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Research Article

Environmental design for accelerated learning and intrinsic motivation in primary education

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This study introduces and validates the concept of "daring energy"—a distinct motivational-cognitive state that emerges under specific environmental conditions in primary education. The research employed a quasi-experimental design during the 2018-2019 academic year at a private school in Almaty, Kazakhstan. The study involved four experimental classes with matched control groups from parallel classes. The intervention, occupying only 10% of academic time, focused on a systematic environmental redesign based on autonomy-supportive principles. Data were analyzed using quantitative methods (t-tests, effect size calculations) and qualitative observations. We demonstrate how this redesign enables extraordinary learning engagement and accelerated cognitive development. Experimental groups showed significant IQ gains and remarkable learning acceleration. These outcomes suggest efficient transformation possibilities within existing educational systems. Our findings extend Self-Determination Theory by demonstrating how institutional structures can systematically support the emergence of intrinsic motivation, offering both a theoretical framework and practical evidence for transforming educational practice. The study highlights key pedagogical insights, providing a replicable model for fostering student agency and deep engagement.

Keywords: Accelerated learning, Daring energy, Educational transformation, Environmental design, Intrinsic motivation, Primary education

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1. Introduction

Traditional educational systems consistently face a fundamental challenge: activating and sustaining students' intrinsic motivation for learning. This issue is particularly acute in primary education, where early experiences shape lifelong learning attitudes (Darling-Hammond et al., 2020; Freire, 2018). While external motivation has been extensively studied, a significant research gap exists regarding the specific, systematic design of institutional environments that can reliably foster genuine intrinsic motivation. The dominance of what Freire (2018) terms "banking education"—where students are passive recipients—fundamentally contradicts natural learning processes and suppresses student agency. This contradiction is evident when children, who acquire complex skills like language naturally, often struggle with academic subjects despite structured teaching. This suggests the challenge lies not in children's capacity but in the educational environment's design.

The rationale for this study is to address this gap by proposing and testing a model of Environmental Design [ED]. ED is a structured approach to crafting learning environments that combine physical, social, and psychological elements to stimulate intrinsic motivation. Unlike traditional models focused on direct knowledge transfer, ED prioritizes establishing conditions where motivation arises organically. This

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approach is rooted in Self-Determination Theory [SDT] (Ryan & Deci, 2017), expanding it with specific frameworks to nurture autonomy. The present study investigates how systematic environmental redesign can transform learning dynamics. Building on advances in educational psychology and neuroscience (Immordino-Yang & Damasio, 2007), we examine the emergence of what we term "daring energy" [DE]—a distinct motivational-cognitive state serving as a key mechanism for activating intrinsic motivation. The aim of this research is to test two key hypotheses:

H1: A specially designed educational environment can activate students' intrinsic motivation with minimal intervention time (10% of academic time), manifesting in substantial voluntary learning activity.

H2: Environmental Design based on autonomy-supportive principles leads to significant improvements in students' cognitive indicators and academic performance.

This study's importance lies in demonstrating that significant educational transformation is possible with minimal resource allocation by focusing on the underlying mechanism through which these changes occur. It illustrates how institutional frameworks can methodically foster intrinsic motivation, providing a practical model for educators. This study was conducted in a private mathematics school in Kazakhstan, involving four experimental classes with corresponding control groups.

2. Theoretical Framework

The dominant "giving pedagogy" model in education (Freire, 2018; Illich, 2006), where teachers impart knowledge to passive students, fundamentally contradicts natural learning processes. Just as children learn to walk without formal instruction, academic learning could potentially follow similar patterns if properly structured.

Contemporary theories of motivation in education, while valuable in addressing individual psychological factors, often operate within traditional educational frameworks where teacher agency dominates student agency. The concept of daring energy emerged from observations of a specific phenomenon: when given proper conditions, children demonstrate capabilities far beyond conventional expectations. The importance of emotional states and intrinsic drive in learning processes is further supported by recent neuroscience research (Immordino-Yang & Damasio, 2007), which highlights the critical role of emotional engagement in shaping cognitive processes and memory formation. This aligns with documented observations of enhanced learning capabilities during states of DE.

This approach fundamentally reimagines the educational process through what is termed here "non-giving pedagogy." Unlike traditional educational models where knowledge is "given" through direct instruction, this model creates conditions where knowledge is actively constructed by students through their own agency, building on Gatanov's (1998) principles of developing personalities capable of creative self-realization.

