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Front Pages

RENE MARTINEZ, MERVYN WIGHTING & DANIEL TUBBS

[Improving Teacher-student Relationships via PBIS: A Study of First-year Teachers](#)

JOHN I. LIONTAS

[Cultivating ISI: Shaping the Future of Idiomatics in Language Education and Research](#)

ELIZABETH D. DIAZ

[Using AI in Book Writing with Human Supervision: A Case Study in Astronomy for Kids](#)

CARSTEN LECON, STEFANIE SOESER & ANDRE STEGMAIER

[Designing Immersive Learning Experiences: Teaching Robotics Programming in Virtual 3D Environments](#)

GER COFFEY

[An Investigation into the Essence of Short-Term Experiential Learning Field Trips to an Operational Prison](#)

ULRIKA GIDLUND & MARCIA HÅKANSSON LINDQVIST

[Teacher Shortages: What can be learnt from Countries without a Teacher Shortage?](#)

RITA COLACE, MICHELE DOMENICO TODINO & IOLANDA ZOLLO

[Artificial Intelligence and Didactics: Insights for teaching Latin](#)

NAOMI LA MANNA, EMANUELA ZAPPALÀ & MAURIZIO SIBILIO

[Fostering Students' Engagement and learning through Simplex Didactics Approach](#)

MIHAIL CALALB

[Application of Combined Constructivist Strategies in Physics Teaching](#)

EVA REID & DOMINIKA MIHALOVÁ

[Exploring Pronunciation Teaching: A Case Study of Practices and Perceptions in an English Classroom](#)

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Download the entire issue ([PDF](#))

<u>Front Pages</u>	i-viii
<u>Improving Teacher-student Relationships via PBIS: A Study of First-year Teachers</u> <i>Rene Martinez, Mervyn Wighting & Daniel Tubbs</i>	587
<u>Cultivating ISI: Shaping the Future of Idiomatics in Language Education and Research</u> <i>John I. Liontas</i>	607
<u>Using AI in Book Writing with Human Supervision: A Case Study in Astronomy for Kids</u> <i>Elizabeth D. Diaz</i>	633
<u>Designing Immersive Learning Experiences: Teaching Robotics Programming in Virtual 3D Environments</u> <i>Carsten Lecon, Stefanie Soeser & Andre Stegmaier</i>	661
<u>An Investigation into the Essence of Short-Term Experiential Learning Field Trips to an Operational Prison</u> <i>Ger Coffey</i>	665
<u>Teacher Shortages: What can be learnt from Countries without a Teacher Shortage?</u> <i>Ulrika Gidlund & Marcia Håkansson Lindqvist</i>	703
<u>Artificial Intelligence and Didactics: Insights for teaching Latin</u> <i>Rita Colace, Michele Domenico Todino & Iolanda Zollo</i>	727
<u>Fostering Students' Engagement and learning through Simplex Didactics Approach</u> <i>Naomi La Manna, Emanuela Zappalà & Maurizio Sibilio</i>	741
<u>Application of Combined Constructivist Strategies in Physics Teaching</u> <i>Mihail Calalb</i>	763
<u>Exploring Pronunciation Teaching: A Case Study of Practices and Perceptions in an English Classroom</u> <i>Eva Reid & Dominika Mihaľová</i>	789

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The current issue is the fourth of the thirteenth volume of the *Athens Journal of Education (AJE)*, published by the [Education Unit](#) of Athens Institute.

Gregory T. Papanikos
President
Athens Institute



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- Abstract Submission: **15 December 2026**
- Acceptance of Abstract: 4 Weeks after Submission
- Submission of Paper: **19 April 2027**

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The Social Program Emphasizes the Educational Aspect of the Academic Meetings of Athens Institute.

