

Luis Fernando González-Beltrán
(Organizador)

Educação no Século XXI:

Perspectivas
Contemporâneas
sobre
Ensino-Aprendizagem

VOL IX



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PRÓLOGO

Los procesos de enseñanza y aprendizaje se desarrollan actualmente en escenarios caracterizados por una creciente diversidad estudiantil, nuevas formas de producción y acceso al conocimiento, transformaciones tecnológicas aceleradas y demandas profesionales cada vez más complejas. En este contexto, las instituciones educativas enfrentan el desafío de promover aprendizajes significativos e inclusivos y, al mismo tiempo, desarrollar prácticas pedagógicas capaces de incluir dimensiones cognitivas, motivacionales, sociales, corporales y tecnológicas.

El volumen *Educação no século XXI: Perspectivas Contemporâneas sobre Ensino-Aprendizagem IX* reúne investigaciones que permiten aproximarse a estos desafíos desde diferentes perspectivas. Sus contenidos destacan el análisis de los procesos de aprendizaje y acompañamiento de los estudiantes, las estrategias y metodologías utilizadas en distintos contextos formativos y las oportunidades y tensiones derivadas de la transformación digital y del creciente uso de la inteligencia artificial en la educación.

La obra se organiza en tres ejes temáticos. El primero, **Aprendizaje, Inclusión y Desarrollo del Estudiante**, concentra la atención en los sujetos que aprenden y en las condiciones necesarias para favorecer trayectorias educativas más equitativas y significativas. Los capítulos exploran la diversidad del estudiantado y las prácticas de acompañamiento universitario, la construcción de entornos neuroinclusivos en la educación superior, el desarrollo de estrategias de aprendizaje autorregulado, la relación entre interés situacional, motivación y permanencia académica, las competencias cognitivas necesarias para afrontar las exigencias del aprendizaje universitario y el papel del cuerpo y de la cognición incorporada en la construcción de aprendizajes significativos. En conjunto, estas investigaciones muestran que aprender es un proceso multidimensional que requiere atender tanto a las capacidades cognitivas como a las diferencias individuales, las motivaciones y las condiciones institucionales. Con ello se pueden estudiar, explicar y resolver problemas como los bajos desempeños en lectura y matemáticas en la prueba PISA 2025, la correlación negativa entre procrastinación y aprendizaje autorregulado, y el creciente abandono escolar.

El segundo eje, **Prácticas Pedagógicas y Formación Profesional**, muestra un sólido equilibrio al reunir experiencias y estudios centrados en las estrategias mediante las cuales la enseñanza se concreta en contextos educativos y profesionales diversos. La alfabetización académica y el aprendizaje de lenguas extranjeras, la creación de materiales por parte de los propios estudiantes, las estrategias para la enseñanza de las artes visuales, la formación deportiva en edades tempranas y el aprendizaje basado

en retos y procesos de mejora continua muestran distintas posibilidades de innovación metodológica. Más allá de sus particularidades disciplinares, estos trabajos comparten la búsqueda de experiencias educativas capaces de promover participación, autonomía, motivación y desarrollo de competencias.

El tercer eje, **Tecnologías, Inteligencia Artificial e Innovación en la Educación Superior**, aborda uno de los campos que actualmente experimenta transformaciones más aceleradas. Los capítulos analizan la relación entre experiencia digital y uso académico de herramientas de inteligencia artificial, la necesidad de una formación crítica frente a los sistemas generativos, los retos y oportunidades de la articulación entre aprendizaje presencial y virtual, las nuevas competencias profesionales demandadas por la transformación tecnológica, el empleo de Design Thinking y simulaciones gamificadas como arquitecturas de aprendizaje, el desarrollo de chatbots educativos con arquitecturas de recuperación de información y apoyo socioemocional para la tutoría universitaria, y las posibilidades de la inteligencia artificial aplicada a la formación docente y a la simulación clínica.

La tecnología, en estos estudios, no se reduce a un fin en sí misma, sino a un elemento que modifica las formas de aprender, enseñar y ejercer profesionalmente. Su incorporación educativa exige, por ello, reflexión pedagógica, desarrollo de nuevas competencias, análisis crítico y capacidad para reconocer tanto sus posibilidades como sus límites.