2.1. Critical Analysis of Traditional Approaches

The dominant "giving pedagogy" model in education, despite decades of criticism (Freire, 2018; Illich, 2006), remains remarkably persistent. In this model, particularly entrenched in primary education, teachers are positioned as knowledge providers and students as passive recipients, establishing detrimental patterns of learning behavior: passivity, inertia, avoidance orientation, and fixed mindset. These early-formed patterns pose substantial barriers to later educational progress and the development of student agency (Dweck, 2016; Liu et al., 2016).

Contemporary theories of motivation in education, including Self-Determination Theory [SDT] and Growth Mindset (Dweck, 2016), while valuable, often focus on individual psychological factors without addressing the systemic nature of educational environments. These approaches, while recognizing the importance of autonomy and competence, still operate within the framework of traditional educational systems where teacher agency dominates student agency (Liu et al., 2016).

The persistence of traditional pedagogical models, which Freire (2018) terms "banking education," continues to suppress children's natural drive for learning. This suppression occurs despite mounting evidence that such approaches are increasingly ineffective in developing the kind of self-directed learning capabilities required in the modern world (Darling-Hammond et al., 2020). Even contemporary educational innovations, while acknowledging the importance of student engagement, often fail to address the fundamental issue of student agency in the learning process (Moreno-Murcia & Sánchez-Latorre, 2016).

2.2. Theoretical Foundations of Daring Energy

The concept of DE arose from observations of a distinct phenomenon: under appropriate conditions, children exhibit abilities that surpass typical expectations. This state shares some characteristics with Csikszentmihalyi's (1990) concept of flow, particularly in terms of complete immersion and optimal challenge levels. However, it differs in several crucial aspects.

While flow theory emphasizes the balance between challenge and skill level, DE emerges when students face challenges that seem to exceed their current capabilities. This apparent paradox is resolved through what termed here the "heroic learning cycle" – a pattern where students, inspired by the possibility of achievement rather than constrained by current competence levels, enter a state of heightened cognitive and motivational activation (Campbell, 1949; Pekrun, 2019).

The phenomenon aligns with Vygotsky's (1978) concept of the zone of proximal development but extends it in important ways. Rather than requiring constant adult scaffolding, this approach creates environmental conditions where students naturally gravitate toward challenges at the edge of (and sometimes seemingly beyond) their capabilities. The key distinction lies in student agency: the challenge must be self-chosen and the approach self-directed (Liu et al., 2016).

This understanding of motivation as an emergent property of well-designed environments rather than an individual trait to be managed marks a notable shift from traditional motivational theories. It indicates that proper ED can methodically nurture the growth of what Achor (2018) calls 'big potential' through interconnected achievement experiences.

2.3. Integration with Existing Frameworks

The theoretical framework of this study integrates several established approaches to create a comprehensive model for fostering intrinsic motivation. From Cultural-Historical Theory (Vygotsky, 1978), it adopts the understanding of learning as a culturally mediated process but reorients it toward student-initiated development with minimal direct adult intervention, a concept supported by modern research on effective learning environments (Darling-Hammond et al., 2020). It incorporates the importance of meaningful activity from Activity Theory (Leontiev, 1978), but crucially focuses on student-initiated rather than teacher-directed activities, which aligns with contemporary studies on autonomous learning (Moreno-Murcia & & Sánchez-Latorre, 2016). The framework also builds on Flow Theory (Csikszentmihalyi, 1990) by incorporating the concept of optimal experience, yet expands it to include moments of 'impossible' challenges, a notion reinforced by research on achievement emotions (Pekrun, 2019). Finally, and most centrally, it operationalizes the core tenets of Self-Determination Theory (Ryan & Deci, 2017) by offering specific, replicable environmental designs that systematically facilitate the development of autonomy, competence, and relatedness, whose efficacy is validated in recent studies (Liu et al., 2016). This integration provides a robust foundation that addresses both individual psychological needs and the systemic environmental conditions necessary for their fulfillment (Hattie, 2021).

2.4. The Non-Giving Pedagogy Model

This approach fundamentally reimagines the educational process through what is termed here "non-giving pedagogy." Unlike traditional educational models where knowledge is "given" through direct instruction, this model creates conditions where knowledge is actively constructed by students through their own agency (Freire, 2018), with specific emphasis on autonomy-supportive teaching practices (Reeve & Cheon, 2021). This approach is based on key theoretical insights into the learning journey, environmental design, and the evolving role of the teacher. Drawing on Campbell's (1949) monomyth structure, it recognizes that meaningful learning begins with emotional and cultural immersion, creating an anticipatory energy that transforms into personal challenge acceptance. This narrative framework explains why children in the study voluntarily sought mathematical challenges, as each problem represented a personal quest, aligning with the brain's reward response to achievement (Rock, 2009).

