is a superior alternative to traditional "one-direction" learning media.

8. Pedagogical / Cognitive Implications

• **Supports Constructivism:** By using the CLIS model, the game encourages students to reveal their early ideas, discuss them with a group, and construct new concepts through guided conflict resolution.

• **Concept Mastery:** The study emphasizes that early conceptual understanding acts as a "trigger" for acquiring more complex learning later on.

9. Design & UX Implications

• **Harmony in Aesthetics:** Using nature-related colors (green, brown, blue) and consistent themes in each stage improves the aesthetic experience.

• **Engagement through NPC Interaction:** Integrating NPCs to support the "disclosure and exchange of ideas" helps students feel less isolated in problem-solving.

10. Practical Takeaways for Our Game ("Auri's Journey")

• **Incorporate a Mentor NPC:** Use a virtual character to provide hints and scaffolding during difficult logic puzzles to keep students from getting stuck.

• **Use a Nature-Themed Palette:** Apply harmonious, nature-based color schemes to create a calming and professional learning environment.

• **Sequence via CLIS:** Structure levels to follow the "Orientation -> Idea -> Application" flow to ensure students are grounded in concepts before they are tested.

11. Strengths & Novel Contributions

• **Model Integration:** Successfully maps a specific scientific learning model (CLIS) directly into game mechanics.

• **Group Analysis:** Provides granular data on how different tiers of learners (upper vs. lower) respond to gamification.

12. Limitations & Research Gaps

• **Small Sample Size:** Conducted with only 31 students in a single school.

• **Focus Issues:** Identified that lower-performing students still struggle with focus, suggesting a need for even more engaging or adaptive elements.

• **TPACK Scope:** The research only focused on the media's impact on students, not on the broader integration of technology and pedagogy for teachers.

13. Key Quotes / Definitions

• **Gamification:** "The utilization of game mechanical elements and logical games to bind people, actions motivate, promote the learning, and solve problems".

• **CLIS Impact:** "CLIS is considered to make students more independent, especially in solving problems and creating some creative things".

14. Tags / Keywords

["basic_programming", "CLIS_model", "gamification", "vocational_education", "conceptual_understanding", "multimedia_learning"]

15. Relevance Score & Applicability

Category	Rating
Relevance to cognitive/learning focus	★★★★★
Relevance to UX/design focus	★★★★
Applicability to Auri's Journey	★★★★★
Novelty for thesis	★★★

16. Notes for Thesis Synthesis

Prabawa et al. (2018) demonstrate that integrating the **CLIS model** into gamified multimedia significantly improves conceptual understanding in programming, with a 90% student satisfaction rate. Their findings suggest that **aesthetic harmony** and **NPC-led scaffolding** are essential for maintaining student interest and facilitating the transition from memorization to logical problem-solving.