Los tres ejes que componen este volumen convergen en una misma preocupación: comprender cómo ofrecer experiencias educativas pertinentes ante estudiantes, contextos y formas de conocimiento que están cambiando rápidamente. Inclusión, autorregulación, innovación pedagógica, formación profesional, cultura digital e inteligencia artificial forman parte de un escenario en el que la educación debe seguir colocando en el centro los procesos humanos de aprendizaje, pensamiento y construcción de conocimiento.

Esperamos que los trabajos reunidos en esta obra contribuyan al intercambio académico y profesional y estimulen nuevas investigaciones, experiencias y propuestas capaces de responder de manera crítica, creativa e inclusiva a los desafíos educativos del siglo XXI.

Dr. Luis Fernando González Beltrán

Universidad Nacional Autónoma de México (UNAM)

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FROM ENGAGEMENT TO SUSTAINABLE ACTION. GAMIFIED DESIGN THINKING AND BUSINESS SIMULATION AS A STRATEGIC LEARNING ARCHITECTURE

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ABSTRACT: This chapter assesses a strategic educational framework that merges Design Thinking, gamified business simulation, interdisciplinary collaboration, and sustainability challenges. A matched within-subject pretest-posttest design was employed with 37 students from engineering and business disciplines. Academic engagement was evaluated through vigor, dedication,

absorption, and an overall score; sustainable behavior was assessed via pro-ecological behavior, frugality, equity, and altruism. Various statistical methods – including descriptive statistics, paired-samples t-tests, Wilcoxon sensitivity tests, false-discovery-rate correction, Cronbach's alpha, bootstrap confidence intervals for Cohen's d_z , ceiling diagnostics, and change-score correlations – were utilized. Notable increases were found in the sustainability index, pro-ecological behavior, frugality, altruism, vigor, absorption, and overall engagement. Equity remained statistically stable due to ceiling effects, while dedication showed inconsistent results across different tests. Changes in engagement were not significantly correlated with changes in sustainability, indicating parallel rather than sequential outcomes. This chapter adds to business strategy literature by highlighting Design Thinking as a capability-building framework that combines systems framing, iterative experimentation, simulated decision feedback, and cross-functional dialogue. Due to the absence of a control group, results should be interpreted as changes associated with the intervention rather than definitive causal effects. The chapter concludes with a concise framework for deploying and evaluating gamified Design Thinking in business strategy education.

KEYWORDS: Design Thinking; business simulation; sustainability strategy; academic engagement; experiential learning.

1. INTRODUCTION

The incorporation of Design Thinking (DT), gamification, and sustainability challenges into educational settings has gained substantial momentum, highlighting its potential to tackle complex global issues through innovative and interdisciplinary methods (Micheli et al., 2019). Educational systems must equip students with the capability to think critically, collaborate across disciplines, and develop innovative solutions that address economic, environmental, and social dimensions concurrently (Howard et al., 2021; Wrigley & Straker, 2021). This chapter investigates a strategic learning framework combining DT, gamified business simulation, interdisciplinary collaboration, and sustainability challenges, aiming to cultivate key competencies for business strategy development in the 21st century.

Design Thinking has emerged as a pivotal methodology for fostering human-centered problem-solving, harnessing empathy, creativity, and iterative experimentation to address ill-structured problems (Micheli et al., 2019). Meanwhile, gamified simulations have proven effective in enhancing academic engagement by immersing participants in realistic decision-making environments and providing immediate feedback on their actions (Landers et al., 2021; Sailer & Homner, 2020). Both approaches are in line with the principles of experiential learning, which emphasize learning through active participation and reflection (Kolb, 1984; Wrigley & Straker, 2021).

The rising focus on sustainability education underscores the pressing need to confront global challenges such as climate change, resource depletion, and social inequity. Educational interventions promoting pro-ecological behavior, frugality, equity, and altruism are increasingly viewed as essential for equipping future leaders with the skills and values necessary to drive sustainable transformation (Steg et al., 2021; Fischer et al., 2020).

This chapter builds on these foundations by examining the impact of a bundled learning framework on two primary outcome families: academic engagement and sustainable behavior. By employing a matched within-subject pretest-posttest design, the study evaluates the extent to which this intervention fosters vigor, dedication, absorption, and sustainability-related behaviors among a sample of 37 students from engineering and business disciplines. The findings contribute to the literature on business strategy education by highlighting the potential of DT to serve as a capability-building framework that integrates systems thinking, cross-functional collaboration, and decision-feedback loops.