The study outlined seven interconnected principles that foster intrinsic motivation, which were applied in paragraph form. These principles are designed to work in synergy to create a self-reinforcing ecosystem of engagement. The "Goldilocks Zone Principle" leverages the dynamic relationship between perceived and actual task complexity to maintain optimal challenge (Csikszentmihalyi, 1990; Ryan & Deci, 2017). A "Positive Feedback Cycle" establishes immediate, informative feedback that celebrates progress, grounded in research on competence development (Liu et al., 2016) and learning reinforcement (Pekrun, 2019). The principle of "Freedom and Agency" underscores complete learner autonomy, building on Freire's (2018) critique of 'banking education' and bolstered by findings on autonomy-facilitating practices (Moreno-Murcia & Sánchez-Latorre, 2016). "Motivational Structure and Flow Development" focuses on creating conditions for sustainable intrinsic motivation (Pink, 2011), while "Social Organization Through Intensive Communication" promotes rich communication networks based on sociocultural theory (Darling-Hammond et al., 2020;

Vygotsky, 1978). Finally, "Educational Microeconomics" develops decision-making skills through a game-based economy. These principles expand on Gatanov's (1998) pioneering work on environments for creative self-realization by integrating new formats like tournaments and auctions to enhance intrinsic motivation.

This model also transforms the traditional teacher role into that of an "edu-designer"—a professional who architects learning environments rather than directly transmitting knowledge (Darling-Hammond et al., 2020). This shift from "giving" to "enabling" pedagogy is a fundamental change aligned with a contemporary understanding of effective learning environments (Hattie, 2021). The edu-designer's role involves calibrating challenge levels, managing the in-class economy, facilitating peer-to-peer interactions, and observing emergent learning patterns to continuously refine the environment, rather than delivering pre-scripted lessons. This requires a different skill set focused on facilitation, observation, and systems thinking.

2.5. Mechanisms of Daring Energy

The phenomenon of DE represents a distinct motivational-cognitive state characterized by heightened engagement, persistence, and cognitive capability (Immordino-Yang, 2016). This state emerges when specific environmental conditions align with student agency and perceived challenge levels. The state of DE manifests through several observable indicators.

Behavioral Markers, such as sustained voluntary engagement in challenging tasks and spontaneous knowledge sharing, reflect deep intrinsic motivation.

Objective Indicators, including increased task completion volume and progressive engagement with higher difficulty levels, provide quantifiable evidence of this heightened state.

The activation mechanism of DE is crucial. The intensity of Daring Energy appears to be proportional to the ratio of the perceived complexity of a task to its actual complexity. This aligns with contemporary research on how the interplay between perceived challenges and actual capabilities shapes student interest and engagement (Pekrun, 2019). This mechanism, however, is most effective when preceded by positive emotional preparation, which amplifies the motivational surge when students discover they can accomplish tasks they previously perceived as highly challenging.

Critical environmental prerequisites must be in place for DE to emerge. These begin with cultural-mythological immersion to create preliminary emotional engagement. This foundation supports subsequent conditions: complete freedom in challenge selection, a safe and positive learning atmosphere, 'Goldilocks zone' challenges, high challenge density, immediate informative feedback, and an absence of external evaluation stress. These conditions are designed to foster the psychological safety and autonomy necessary for students to take intellectual risks (Ryan & Deci, 2017).

The mechanism of sustainable motivation develops through a positive activity cycle fueled by three key energy states that are amplified through collective class dynamics. The cycle begins with Anticipatory Energy, an initial state of positive emotional tension created through cultural immersion or intriguing demonstrations, a state similar to what Yerkes and Dodson (1908) described in their landmark research on arousal and performance, where individual curiosity catalyzes group interest (Zuckerman, 2014). This transitions into Daring Energy, the state of heightened cognitive readiness and persistence, which is reinforced by observing peer effort and success. Finally, Success Energy, a flow-like state following achievement, creates readiness for new challenges (Csikszentmihalyi, 1990), with individual successes inspiring and accelerating others' progress in a pattern of interconnected achievement (Achor, 2018). The development of student self-efficacy—the belief in their own ability to succeed—is crucial for sustaining this momentum (Bandura, 2006). While external motivational tools can help initiate this cycle, they must be used sparingly as catalysts, because the cycle is only sustainable when students pursue their own goals (Ryan & Deci, 2017). This understanding leads to a fundamental shift from "assignments" to "challenges" in educational design, requiring an environment that nurtures student agency with minimal external intervention (Liu et al., 2016).

