Momo: Visualizing Neuroplasticity Through Simulation Games

An interactive web-based simulation game helping children develop a growth mindset

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Abstract

Momo is a web-based simulation game designed to help children aged seven to nine develop a growth mindset by exploring the science of brain plasticity through interactive storytelling and decision-making. Decades of research have shown that the belief in intelligence as an innate trait can negatively impact academic performance, well-being, and even long-term life choices. Growth mindset interventions have traditionally relied on self-paced videos or classroom workshops, and these formats have failed to engage young learners to translate abstract psychological and neuroscience concepts into meaningful experiences. Momo addresses this gap by combining self-efficacy theory and the science of neuroplasticity to create a narrative-driven, game-based simulation learning experience. Players guide an avatar through key life stages, making choices that influence academic growth and overall well-being. The game also features a character named Momo, who dynamically reflects the players' progress and embodies the brain's capacity to change. By simulating everyday struggles and successes, Momo makes complex concepts like learning and brain development more concrete and relatable, offering a more engaging approach to cultivating a growth mindset in children.

CCS Concepts

• **Applied computing** → Education; Interactive learning environments; • **Human-centered computing** → Interaction design; Interaction design process and methods; Scenario-based design.

Keywords

Growth Mindset, Neuroplasticity, Game-based Learning

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1 Introduction

The assumption that intelligence, talent, or giftedness are innate traits possessed by the lucky few has serious implications not only for learning motivation and academic performance [5, 18, 21] but also for mental health and overall well-being [8, 24]. This perspective, as suggested by Dweck [2012], is known as a fixed mindset and it assumes that personal qualities such as intelligence or personality are fixed and unchangeable. In contrast, a growth mindset is a belief that these attributes can be developed over time through deliberate effort, effective learning strategies, and mentorship [7]. As a pioneer in mindset research, Carol Dweck has studied how a growth mindset can guide students' motivations, goals, and behaviors in education [8]. A growth mindset has been associated with greater openness to learning new strategies and technologies [10], higher academic aspirations [17], and higher interest in STEM-related courses [9]. Over the past decades, there has been an increasing number of interventions relying on self-paced online modules and workshops conducted in classroom or lab settings [11]. However, these interventions have been shown to produce mixed results, and the Organization for Economic Co-operation and Development (OECD) noted that in 2022, only 35% of students reported having a growth mindset in the domain of mathematics despite these interventions [20]. This underscores a need to re-evaluate new possibilities and different intervention modalities. In this paper, we explore the potential of game-based simulations as an innovative and interactive method to cultivate a growth mindset in a cost-effective and scalable format.

2 Related Work

2.1 Growth mindset intervention

In recent years, government, non-profit institutions, and private foundations have poured resources into funding growth mindset interventions, especially in low-income, vulnerable schools, targeted toward achieving better academic outcomes. For example, WhatWorks Clearinghouse from the Institute of Education Sciences has supported more than 15 growth mindset interventions across more than 8000 students [26]. Private foundations such as the American Honda Foundation Grants and Toshiba America Foundation also support growth mindset intervention projects by offering grants [19]. Khan Academy has developed online videos for different target groups such as teachers and elementary, middle, and high school students developed in partnership with Project for Educational Research That Scales (PERTS) to help build students' growth mindset [12]. A systematic review conducted by Jiang et al. [2025] suggests that the growth mindset intervention has been highly similar in core components of the intervention content, outcome measures, and design. Most of the interventions focused on mindsets of personality and intelligence through self-administered activities delivered via single sessions ranging between 20 to 50 minutes. There are three common learning objectives identified:

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(1) provide students with a scientific basis for believing in the potential for change, usually through instructional methods such as presentations or recorded modules (2) bring credibility to incremental theory and further processing of the new knowledge through providing examples of famous people and testimonials from alumni, and (3) facilitate the internalization of the earlier message conveyed through skits, writing narratives and letters [11].

2.2 Simulation game-based learning

Game-based learning has been shown to support cognitive development by encouraging students to be active, goal-driven participants in their own learning process [4]. In the educational field, the term serious game is widely used and is referred to as a game that serves not only as entertainment but also for explicit educational purposes [22]. Serious games are used in multiple educational fields, such as to teach about well-being, medicine, healthcare, and cultural heritage [16]. A subset of serious games is game-based simulation, which refers to a learning method that combines game elements, simulations, and learning objectives [13]. Game-based simulation focuses on realistic scenarios and precise processes to enable knowledge transfer [15]. It offers a unique advantage by replicating actual and probable real-world scenarios to predict the behavior of complex systems, which is impossible in traditional instructional materials. As growth mindset intervention usually requires learners to visualize the implications of their actions, game-based simulation might propose a novel approach. Although some studies have explored serious games for growth mindset interventions [25], game-based simulations remain largely underexplored. To address this gap, we introduce Momo, a web-based simulation game that promotes an interactive growth mindset intervention among children.