However, the study acknowledges its limitations, including the absence of a control group, potential ceiling effects in certain measures, and reliance on self-reported data. These limitations underscore the need for cautious interpretation of the results, which

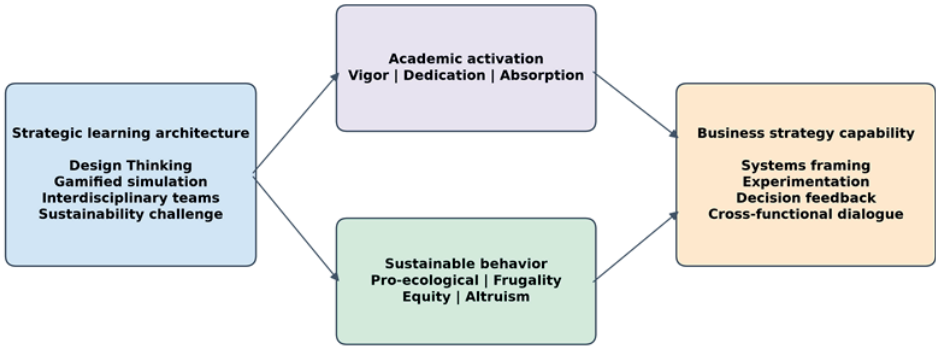
are best understood as intervention-associated changes rather than definitive causal effects. Nonetheless, the chapter offers a valuable conceptual and empirical foundation for deploying gamified DT interventions in sustainability-focused education.

2. CONCEPTUAL FRAMEWORK

The proposed framework views DT, simulation, gamification, interdisciplinary teamwork, and sustainability challenges as a bundled strategic learning architecture. Academic engagement and sustainable behavior are modeled as parallel outcome families. This model does not assume that increased engagement necessarily leads to sustainable behavior.

Figure 1 summarizes the proposed architecture.

Figure 1. Strategic learning architecture and dual-outcome model.



Parallel outcomes; causal mediation is not claimed.

2.1. DESIGN THINKING AS STRATEGIC CAPABILITY

Design Thinking (DT) has evolved into a crucial strategic capability for tackling complex, poorly defined challenges in both educational and professional settings (Micheli et al., 2019). By focusing on human-centered problem-solving, systemic thinking, and iterative prototyping, DT equips learners with the tools to navigate uncertainty and foster innovation. DT emphasizes empathy-driven exploration, enabling participants to deeply understand stakeholder needs and frame problems effectively (Howard et al., 2021). This approach is particularly relevant in sustainability education, where challenges often involve conflicting priorities, long-term uncertainty, and the need for interdisciplinary collaboration (Wrigley & Straker, 2021).

Moreover, the iterative nature of DT aligns with experiential learning principles, as it fosters reflective practices through cycles of ideation, prototyping, and testing (Kolb, 1984). In doing so, DT builds creative confidence and enhances participants' capacity to generate actionable solutions that integrate environmental, social, and economic dimensions (Brown, 2009; Landers et al., 2021). By embedding DT as a strategic capability within sustainability-focused curricula, educators can cultivate meta-cognitive skills that enable learners to adapt to evolving challenges. This positions DT as more than a methodology; it becomes a transformational mindset that transcends disciplinary boundaries and equips future leaders to drive sustainable innovation (Micheli et al., 2019; Steg et al., 2021).

2.2. SIMULATION, ENGAGEMENT, AND DECISION FEEDBACK

Simulation and gamification have emerged as powerful tools for fostering academic engagement and improving decision-making skills in sustainability education (Sailer & Homner, 2020; Landers et al., 2021). These methodologies immerse learners in realistic, risk-free environments where they can experiment with strategies, observe the consequences of their decisions, and refine their approaches (Garris et al., 2002). Gamified simulations are particularly effective in promoting active participation through elements like points, leaderboards, and challenges. These features tap into intrinsic motivations, such as competition, achievement, and social connectedness, which are vital for sustaining attention and effort (Deterding et al., 2011; Sailer & Homner, 2020).

A key strength of simulation-based learning lies in its ability to provide immediate and context-specific feedback. This feedback loop enables learners to reflect on their decisions, identify areas for improvement, and develop a deeper understanding of the systemic consequences of their actions (Schön, 1983; Sterman, 2000). For instance, in the context of sustainability, students can explore trade-offs between economic growth, environmental preservation, and social equity in a controlled setting, gaining insights directly transferable to real-world challenges (Fischer et al., 2020).