- Greek Night Entertainment (This is the official dinner of the conference)
- Athens Sightseeing: Old and New-An Educational Urban Walk
- Social Dinner
- Mycenae Visit
- Exploration of the Aegean Islands
- Delphi Visit

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Conference fees vary from 400€ to 2000€
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A World Association of Academics and Researchers

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The [Education Unit](#) of Athens Institute is organizing the 11th Annual International Symposium on “Higher Education in a Global World”, 5-10 July 2027, Athens, Greece sponsored by the [Athens Journal of Education](#). The aim of the symposium is to examine educational developments throughout the world in universities, polytechnics, colleges, and vocational and education institutions. Academics and researchers from all areas of education are welcomed. You may participate as stream organizer, presenter of one paper, chair a session or observer. Please submit a proposal using the form available (<https://www.atiner.gr/2027/FORM-COLEDU.doc>).

Important Dates

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- Acceptance of Abstract: 4 Weeks after Submission
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Improving Teacher-student Relationships via PBIS: A Study of First-year Teachers

By Rene Martinez*, Mervyn Wighting[±] & Daniel Tubbs[°]

This mixed-methods study examined whether first-year teachers could improve relationships with students through Positive Behavioral Interventions and Supports (PBIS). Fifty novice teachers implemented one of three PBIS strategies: daily one-on-one conversation, verbal praise, or immediate rewards with 192 selected students over a two-week period. Teacher-student relationships were measured using the Student-Teacher Relationship Scale (STRS) before and after the intervention. Results showed significant reductions in conflict ($t(191) = 7.14, p < .001, d = 0.98$) and moderate increases in closeness ($t(191) = -7.11, p < .001, d = 0.67$). No significant differences emerged across grade levels, teacher and student gender, or PBIS strategy type. Thematic analysis of teacher reflections highlighted improvements in engagement, cooperation, emotional regulation, and relational trust. Although the study was limited by its two-week duration and reliance on teacher self-reports, the findings demonstrate that even brief PBIS interventions can yield measurable relational benefits. Implications are discussed for teacher preparation programs and school-based practice.

Keywords: teacher-student relationships, Positive Behavioral Interventions and Supports (PBIS), teacher preparation programs, first-year/novice teachers, school climate.

Introduction

The quality of the relationship between teachers and students is a critical factor in shaping classroom environments, influencing student behavior, academic outcomes, and overall school climate. Research has consistently shown that positive, learner-centered teacher-student relationships are associated with increased student engagement, improved academic performance, and decreased behavioral challenges (Cornelius-White, 2007; Hughes et al., 2008; Roorda et al., 2011; Spilt et al., 2012; Poling et al., 2022). In contrast, strained or conflictual relationships may contribute to disengagement and elevated discipline issues. First-year teachers frequently report classroom management and relationship-building as pressing challenges (Ingersoll & Strong, 2011; Pogodzinski et al., 2013). International evidence echoes these concerns. The Teaching and Learning International Survey (2018) shows nearly one-quarter of class time is devoted to managing the classroom and administrative tasks, signaling the pivotal importance of classroom management. Novice teachers also experience higher levels of stress, attrition, and difficulty in establishing effective instructional routines compared to their more

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experienced peers (Fantilli & McDougall, 2009), and early experiences with managing behavior and fostering relationships can shape their long-term instructional efficacy and career trajectories (Smith & Ingersoll, 2004). As educational institutions seek sustainable strategies to improve student outcomes, Positive Behavioral Interventions and Supports (PBIS) has emerged as a widely adopted framework aimed at promoting positive behavior and enhancing school climate (Santiago-Rosario et al., 2023). However, less is known about the specific effects of PBIS on teacher-student relationships, particularly from the perspective of first-year teachers navigating early classroom management challenges.

This paper presents findings from a 2025 research study that builds upon two prior investigations (Martinez & Wighting, 2023; Martinez et al., 2025). The study explores how PBIS implementation influences the quality of teacher-student relationships, specifically focusing on the constructs of conflict and closeness as measured by the Student-Teacher Relationship Scale (STRS), a validated instrument widely used to assess teacher perceptions of relational quality (Pianta, 2001). By examining pre- and post-survey data from 50 first-year teachers and 192 students, with each teacher selecting 3–4 students and implementing PBIS strategies over a two-week period, the study presents an analysis of how relationship-focused behavior supports can impact classroom dynamics. In addition, the research investigates whether teacher or student gender, grade level, or selected PBIS methods influence outcomes, offering nuanced insights into the complex interplay of personal and contextual factors in classroom relationships.

