Designing Early Childhood Math Games: A Research-Driven Approach

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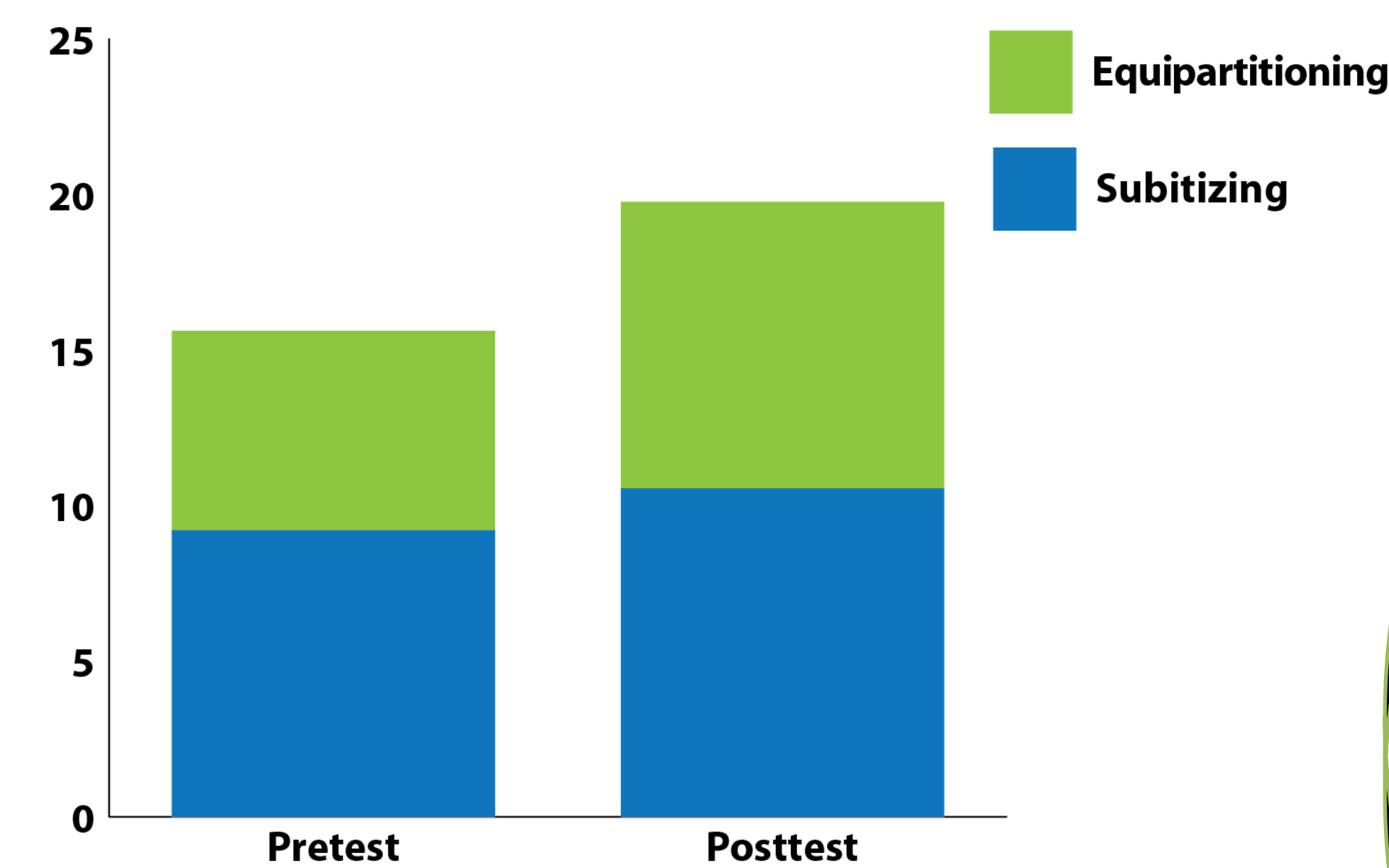
Project Goals

This paper describes the iterative research and development process used by the Next Generation Preschool Math project, which integrates content analysis, logic model processes, and iterative design and research approaches. An innovative aspect of this process is the inclusion of an adapted version of evidence-centered design—an approach traditionally used to create assessments—to align the mathematical goals with the design of instructional materials as well as with the assessment.