Furthermore, simulation-based learning aligns with the three dimensions of academic engagement: vigor, dedication, and absorption (Ryan & Deci, 2000). By creating immersive and interactive experiences, simulations encourage students to invest sustained effort, derive intrinsic satisfaction, and develop a deep connection to the subject matter (Howard et al., 2021).

2.3. SUSTAINABLE BEHAVIOR AND ACADEMIC ENGAGEMENT

The relationship between sustainable behavior and academic engagement is multifaceted, as both concepts can mutually reinforce each other while remaining distinct constructs (Steg et al., 2021; Fischer et al., 2020). While academic engagement focuses on students' emotional, cognitive, and behavioral investment in learning, sustainable behavior encompasses actions that prioritize ecological preservation, social equity, and resource efficiency (Steg et al., 2021).

Educational interventions aimed at sustainability often emphasize systems thinking, behavioral orientation, and stakeholder integration as essential competencies (Stermann, 2000; Fischer et al., 2020). For example, students who deeply engage with sustainability challenges are more likely to develop pro-environmental behaviors and adopt values like frugality, equity, and altruism (Steg et al., 2021). However, research suggests that academic engagement and sustainable behavior may evolve independently, highlighting the need for instructional designs that address both domains simultaneously (Garris et al., 2002; Rubin et al., 2018).

Fostering sustainable behavior requires more than motivation and engagement; it involves creating opportunities for action-oriented learning and encouraging students to apply their knowledge in real-world contexts (Wrigley & Straker, 2021). A practical example of this integration is the use of simulators that allow students to manage sustainable projects, facing complex decisions related to balancing economic growth, social equity, and environmental preservation. These tools provide a safe space for experimentation and help students understand the systemic consequences of their decisions, strengthening their ability to act sustainably in real-world scenarios.

By integrating sustainability goals into gamified simulations and Design Thinking (DT) exercises, educators can bridge the gap between academic engagement and sustainable behavior. DT's iterative approach, which fosters empathy and reflection, enables students to deeply understand sustainability challenges and design solutions that integrate environmental, social, and economic dimensions. For instance, in a DT exercise, students could work in interdisciplinary teams to develop prototypes of sustainable initiatives, such as renewable energy systems or strategies to reduce waste in supply chains. This process strengthens their academic engagement and prepares them to implement practical and effective solutions in real-world contexts.

3. OBJECTIVES AND HYPOTHESES

General objective. To evaluate whether participation in a gamified Design Thinking learning architecture is associated with pre-post changes in academic engagement and multidimensional sustainable behavior.

- Estimate descriptive and paired change statistics for all outcome dimensions.
- Estimate pre-post changes in vigor, dedication, absorption, and overall engagement.
- Estimate pre-post changes in pro-ecological behavior, frugality, equity, altruism, and a complementary sustainability index.
- Quantify the magnitude and robustness of observed changes using effect sizes and parametric and non-parametric tests.
- Quantify standardized change and uncertainty.
- Evaluate measurement reliability and ceiling effects.
- Test whether engagement change is associated with sustainable-behavior change.
- Translate findings into strategic design principles for higher education.

Hypotheses.

- H1. Overall academic engagement will be higher after the intervention than before the intervention.
- H2. The complementary sustainability index will be higher after the intervention than before the intervention.
- H3. Vigor, dedication, and absorption will each show positive pre-post change.
- H4. Pro-ecological behavior, frugality, equity, and altruism will each show positive pre-post change.
- H5. Increases in academic engagement will be positively associated with increases in sustainable behavior.

Hypothesis	Formal statement	Decision rule
H1	$\mu\Delta \text{Engagement} > 0$	Support if adjusted $p < .05$ and change > 0
H2	$\mu\Delta \text{Sustainability index} > 0$	Support if adjusted $p < .05$ and change > 0
H3	$\mu\Delta > 0$ for vigor, dedication, absorption	Full support requires all three dimensions
H4	$\mu\Delta > 0$ for four sustainability dimensions	Full support requires all four dimensions
H5	$\rho(\Delta\text{Engagement}, \Delta\text{Sustainability}) > 0$	Support if adjusted correlation $p < .05$

4. METHOD

4.1. DESIGN AND PARTICIPANTS

The study employed a matched within-subject, single-group pretest-posttest intervention design. Each of the 37 students served as an individual baseline, providing direct estimation of within-person change, though without an independent comparison group to rule out all time-related alternatives.