3. Methodology

This research combined multiple methodological approaches to investigate the complex nature of intrinsic motivation and the innovative character of the interventions.

3.1. Research Design

The study employed a quasi-experimental, mixed-methods research design. The quantitative component involved psychometric testing, academic performance monitoring, and statistical analysis of voluntary learning activities to measure the intervention's impact on cognitive and motivational variables. The qualitative component included systematic observation, analysis of student-created artifacts, and case studies to provide a rich, contextual understanding of the processes of change, such as leadership development and self-organization.

3.2. Participants

The study was conducted during the 2018-2019 academic year at Tamos Education, a private school in Almaty, Kazakhstan. The sample included four experimental classes: three first-grade classes (n=66) and one third-grade class (n=27), for a total of 93 students. Corresponding control groups were selected from parallel classes within the same school. These groups were carefully matched based on socio-economic backgrounds and prior educational environments to ensure comparative validity. To control for teacher effect, the same teacher taught both the experimental and control groups in the third grade, while early-career teachers were assigned to the first-grade classes.

3.3. Data Collection and Instruments

A comprehensive set of instruments was used to measure cognitive development, intrinsic motivation, and social-personal growth.

Cognitive Development: Cognitive abilities were assessed using Raven's Progressive Matrices, administered by an independent expert at the beginning and end of the academic year. Academic performance was tracked using the school's internal mathematics rankings and results from standardized tests.

Intrinsic Motivation: This was measured through activity metrics, including the number of voluntarily solved problems (tracked via a digital system), participation rates in optional consultations and tournaments, and the quantity and nature of student-initiated projects.

Qualitative Data: Data were collected through direct observation, video documentation of class sessions and spontaneous activities, and collection of student-generated materials (e.g., mini-books, graphic summaries, self-developed games).

3.4. Procedure and Intervention

The intervention consisted of regular sessions using the specially designed ED activities, occupying approximately 10% of total academic time (three 40-minute sessions per week). The core of the intervention was a comprehensive system operationalizing the theoretical principles. This included: a multi-level challenge system with dynamic difficulty calibration, immediate electronic feedback mechanisms, a class-as-state model with student-led governance, and an educational economy using game currency. Learning activities ranged from individual mathematical 'mining' to student-organized tournaments and peer teaching sessions. The year-long implementation period was designed to mitigate the Hawthorne effect.

3.5. Data Analysis

The analytical approach combined quantitative and qualitative methods. Quantitative data, such as changes in IQ scores and academic performance, were analyzed using descriptive statistics, *t*-tests for paired and independent samples, and effect size calculations (Cohen's d) to determine the magnitude of the intervention's impact. Prior to analysis, data were assessed for statistical assumptions. The Shapiro-Wilk test indicated that the key dependent variables, such as IQ scores, were normally distributed ($W = 0.96$, $p = .251$). Additionally, Levene's test confirmed the homogeneity of variances between the experimental and control groups ($F(1, 42) = 1.35$, $p = .252$). As the assumptions were met, parametric tests (t-tests) were used for analysis. Qualitative data from observations and student work were thematically analyzed to identify patterns in behavior, engagement, and social dynamics. Data triangulation was used to cross-validate findings from different sources (e.g., comparing observed engagement with quantitative activity metrics).

3.6. Ethical Considerations

The study received full institutional approval from Tamos Education. Written informed consent was obtained from the parents or legal guardians of all student participants prior to the start of the research. Participation was voluntary, and all data were anonymized to ensure confidentiality. The research protocol adhered to all ethical guidelines for educational research involving minors.

4. Results

The experimental classes demonstrated significant positive changes across multiple dimensions of student development. The comprehensive nature of these changes, validated through multiple independent data sources, suggests the effectiveness of the proposed educational environment redesign.

4.1. Cognitive Development and IQ Changes

The experimental groups exhibited notable gains in cognitive abilities. Table 1 shows the changes in IQ scores for the third-grade experimental and control groups.

Table 1
Changes in IQ Scores and Statistical Significance (2018-2019)

Class Group	*Initial Assessment*		*Final Assessment*		*Change Analysis*	
	Mean IQ±SD (n)	95% CI	Mean IQ±SD (n)	95% CI	ΔIQ	Effect Size (*d*)
Experimental (3E)	122 ± 6.10 (22)	[119.3-124.7]	128 ± 5.29 (22)	[125.7-130.3]	+6*	1.17
Control (3I)	125 ± 6.94 (22)	[121.9-128.1]	125 ± 6.96 (22)	[121.9-128.1]	0	0.27
Between-group difference	-3†		+3†		+6*	

Note. Effect size calculated using pooled standard deviation. $p < .01$; †$p < .05$.