We created a curriculum supplement that:
- promotes children's understanding of subitizing and equipartitioning,
- uses interactive media on touch-screen tablets,
- integrating new multi-touch activities with existing hands-on activities;
- enhances opportunities for learning with interactive media through shared use with adult guides and peers; and
- provides professional and technical support materials for preschool educators.

Figure 1. Phases of Development and Research

Iterating Design & Research

We employed a design-based research approach that showcases how learning is deepened through successive interactions with specific concepts and skills across media, with adult- and peer-mediated discussion becoming richer with each subsequent interaction. During our design process, there was extensive interplay between educational researchers and the media production team across several phases of work (Figure 1).

Phases of Development and Research
- Literature Review
- Logic Model Process
- Technology Review
- Game Review and Formative Testing
- Learning Blueprint
- Prototype Development
- Assessment Development
- Alpha Pilot Study
- Concluding Development
- Field Testing

Figure 2. Pilot Student Achievement Results

- Equipartitioning
- Subitizing
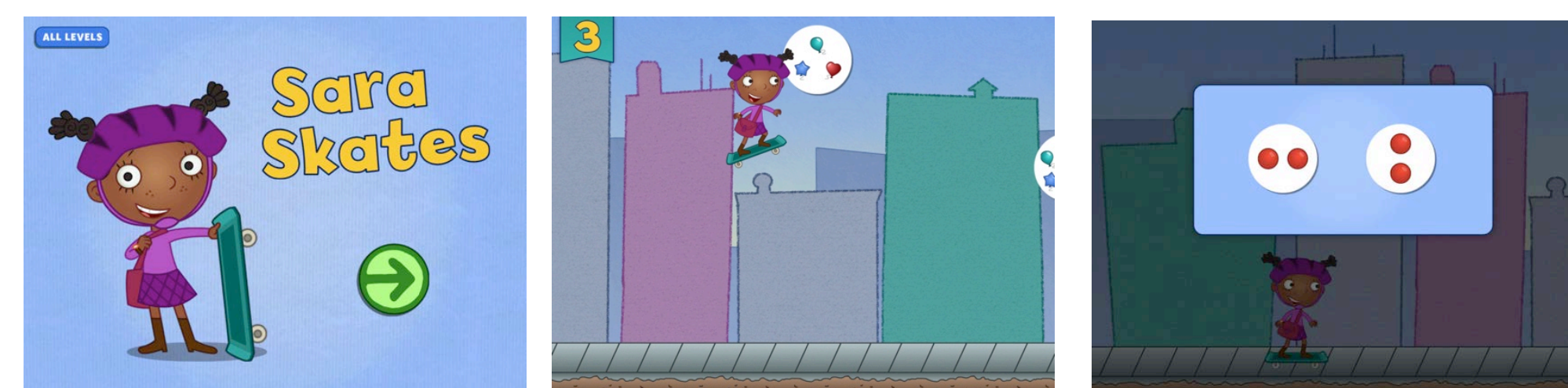
Subitizing Games