4.2. MEASURES

Domain	Scale	Items	Range	Scoring
Sustainability	Pro-ecological behavior	16	0-3	Mean of valid items
Sustainability	Frugality	10	0-4	Mean of valid items
Sustainability	Equity	7	1-5	Mean of valid items
Sustainability	Altruism	10	1-4	Mean of valid items
Engagement	Vigor	3	0-100	Mean / source score
Engagement	Dedication	3	0-100	Mean / source score
Engagement	Absorption	3	0-100	Mean / source score
Engagement	Overall engagement	9	0-100	Mean / source score

4.3. STATISTICAL MODEL AND METRICS

For student i , the paired change score for outcome Y is:

$$\Delta_i = Y_{i,\text{post}} - Y_{i,\text{pre}} \quad (1)$$

The primary null hypothesis for each outcome is:

$$H_0: \mu\Delta = 0 \quad \text{versus} \quad H_1: \mu\Delta > 0 \quad (2)$$

The paired t statistic is:

$$t = \bar{\Delta} / (s\Delta / \sqrt{n}), \quad df = n - 1 \quad (3)$$

The paired standardized mean change is:

$$d_z = \bar{\Delta} / s\Delta \quad (4)$$

Because sustainability dimensions have different response ranges, the complementary normalized score is:

$$X_{0-100} = [(X - X_{\min}) / (X_{\max} - X_{\min})] \times 100 \quad (5)$$

The complementary sustainability index is:

$$SBI_i = (PE_i + FR_i + EQ_i + AL_i) / 4 \quad (6)$$

Cronbach alpha was estimated as:

$$\alpha = [k / (k - 1)] [1 - \Sigma \sigma_j^2 / \sigma^2_{total}] \quad (7)$$

The paired change score for each student was calculated, and various statistical methods were applied to evaluate the results, including paired t-tests, Wilcoxon signed-rank tests, bootstrap confidence intervals, and correlation analyses.

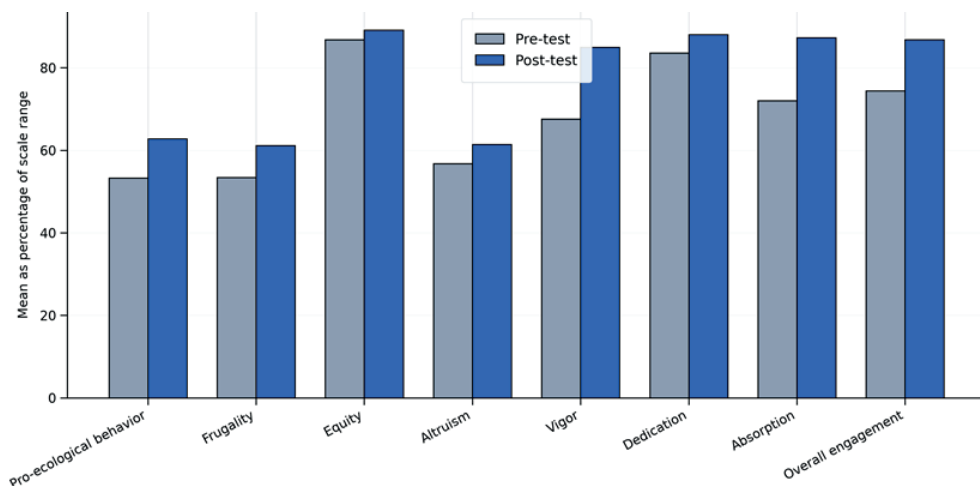
5. RESULTS

5.1. DESCRIPTIVE ANÁLISIS

Table 1. Descriptive statistics show increases in seven of nine reported outcomes. The largest raw engagement changes occurred in vigor and absorption. The sustainability index increased by 6.07 points on its 0-100 metric. Thirty of 37 students increased on the sustainability index and 28 increased on overall engagement.