3 Design

Momo uses the basis of self-efficacy theory and the concept of neuroplasticity to promote the development of a growth mindset. Self-efficacy theory refers to the belief that one can be successful on a task. More specifically, Bandura refers to it as "the belief in one's capabilities to organize and execute the courses of action required to produce given attainments" [3]. This belief is shaped by four primary sources: mastery experiences (being the most prominent), vicarious experiences, social persuasion, and emotional states [2]. While self-efficacy and a growth mindset are closely related, they are distinct constructs. Self-efficacy is the ability to accomplish a task with a greater focus on the internal locus of control, whereas a growth mindset is more concerned with the belief that abilities can improve with deliberate effort. Both of these attributes are necessary for students to achieve optimal success [1]. Additionally, previous research suggests that growth mindsets and academic self-efficacy should be related in that students with lower self-efficacy should believe that intellectual abilities are innate and unchangeable [14]. The concept of this malleability of the brain is referred to as neuroplasticity. It has been found that teaching students the concept of neuroplasticity alters how students think [7] , and it has been used as a standard learning module in various interventions [11]. The same concept will also be used in Momo to show how behavior is controlled by thoughts and feelings in the brain and how the neurons in the brain make new connections and potential growth via personal efforts through neuroscientific findings.

3.1 Learning Objectives

Momo is designed to achieve these two main objectives: (1) players will have an understanding of neuroplasticity and recognize that intelligence is not a fixed trait but rather a malleable quality that can be developed through deliberate practice, and (2) players will have an awareness of the impact of sleep, nutrition, physical activity and emotional regulation on brain function and learning ability. These learning objectives are developed through decision-making, in-game challenges, and interactive quizzes, followed by a post-game quiz.

3.2 Game Mechanics

An avatar is used instead of the player's identity to create a psychological distance between the player's personal experience and the game environment [23]. The avatar begins at the age of one year old, and the game will conclude when the avatar reaches age 12. The avatar starts with an empty superpower that can be developed through effort and experience. The superpowers are categorized into three domains – English, Mathematics, and Science, and these were selected due to their relevance to the universal target audience of children aged between seven and nine. A character, Momo, will also be introduced as a metaphorical representation whose power can change in response to the avatar's choices, reinforcing the idea of the brain's health (see Figure 1).

3.3 Game Stages

The game unfolds in four main stages, each aligned with a core learning theme. Stage 1 introduces the narrative, mechanics, and key concepts of neuroplasticity and growth mindset. Stages 2 to 4 are structured based on Bandura's sources of self-efficacy theory [2].

3.3.1 Stage 1: Neuroplasticity & growth mindset. In Stage 1, the avatar can enhance its superpower by engaging in informal learning activities like reading, playing, listening to music, and exploring. While most of the gameplay is guided by a narrative, players will still have the autonomy to make choices that influence the early learning experiences.

3.3.2 Stage 2: Vicarious experience. Stage 2 begins at age four as the avatar enters preschool and encounters peers with varying abilities shaped by the informal learning in the previous stage. This stage focuses on vicarious experiences, where observing the performance of others influences their self-belief [2]. The game algorithm is designed in a way that generates peers with a range of abilities relative to the avatar (see Figure 2). Players can view their peers' superpowers and learn that initial differences are not fixed but can be improved through effort and learning experiences. A new study module is also introduced, enabling players to choose targeted academic activities to strengthen specific superpowers.

3.3.3 Stage 3: Mastery experience & social persuasion. Stage 3 targets the development of self-efficacy through mastery experiences by introducing academic assessments. Exam results reflect

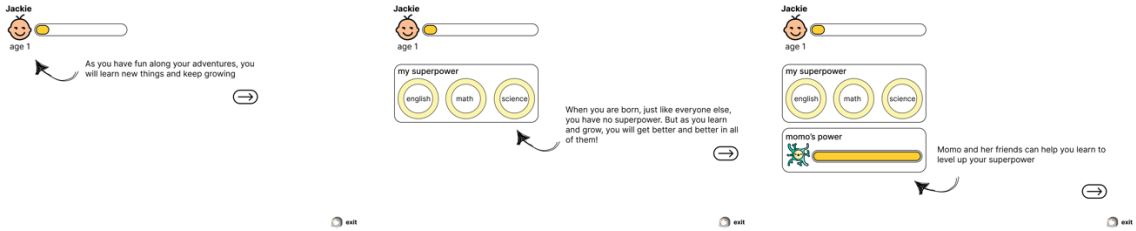

Figure 1: User interface of onboarding tutorials introducing core game elements (avatar's age, avatar's superpower, and Momo's power)