Equipartitioning Games
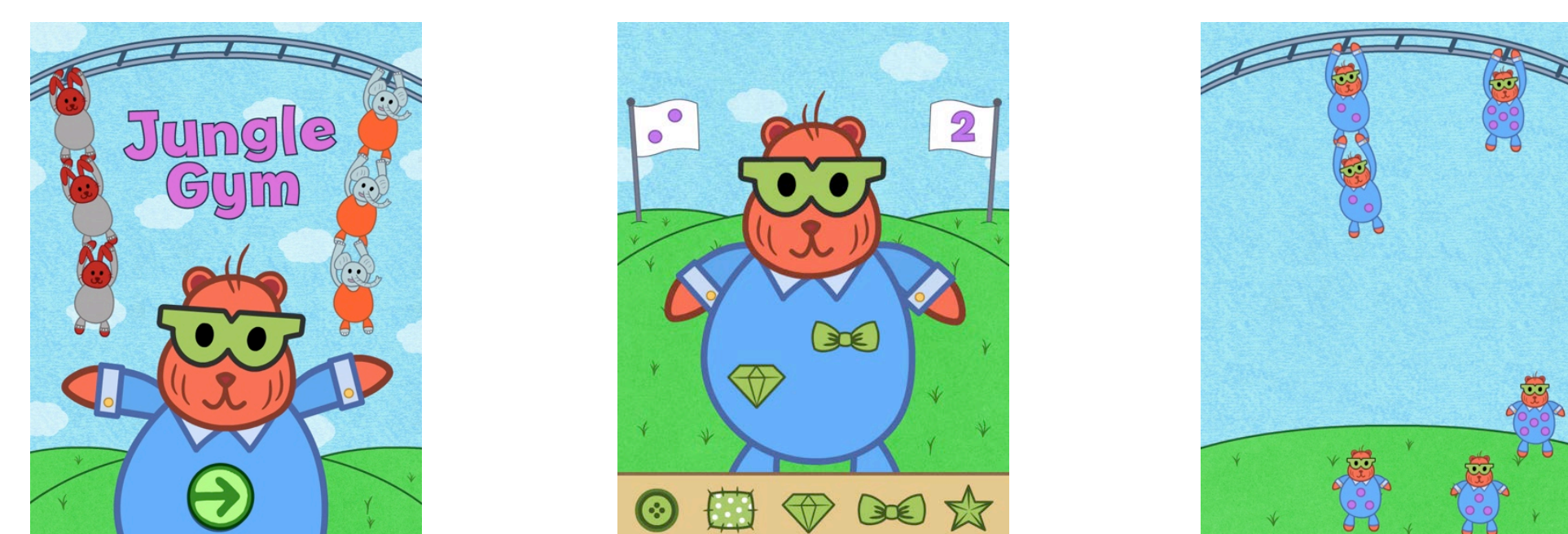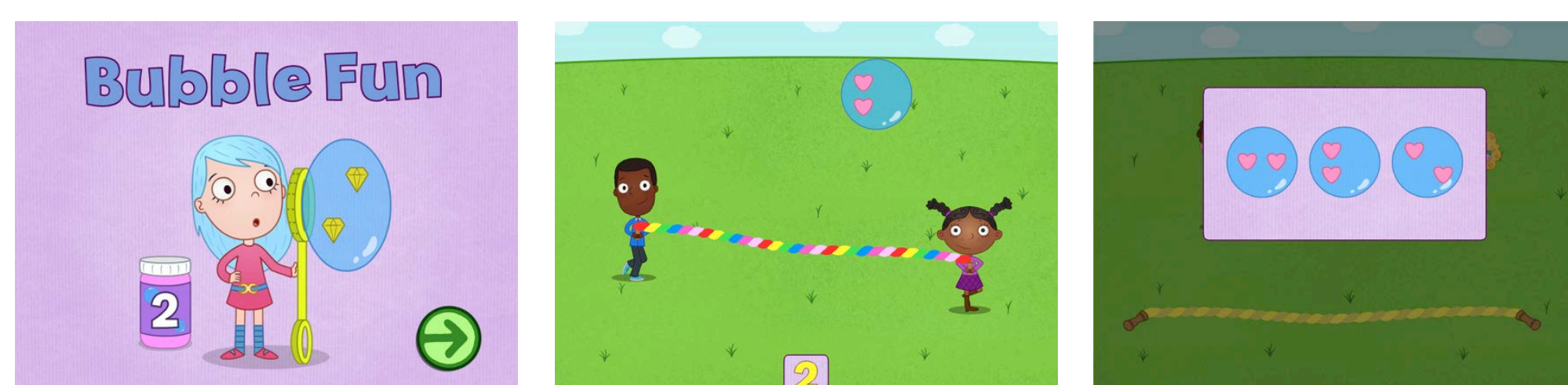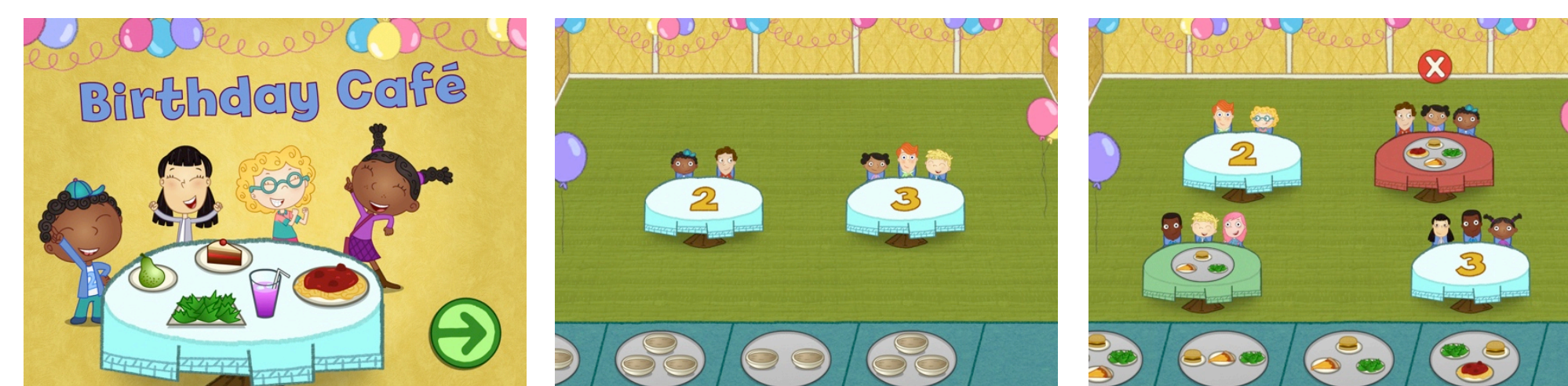
Figure 3. Using Learning Blueprint for Game Development