Outcome	Pre M	Pre SD	Post M	Post SD	Mean Δ	Improved/ Same/ Decreased
Pro-ecological behavior	1.60	0.33	1.88	0.37	0.29	29/0/8
Frugality	2.14	0.53	2.45	0.53	0.31	25/4/8
Equity	4.47	0.50	4.56	0.53	0.09	18/10/9
Altruism	2.70	0.53	2.84	0.59	0.14	24/2/11
Sustainability index	62.54	10.19	68.61	10.32	6.07	30/0/7
Vigor	67.55	25.75	84.98	20.99	17.43	28/2/7
Dedication	83.58	19.65	88.05	19.81	4.48	22/7/8
Absorption	72.02	23.77	87.29	19.73	15.27	27/1/9
Overall engagement	74.38	21.28	86.77	19.75	12.39	28/1/8

Figure 2. Pre- and post-test means expressed as percentages of scale range.

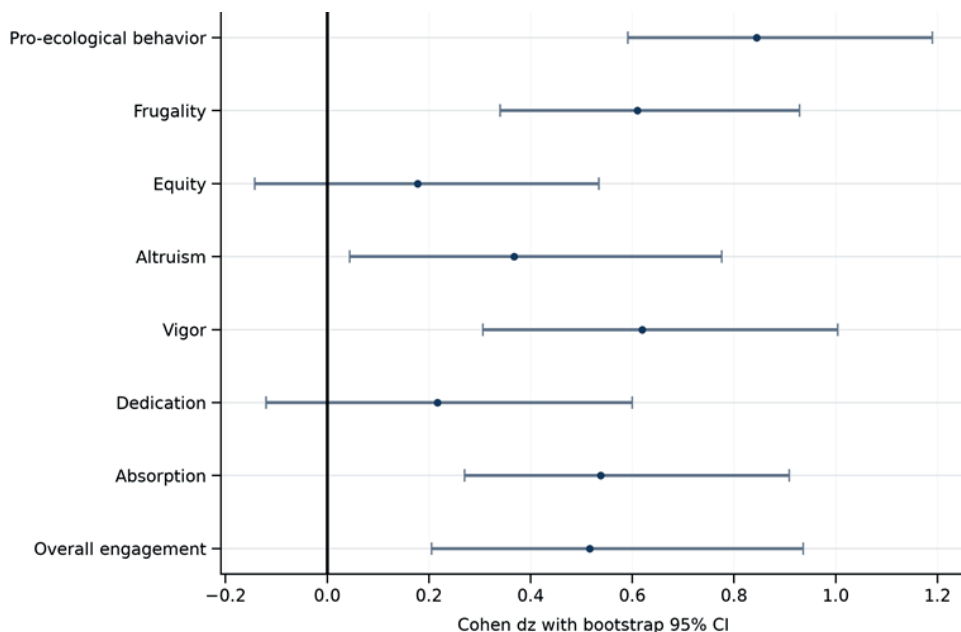


5.2. PAIRED INFERENCE AND EFFECT SIZES

Table 2. The sustainability index, pro-ecological behavior, frugality, altruism, vigor, absorption, and overall engagement remained statistically significant after false-discovery-rate adjustment. Equity and dedication did not satisfy the primary paired-t decision criterion. Effect sizes were large for the sustainability index and pro-ecological behavior, moderate for frugality, vigor, absorption, and overall engagement, and small for altruism. Confidence intervals for equity and dedication crossed zero.

Outcome	Mean Δ	95% CI Δ	t	p	pBH	dz	95% CI dz
Pro-ecological behavior	0.29	[0.17, 0.40]	5.14	<.001	0.000	0.84	[0.59, 1.19]
Frugality	0.31	[0.14, 0.48]	3.71	<.001	0.002	0.61	[0.34, 0.93]
Equity	0.09	[-0.08, 0.27]	1.08	0.286	0.286	0.18	[-0.14, 0.53]
Altruism	0.14	[0.01, 0.27]	2.23	0.032	0.041	0.37	[0.04, 0.78]
Sustainability index	6.07	[3.72, 8.43]	5.23	<.001	0.000	0.86	[0.59, 1.20]
Vigor	17.43	[8.05, 26.82]	3.77	<.001	0.002	0.62	[0.31, 1.00]
Dedication	4.48	[-2.41, 11.37]	1.32	0.196	0.220	0.22	[-0.12, 0.60]
Absorption	15.27	[5.81, 24.73]	3.28	0.002	0.004	0.54	[0.27, 0.91]
Overall engagement	12.39	[4.39, 20.40]	3.14	0.003	0.005	0.52	[0.20, 0.94]