As the table indicates, the third-grade experimental class displayed a statistically significant IQ rise of 6 points ($p < .01$, $d = 1.17$), a very large effect size, whereas the control group's scores remained unchanged.

First-grade experimental classes showed similar improvements relative to their control groups, as detailed in Table 2.

Table 2
Comparative Progress in First Grade Classes (October 2018 - May 2019)

Class	*Change in Standard Scores*		*Statistical Significance*
	Initial σ diff*	Final σ diff*	Effect Size (σ)
1G Experimental	−0.59	+0.18	0.77†
1E Experimental	−0.24	+0.35	0.59†

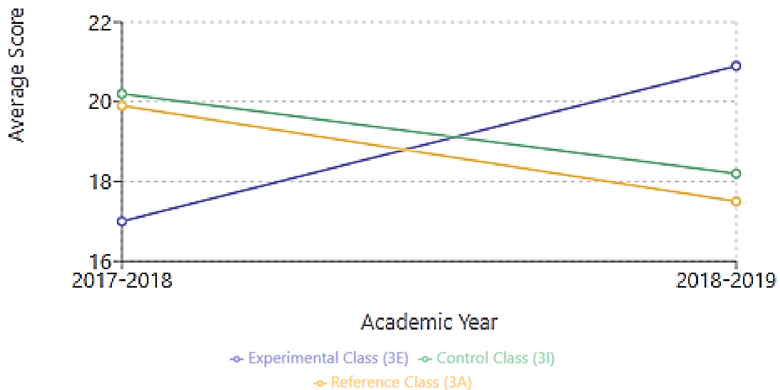
Note. *Difference from control group mean in standard deviations; †p < .01

These results are particularly noteworthy as the improvements occurred despite the experimental classes starting from lower baseline scores, suggesting the intervention was highly effective in accelerating cognitive development.

4.2. Academic Performance and Excellence

The impact on academic performance was particularly striking. Figure 1 illustrates the dramatic improvement in the experimental third-grade class's mathematics performance. As shown in Figure 1, Class 3E exhibited a striking transformation, climbing from the lowest performance level to the top among parallel classes. The experimental group displayed outstanding results, with students not only attaining maximum scores in standardized tests but also recording the highest engagement rates in advanced mathematical competitions.

Figure 1
Academic Performance in Mathematics: Experimental vs Control Classes



This improvement in performance was accompanied by a reduction in score variance, suggesting that the intervention benefited students across all ability levels (Yeager et al., 2019), with particular impact on students' belief in their ability to grow and improve. Moreover, three students from the experimental class qualified for the Leonard Euler Mathematics Olympiad, the highest number among all parallel classes.

4.3. Accelerated Learning Capabilities

The multiplication tournament experiment provided compelling evidence of enhanced learning capabilities. First-grade experimental classes showed remarkable progress after three weeks of instruction ($p < .01$, Table 3), outperforming multiple second-grade classes in cross-grade tournaments with 100% participation rates (see Figure 2).

Table 3

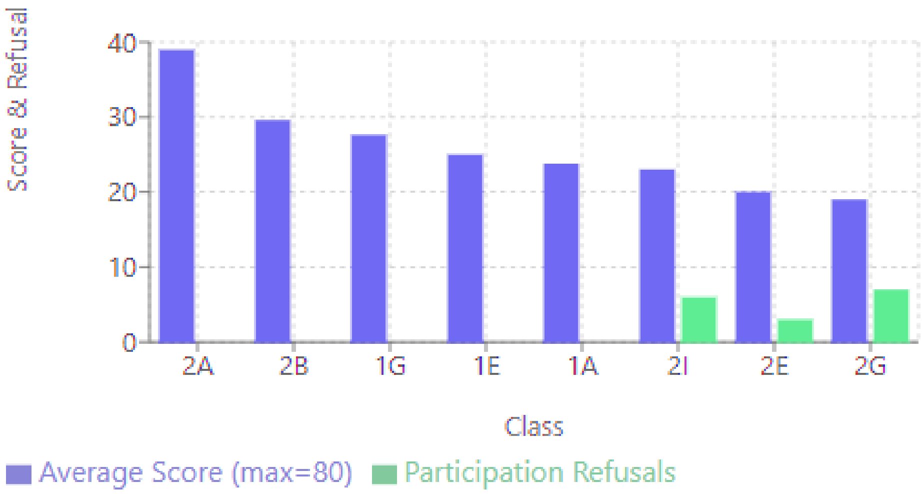
Progress in Multiplication Skills in First Grade (N=66)