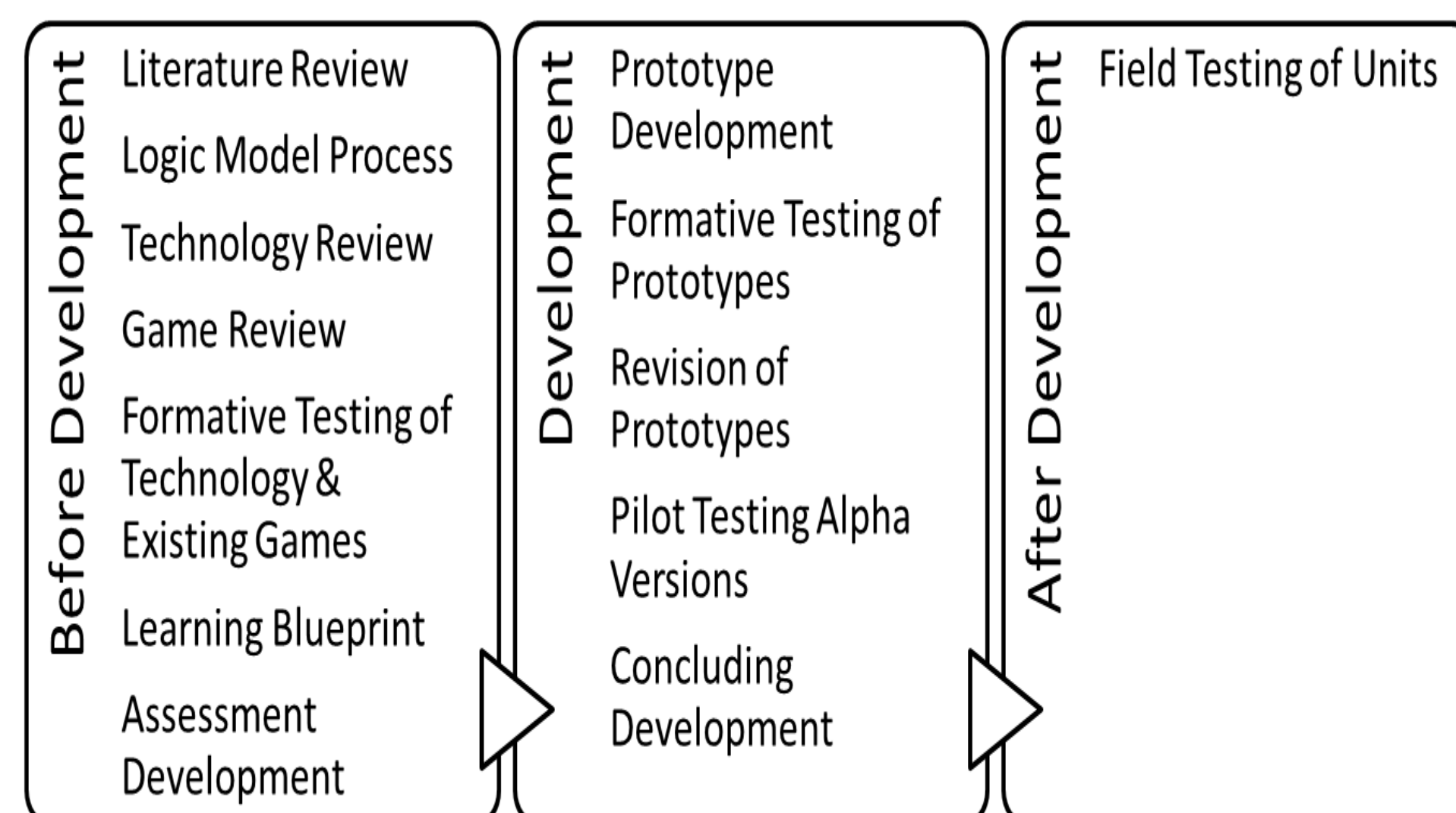| Detailed learning goal (developmentally appropriate to already know or learn)	Task (instructional or assessment)	Ways to vary difficulty	Possible scaffolding activities (if not successful in original activity)	Suggestions going forward
Identifying wholes as equipartitioned or not equipartitioned	Show a child portions of an object (e.g., pizza) ask them if each portion is an equal amount	"Complexibility of object (rectangles easier than circles) Varying number of receivers (easiest case is 2 receivers; then 2^n; then 2n and finally odds, starting with 3)"	Afterward: Promote overlays	"This could be built into the introduction (to be used as a training space) e.g., show