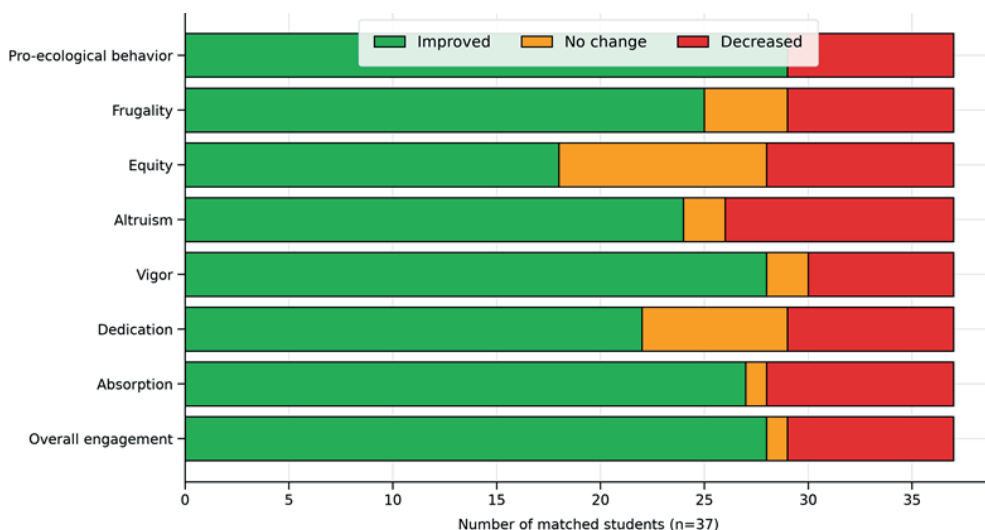
Figure 3. Forest plot of paired standardized mean changes and bootstrap 95% confidence intervals.



5.3 INDIVIDUAL RESPONSE HETEROGENEITY

The study noted variability in individual responses, with some students showing decreases in certain behaviors, supporting the need for reporting individual-direction counts alongside average effects.

Figure 4. Direction of individual pre-post change.

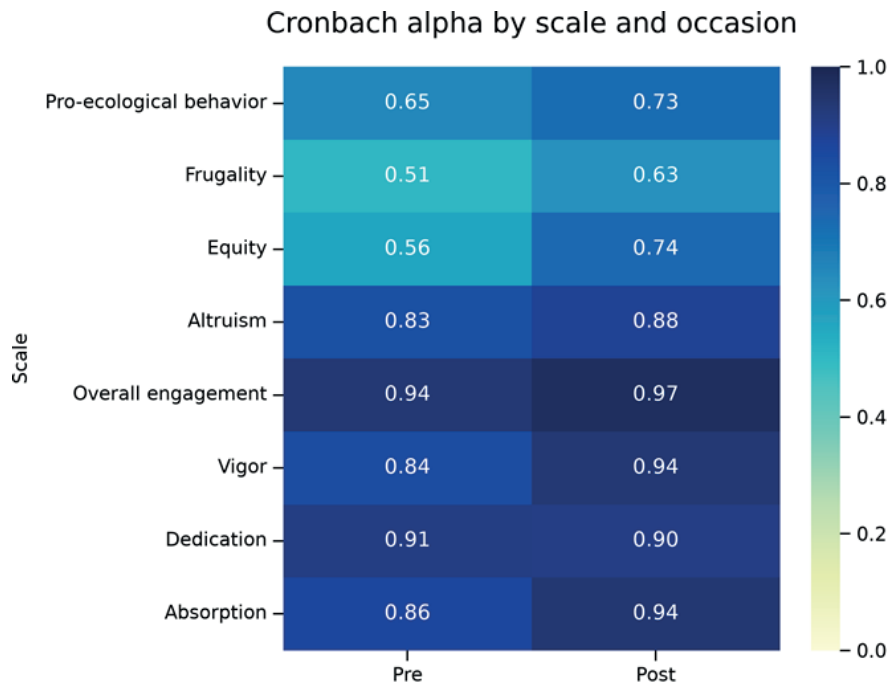


5.4. RELIABILITY AND CEILING EFFECTS

Table 3. Engagement measures demonstrated strong internal consistency. Sustainability reliability was heterogeneous, particularly for pre-test frugality and equity. Equity also showed a ceiling pattern: 21.6% were at the maximum at pre-test and 29.7% at post-test, limiting observable improvement.