Skill Level	*Baseline (%)*	*After 3 Weeks (%)*	*Change*	*Performance in Competition***
Basic multiplication	10	95	+85%*	All experimental classes
Table knowledge	5	40	+35%*	outperformed three
Division operations	2	25	+23%*	second-grade classes
Advanced operations†	1	6	+5%*	in tournament settings

Note. Assessment conducted after ~8 hours of total instruction time. *$p < .01$; †Including powers, roots, and simple logarithms. **See Figure 2 for detailed tournament results

Figure 2

Multiplication Tournament Results: First vs Second Grade



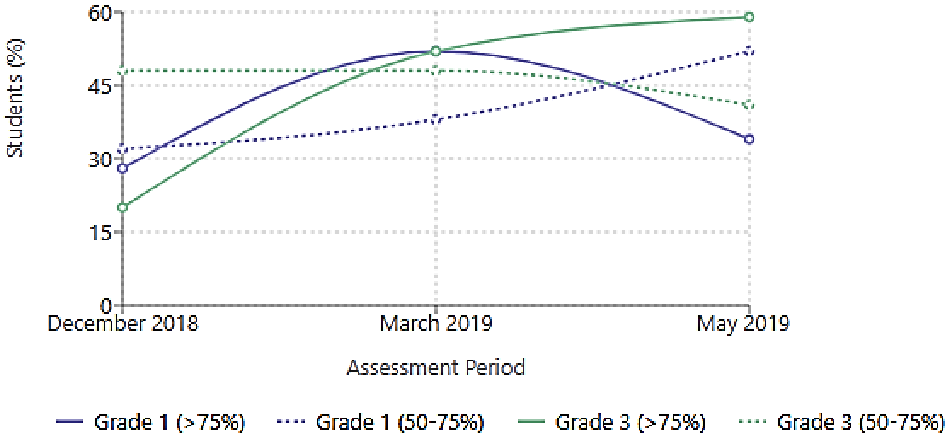
Note. * indicates experimental first-grade classes. Assessment conducted after 3 weeks of multiplication instruction in first grade.

4.4. Additional Content Mastery

The educational environment's effectiveness extended beyond mathematics, as evidenced by voluntary mythology quiz performance (see Figure 3). Third-grade high-performing students (>75% correct) increased from 20% to 59%, while first-grade students showed dynamic improvement patterns coinciding with increased engagement periods.

This voluntary content acquisition is especially noteworthy as it took place without formal instruction or assessment pressure, highlighting the efficacy of autonomy-supportive teaching approaches (Reeve & Cheon, 2021) in cultivating authentic learning engagement. The different patterns between first and third grades suggest that the educational environment successfully adapted to different developmental levels while maintaining effectiveness.

Figure 3
Student Performance in Mythology Knowledge Assessment



Note. Results from voluntary mythology quizzes with no formal preparation

4.5. Voluntary Engagement and Learning Behaviors

4.5.1 Manifestation of daring energy

The relationship between perceived and actual task complexity was particularly evident in the multiplication tournament results. First-grade students, initially perceiving multiplication as highly complex (reported difficulty rating 8.5/10), discovered they could master it through straightforward techniques. This discovery triggered sustained engagement patterns, with average task completion increasing from 20 to 120 problems bi-weekly, voluntary engagement extending from 10-15 to 40 minutes, 85% of students initiating peer teaching, and challenge level progression accelerating by 300% compared to control groups.

Quantitative tracking revealed remarkable levels of voluntary engagement, with each class solving approximately 20,000 problems during regular sessions and an additional 40,000 problems outside class time. Students engaged in problem-solving across various contexts, averaging 100-120 problems bi-weekly per student and submitting 250-750 task cards per class for bi-weekly lottery events. Strong participation in optional paid consultations reflected students' eagerness to allocate their earned 'game currency' toward educational opportunities. This extraordinary level of involvement became evident through the emergence of spontaneous study groups, the launch of student-driven educational projects, the establishment of peer teaching initiatives, and consistent engagement in problem-solving activities during breaks and at home.