how-to, have children decide whether next character carried it out correctly, then move into having the children do their own (next rows in this spreadsheet...) Or if children are not able to perform their own equipartitioning, have the identification as a lower level"
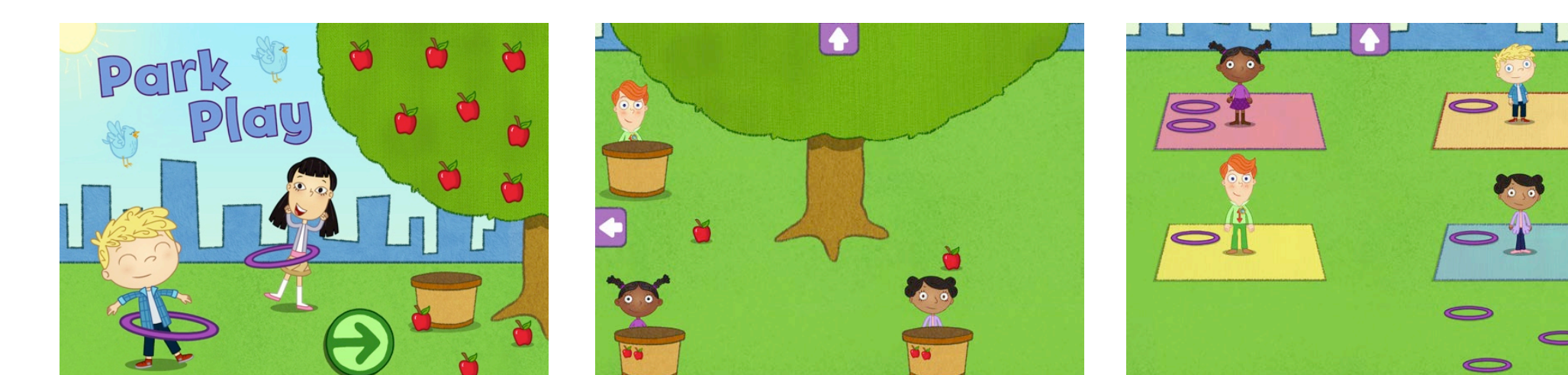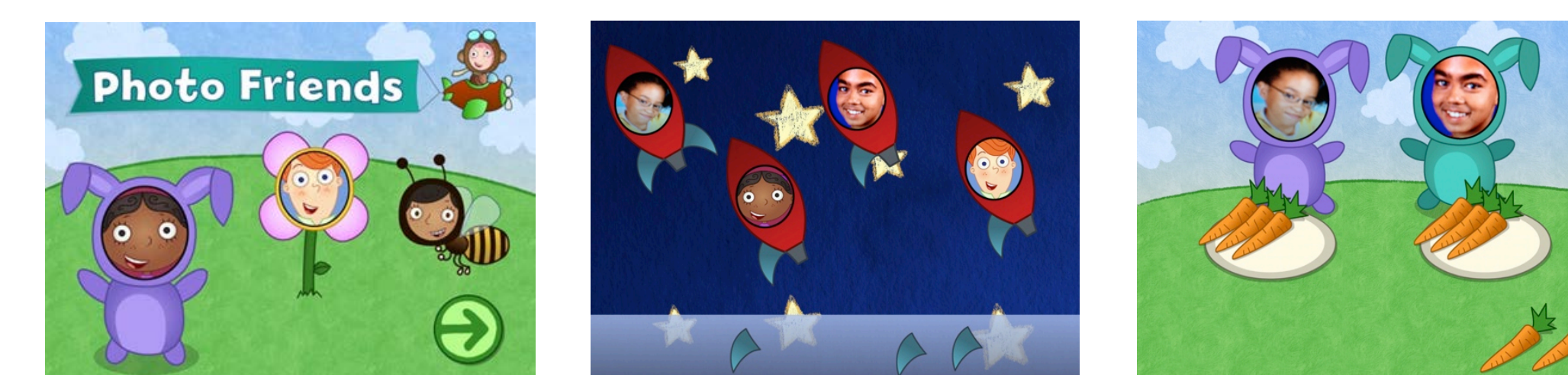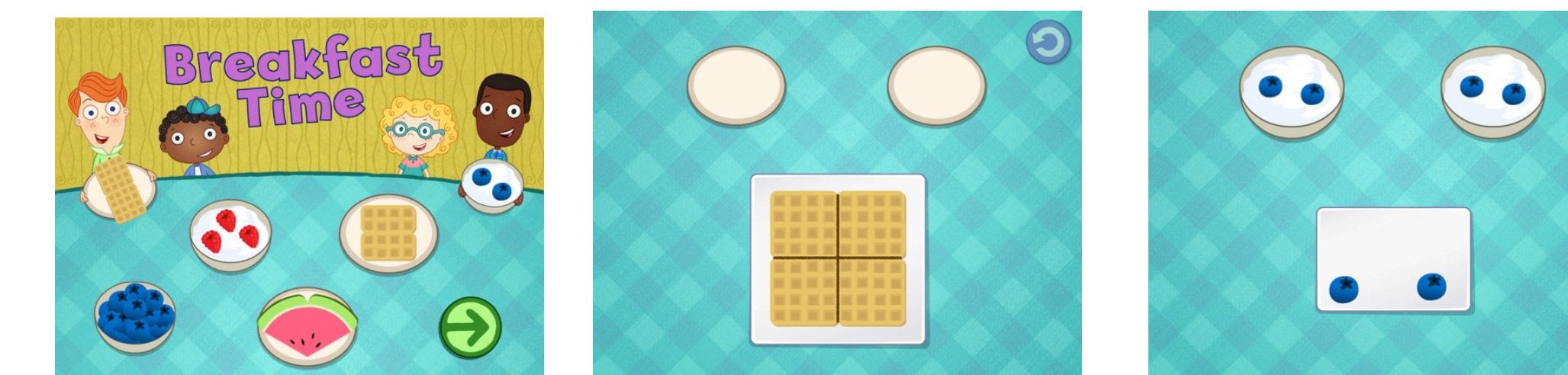
Design Principles for Young Children's Games

NGPM provides both a design process and design principles for developing educational games for young children. A number of design principles for media designers were documented throughout the development process, beginning with the initial literature review. Many of these principles resulted from formative research on the game prototypes, including direct observations of children's gameplay and interviews.

1. *Multiple opportunities to learn across games.*
2. *Multiple opportunities to learn within a game.*
3. *Carefully select visual objects.*
4. *Limit audio cues.*
5. *Provide opportunities to learn the game mechanics.*
6. *Consider the impact of game mechanics on pace.*
7. *Allow touch responses with a wide range.*
8. *Carefully select feedback.*
9. *Selectively integrate physical movement into games.*
10. *Level games to match children's growing competence.*
11. *Provide compelling game context.*

For further information

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