Scale	α Pre	α Post	Interpretive note
Pro-ecological behavior	0.65	0.73	Acceptable/limited
Frugality	0.51	0.63	Acceptable/limited
Equity	0.56	0.74	Acceptable/limited
Altruism	0.83	0.88	Strong
Overall engagement	0.94	0.97	Strong
Vigor	0.84	0.94	Strong
Dedication	0.91	0.90	Strong
Absorption	0.86	0.94	Strong

Figure 5. Internal consistency by construct and occasion.



5.5. HYPOTHESIS TESTING

Hypothesis	Decision	Statistical justification
H1	Supported	Overall engagement: $p=.003$, $dz=.52$
H2	Supported	Sustainability index: $p<.001$, $dz=.86$
H3	Partially supported	Vigor and absorption significant; dedication inconclusive
H4	Partially supported	Three sustainability dimensions significant; equity not
H5	Not supported	Delta engagement vs delta sustainability: $\rho=.10$, $p=.552$

H1 and H2 were accepted under the prespecified decision rule. H3 and H4 received partial support because not every component dimension changed significantly. H5 was rejected: the correlation between change in overall engagement and change in the sustainability index was small and nonsignificant ($\rho = .10$, $p = .552$). Therefore, engagement and sustainable behavior are interpreted as parallel outcomes rather than a demonstrated mediation chain.

Figure 6. Hypothesis decisions and statistical basis.

H1	Supported	Overall engagement: $p=.003$, $dz=.52$
H2	Supported	Sustainability index: $p<.001$, $dz=.86$
H3	Partially supported	Vigor and absorption significant; dedication inconclusive
H4	Partially supported	Three sustainability dimensions significant; equity not
H5	Not supported	Delta engagement vs delta sustainability: $\rho=.10$, $p=.552$

6. DISCUSSION

The intervention was followed by meaningful gains in academic activation and selected sustainable behaviors, but the gains were not universal. Vigor and absorption improved while dedication did not meet the primary criterion. Pro-ecological behavior and frugality produced the clearest sustainability gains, altruism showed a smaller effect, and equity remained stable at a high baseline with ceiling restriction.

The lack of a significant coupling between engagement and sustainable-behavior change is theoretically relevant. Increased energy and immersion may make participation more likely, but these states did not statistically explain who changed in sustainability. The business-strategy implication is that engagement should not be treated as a proxy for

sustainable strategic capability. Instructional designs should separately assess decision quality, systems reasoning, stakeholder integration, and behavioral orientation.

The statistical pattern supports a five-stage strategic learning framework: systemic problem framing; stakeholder-centered exploration; strategic prototyping; simulated consequence testing; and cross-functional reflection. Each stage should be linked to explicit evidence, not only student satisfaction.

7. LIMITATIONS AND RESEARCH AGENDA

The matched design controls stable between-person differences by using each participant as a baseline. Nevertheless, no independent comparison group was included. Other limitations include $n = 37$, a single institution, self-report measures, possible social-desirability effects, ceiling restriction, uncertain reverse scoring for selected sustainability items, and a bundled intervention that prevents component-level attribution. Replication should include a comparison group, confirmed scoring, preregistered primary outcomes, delayed follow-up, objective project-quality indicators, and multilevel modeling when team counts permit.

8. CONCLUSION

A learning architecture combining DT, a gamified business simulator, interdisciplinary work, and sustainability challenges was associated with moderate-to-large gains in overall engagement and a complementary sustainability index. The most consistent changes occurred in vigor, absorption, pro-ecological behavior, and frugality. Equity and dedication remained comparatively stable and change in engagement did not explain change in sustainable behavior. The contribution is therefore best presented as evidence that DT can be embedded in business strategy education to produce parallel academic and sustainability outcomes, while requiring careful facilitation, measurement, and causal restraint.

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APPENDIX A. REPRODUCIBILITY AND PUBLICATION CHECKPOINTS

The accompanying Python file `chapter_analysis_q1.py` reproduces descriptive statistics, paired inference, bootstrap effect-size intervals, reliability, ceiling diagnostics, correlations, exploratory baseline-adjusted regressions, Excel tables, and six publishable figures. Place the two source workbooks beside the script and run it in Python. Required source files: `Conductas_Sustentables_37_Matriculas_Corregido.xls` and `Engagement_Pareado2.xlsx`.

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