Review of the Literature

The Importance of Teacher-Student Relationships

Teacher-student relationships are a cornerstone of effective teaching and learning. According to Pianta (1999), the quality of these relationships can influence a student's motivation, behavior, and academic success. Positive relationships characterized by warmth, trust, and respect create an environment where students feel valued and supported, which in turn facilitates engagement and resilience (Hamre & Pianta, 2001). Conversely, relationships marked by conflict or unpredictability can hinder academic progress and increase behavioral issues, especially among students already at risk (O'Connor & McCartney, 2007).

PBIS as a Relationship-Oriented Framework

Positive Behavioral Interventions and Supports (PBIS) is a tiered, school-wide framework designed to support proactively appropriate student behaviors and to improve school climate. At its core, PBIS emphasizes clear behavioral expectations, consistent reinforcement, and data-driven decision-making (Sugai & Horner, 2002). While much of the literature on PBIS focuses on behavioral outcomes such as reduced office discipline referrals (ODRs) and school suspensions, emerging research highlights the potential of PBIS to influence relational dynamics between teachers and

their students. Strategies like verbal praise, relationship-building conversations, and behavior-specific feedback have been shown to foster student trust and cooperation (Bennett, 2020; McDonald, 2019).

Previous Research on PBIS and Teacher-Student Relationships

The 2023 study by Martinez and Wighting examined how PBIS implementation influenced teacher-student dynamics in a K–12 setting. Findings indicated that PBIS was associated with decreased reports of student misbehavior and improved perceptions of classroom culture. The authors' 2025 follow-up study built upon these results by employing the STRS to measure quantitatively teacher-reported levels of conflict and closeness before and after PBIS strategies were implemented. Results from the 2025 study showed statistically significant reductions in conflict and modest increases in closeness. Additionally, qualitative responses revealed that teachers attributed these shifts to intentional praise, structured routines, and individualized behavior supports.

Although the majority of PBIS research originates in the United States, international and cross-cultural studies also affirm the central role of teacher–student relationships in shaping outcomes. For example, Martin and Collie (2019), in an Australian high school context, demonstrated that the balance of positive and negative teacher–student relationships significantly influenced student engagement. Similarly, Wang and Eccles (2012) found that supportive teacher–student relationships in China were positively associated with adolescents' long-term academic motivation. In addition, Caldarella et al. (2015) reported that behavior-specific praise and other PBIS strategies improved teacher–student interactions in schools across multiple countries, suggesting that the relational aspects of PBIS may generalize beyond U.S. contexts. Together, these findings highlight the global relevance of relationship-centered frameworks such as PBIS and underscore the importance of examining their effects in diverse educational settings.

Current Study and Identified Gaps

Although prior studies demonstrated promising outcomes, questions remained regarding the possible impact of teacher or student gender, teaching grade level, and the comparative effects of different PBIS strategies. Moreover, first-year teachers, who often face challenges with classroom management, have been underrepresented in previous PBIS research. The current study aims to address these gaps by exclusively focusing on novice teachers and examining whether demographic and contextual variables moderate the impact of PBIS on teacher-student relationships. This study builds on previous research while offering practical insights for supporting early-career educators and refining relationship-centered behavior frameworks.

This overall body of literature underscores the importance of relationship quality in teaching, the promise of PBIS as a relational tool, and the need for targeted research to inform implementation strategies. Previous studies have provided a strong foundation incorporating additional perspectives, e.g. Gregory et al. (2016) on culturally responsive behavior support, or Reinke et al. (2013) on teacher coaching in

PBIS implementation and the current study may further enhance understanding. This research contributes to the body of knowledge by offering both empirical data and educators' perspectives on the effect of PBIS on teacher-student relationships.

Research Question

Does the implementation of Positive Behavioral Interventions and Supports (PBIS) by first-year teachers improve measured teacher-student relationships, e.g. by reducing conflict and increasing closeness, and are the outcomes influenced by teacher or student gender, grade level, or the type of PBIS strategy used?