It is important to note that direct quantitative comparisons with control groups for many metrics were not feasible due to fundamental differences in educational approaches. For instance, Greek mythology is typically introduced in 5th grade, not in 1st or 3rd grades as in the experimental groups. In control groups, mathematical tasks were strictly within the curriculum, assigned by teachers rather than voluntarily chosen by students, and their quantity was significantly lower, especially in first grades. Similarly, project activities in standard classes were teacher-initiated and evaluated, often involving parental assistance, whereas in experimental groups, projects were student-initiated and peer-evaluated, often using game currency. These qualitative differences highlight the transformative nature of the ED approach, fostering student agency and intrinsic motivation beyond traditional educational boundaries.

4.6. Detailed Qualitative Observations

The program fostered remarkable student initiatives and profound changes in attitudes and behaviors. These transformations were documented through systematic observation and analysis of student work, revealing a shift towards a sustainable, student-driven learning culture. The key themes are explained in the following.

4.6.1. From passive recipient to active learner

A consistent pattern observed was the transformation of students from passive or struggling learners into highly engaged, active participants. For instance, one third-grade student, who initially had difficulty with basic multiplication and showed signs of math anxiety, began voluntarily attending peer-led practice sessions. Within weeks, she was not only mastering the material but began investing her "game currency" in advanced "consultations" to learn division and exponents, demonstrating a complete reversal in her academic self-concept and behavior.

4.6.2. Development of peer teaching and leadership

The environment organically cultivated leadership and teaching initiatives. Many students who mastered a concept quickly transitioned into the role of peer tutors. This was formalized through the "consultation" system but also occurred spontaneously. We documented 15 distinct student-organized masterclasses on topics ranging from advanced multiplication to Greek mythology. Students created their own presentation materials and quizzes, a tangible proof of their deep learning and desire to share knowledge. For example, a group of first-graders developed and delivered a presentation on "The Labors of Hercules" to another class, managing the entire event independently.

4.6.3. Emergence of economic awareness and autonomy

The in-class micro-economy proved to be a powerful tool for developing decision-making skills and autonomy. Students demonstrated sophisticated resource management, often choosing to "invest" their earned currency in educational opportunities (like buying a challenging problem set or paying for a peer consultation) over immediate rewards (like games or privileges). This behavior indicates a developing understanding of long-term value and responsible choice-making, a key aspect of personal agency. Students produced 14 self-published mini-books and over 30 types of new educational materials, using their own "capital" to fund the printing and distribution to peers.

5. Discussion

The findings of this year-long study demonstrate that a systematic redesign of the educational environment, based on principles of autonomy and optimal challenge, can foster significant improvements in both cognitive development and intrinsic motivation in primary school students. The results provide strong support for our two primary hypotheses and offer insights into the mechanism of "daring energy" as a driver of these transformative outcomes.

The first key finding is that a minimal time investment (10% of academic time) in this specialized environment can generate extraordinary levels of voluntary student engagement. The sheer volume of work completed voluntarily outside of class hours—with students solving tens of thousands of extra math problems—is a powerful testament to the activation of deep intrinsic motivation. This finding challenges the conventional view that extensive instructional time is required for academic gains and suggests that the quality and design of the learning environment are more critical than the quantity of instruction. This result extends the work of Ryan and Deci (2017) by providing a practical, institutional-level demonstration of how to create conditions where the need for autonomy is not just met but actively nurtured, leading to self-determined learning on a massive scale.

The second major finding is the significant and measurable improvement in students' cognitive abilities, evidenced by IQ gains and accelerated academic performance. The experimental groups not only caught up to but, in some cases, surpassed their peers, even starting from a lower baseline. This aligns with research by Yeager et al. (2019) showing that interventions targeting students' beliefs about their potential can lead to significant academic growth and reduce achievement gaps. Our study suggests that the DE state, which combines emotional engagement (Immordino-Yang & Damasio, 2007) with a sense of achievable challenge, creates a powerful cognitive-motivational synergy that fuels this rapid development. It provides a compelling counter-narrative to the idea that there is a trade-off between rigorous academic achievement and student engagement (Liu et al., 2016).

The mechanisms of change appear to be rooted in the interconnected principles of the ED framework. The "Positive Activity Cycle"—moving from anticipation to daring to success—creates a self-reinforcing loop of motivation and achievement, echoing Csikszentmihalyi's (1990) concept of flow but with a greater emphasis on overcoming seemingly insurmountable challenges. The emergence of spontaneous peer-teaching communities demonstrates a practical application of Vygotsky's (1978) sociocultural theory, where learning is amplified through social interaction. However, in our model, these interactions are student-initiated rather than teacher-scaffolded, representing a key extension of the theory. The success of this model suggests that when institutions deliberately design for autonomy, students will naturally construct the social scaffolding they need, a finding that strongly supports recent work on creating autonomous learners (Moreno-Murcia & Sánchez-Latorre, 2016; Reeve & Cheon, 2021).