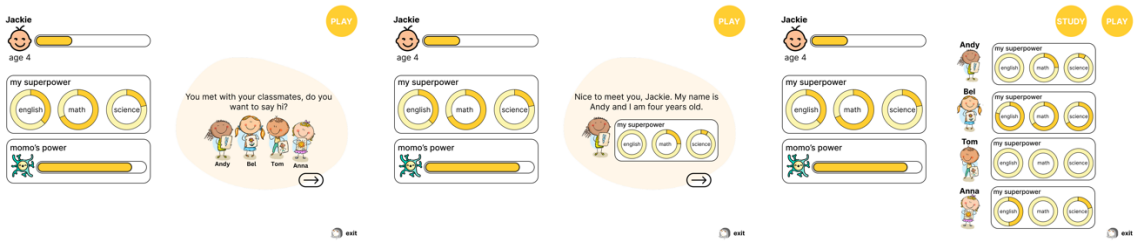

Figure 2: User interface showing peer avatars and their superpowers

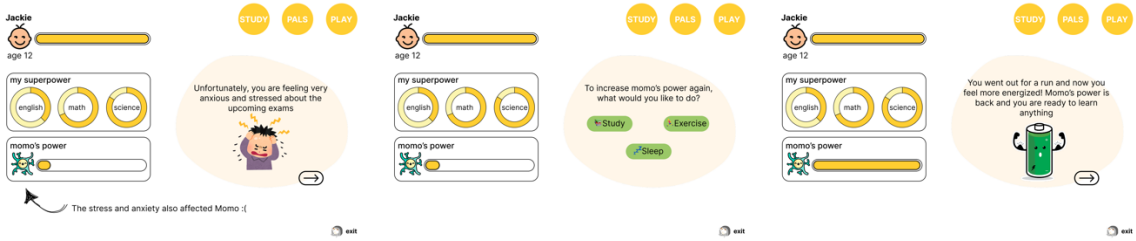

Figure 3: User interface showing an example of a challenge in stage 4

the avatar's current superpower across all the subjects in English, Mathematics, and Science, with the algorithm ensuring at least one failed subject to help players identify differential performance and recognize areas of competence. This aligns with the idea that self-efficacy builds through successfully overcoming challenging tasks [2]. This stage also addresses social persuasion, which refers to the influence of verbal encouragement or discouragement from others on an individual's belief in their own capabilities [2]. Players face two scenario-based challenges – one involving subtle doubt from a parent and another featuring discouragement from a teacher. The players' responses affect both the avatar and Momo's superpowers, highlighting how external feedback shapes self-belief.

3.3.4 Stage 4: Physiological state. Physiological state refers to the emotional state, such as anxiety, stress, arousal, and mood, that can influence an individual self-efficacy belief [2]. At this final stage, the avatar would have reached age 12 and will be facing a high-stakes matriculation exam, triggering stress that causes Momo's power to decline. Players must select restorative activities such as sleep or exercise to reduce stress and restore learning ability (see Figure 3). The objective is to teach the impact of emotional states on performance and introduce practical coping strategies.

3.4 Post-game quiz

The post-game quiz, which is adapted from Dweck [1999], evaluates players' understanding of neuroplasticity and reinforces key content delivered throughout the game [6]. Given the game's simulation-based nature, it is essential to assess comprehension more explicitly and in a structured manner.

4 CONCLUSION

In a world where children are increasingly exposed to uncertainty and pressure to succeed, fostering a growth mindset is important not only for academic goals but also in supporting children's well-being and helping them reach their maximum potential. In this paper, we presented Momo, a web-based simulation game designed to help children develop self-efficacy and a growth mindset through the concept of neuroplasticity. While Momo is still in its prototype phase and has not yet undergone formal testing, future work will

involve design-based research to understand how children engage with the game and to involve them in co-creating future iterations. We see Momo as a small but meaningful step toward building a future where children feel capable and hopeful even when faced with setbacks. By offering a more interactive alternative to traditional growth mindset interventions, Momo aims to inspire children to believe that intelligence is not innate.

5 Supplemental Material

A short video demonstrating the prototype of the Momo game can be accessed here: https://youtu.be/u8urbcBgj4E

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