A key implication of this study is its potential for replicability and scalability. The findings suggest that the principles of Environmental Design are not merely theoretical but can be operationalized into a tangible program for educational reform. The most direct output of this research would be the development of a handbook and professional development program for educators titled "Architecting Daring Energy in the Classroom." This tangible resource would provide teachers with: 1) A guide to the core principles of ED. 2) A blueprint for designing and calibrating multi-level challenges. 3) Actionable strategies for implementing a classroom micro-economy and student governance. 4) Case studies and troubleshooting guides for fostering a culture of peer-to-peer learning. Such a program would equip educators to transition from knowledge transmitters to "edu-designers," making this innovative approach accessible and adaptable for a wider range of educational settings.

While the private school setting provided optimal conditions for this initial validation, it also represents a limitation for generalizability. Future research should focus on implementing and testing this model in diverse public school contexts and across different cultures to validate its broader applicability. Longitudinal studies are also crucial to examine the long-term sustainability of the observed motivational and cognitive gains. Finally, developing and evaluating teacher training protocols based on the "edu-designer" model emerges as a critical next step for any wide-scale adoption of this promising approach (Darling-Hammond et al., 2020).

6. Conclusion

This research provides strong empirical support for the effectiveness of environmental design in fostering intrinsic motivation and accelerating cognitive development in primary education. The study's central contribution lies in demonstrating how carefully designed educational environments can achieve remarkable results with minimal resource allocation, while simultaneously validating the mechanism - daring energy - through which these transformations occur.

6.1. Theoretical Contributions and Practical Implications

The study advances current educational theory in several important respects. Firstly, it offers empirical evidence of how institutional frameworks can methodically foster the emergence of intrinsic motivation, building upon SDT by presenting tangible proof of enduring motivation development within formal educational contexts. The validation of DE as a distinct motivational-cognitive state offers a new framework for understanding optimal learning conditions, building on but distinct from flow theory (Csikszentmihalyi, 1990).

Moreover, the study challenges traditional assumptions about the resources required for educational transformation. The achievement of significant results suggests that effective ED can catalyze learning processes far more efficiently than conventional approaches. This finding has particular relevance for educational systems facing resource constraints while seeking meaningful reform.

The practical significance of these findings extends beyond theoretical advancement to offer concrete pathways for educational transformation. The documented success in activating sustained voluntary engagement - with students completing over 40,000 mathematical problems outside formal classroom hours - demonstrates the power of properly designed environments to foster genuine learning motivation. This achievement is particularly noteworthy given the minimal time investment required for implementation.

The observed cognitive gains, including significant IQ improvements and accelerated skill acquisition, suggest that ED can enhance both learning motivation and academic performance simultaneously. This challenges the common assumption that rapid progress necessarily compromises student engagement or wellbeing. Instead, the study illustrates how appropriate environmental conditions can foster both academic success and the growth of intrinsic motivation.

6.2. Future Directions and Final Reflections

While this study provides compelling evidence for the effectiveness of ED in education, it also opens new avenues for investigation. The immediate priority lies in examining the long-term sustainability of these effects through longitudinal studies. Additionally, research into the implementation of these principles across diverse educational contexts would help establish their broader applicability.

The development of teacher training protocols emerges as another crucial area for future work. Understanding how educators can effectively transition from traditional instructional roles to environmental designers represents a key challenge for widespread adoption of these approaches. This aligns with recent calls for fundamental reconsideration of teacher preparation and professional development (Darling-Hammond et al., 2020).

The demonstrated effectiveness of ED in fostering intrinsic motivation and accelerating learning opens new possibilities for educational transformation. The ability to achieve significant results with minimal time allocation suggests a highly efficient pathway for implementing these principles within existing educational systems. Perhaps most importantly, this research provides both theoretical foundations and practical guidelines for creating learning environments that naturally foster student agency and sustainable motivation, offering a viable approach to addressing persistent challenges in contemporary education.

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Data availability: The official research reports and documentation, verified by Tamos Education and reviewed by the National Academy of Education named after I. Altynsarin, are publicly available through the project website. These materials, including detailed research data and institutional evaluations, can be accessed via Google Drive links provided on the website. Additional datasets used and analyzed during the study are available from the corresponding author upon reasonable request. All data were collected and stored in accordance with institutional privacy policies.

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