Method

This study employed a mixed-methods design involving 50 first-year teachers from diverse K–12 educational settings across one state in the USA. Conducted at the start of an academic year, when some students' behaviors were emerging as potential discipline concerns, teachers selected 3 or 4 students in their classrooms who exhibited behavioral or relational challenges. This process resulted in a study total of 192 student-teacher relationship pairs. The intervention period lasted two weeks between measurements. The participating teachers were employed in a range of school types and communities, providing broad geographic coverage throughout the state.

Participants

All teacher participants were in their first-year of full-time teaching. Student participants ranged from kindergarten to 12th grade and were identified by their teachers based on observed behavioral or relational challenges. These students may have received at least one office referral or demonstrated behaviors inconsistent with classroom expectations. Teachers also provided demographic information, including their own gender, student gender, and student grade level. The students were unaware that their teachers had selected them for this action research.

Design and Procedure

The study used a mixed-methods design incorporating both quantitative and qualitative data to assess the impact of PBIS implementation on teacher-student relationships. Teachers completed the same Student-Teacher Relationship Scale (STRS), (Pianta, 2001), to measure their relationship with students both before and after implementing one of three selected PBIS strategies over a two-week intervention period. The STRS, shown at Appendix A, measures two key relationship constructs using a 5-point Likert scale: Closeness and Conflict.

Teachers then chose one PBIS strategy to implement with each student for two weeks. The PBIS options were:

1. Spending two minutes per day engaging in one-on-one conversation with the student,
2. Providing verbal praise for positive behavior, and
3. Giving immediate rewards (e.g., food, candy, badges) for appropriate behavior.

This study was limited to the option of three Tier 1-PBIS practices to balance the feasibility for first-year teachers with evidence and theory. Behavior-specific praise has robust empirical support that training teachers to use it reduces disruption and increases appropriate behavior (Zoder-Martell et al., 2019). Immediate rewards reflect token reinforcement procedures with demonstrated effects on classroom behavior (Soares et al. 2016). The widely used "2x10" approach involves daily one on-one conversations. This relationship-focused dyadic time is theorized to strengthen teacher student bonds (Henze et al., 2024). Constraining the choice set to three simple strategies also standardized implementation in a short two-week window. At the end of the two-week intervention, teachers completed a post-survey, measuring the relationship using the STRS to obtain quantitative data.

Prior to the intervention, teachers responded to a pre-survey that included demographic questions and open-ended prompts asking them to describe behavioral concerns and several open-ended questions for each selected student; their responses provided data for the study's qualitative section and several open-ended questions shown at Appendix B. Post-intervention prompts asked teachers to reflect on behavior changes, the influence of teacher or student gender and grade level, and outcomes observed when positive relationships were present.

Data Collection and Instruments

The STRS was the instrument used to assess teacher perceptions of their relationships with individual students. The scale provides numeric scores for Closeness (e.g., warmth, trust, openness) and Conflict (e.g., tension, disagreement, defiance). In addition, qualitative data were collected through open-ended responses regarding observed behavior changes, teacher perceptions of their own influence, and relational dynamics in the classroom.

Data Analysis

Quantitative data were analyzed using paired samples t-tests to compare pre- and post-intervention STRS scores. One-way and two-way ANOVAs were used to assess the influence of PBIS strategy, grade level, and gender on changes in Closeness and Conflict. Effect sizes (Cohen's *d*) were calculated to determine the magnitude of changes.

Qualitative responses were analyzed using thematic coding to identify patterns related to teacher perceptions of behavior change, relational improvement, and contextual influences such as grade level and gender. Themes were triangulated with quantitative findings to provide a comprehensive understanding of PBIS impact.

Results

The following section reports the results of quantitative and qualitative findings.

Analysis 1: Conflict and Closeness (Paired Samples t-Tests)

This analysis examined the effect of a two-week PBIS intervention on teacher-student relationships, as measured by the Student-Teacher Relationship Scale (STRS). Specifically, paired samples t-tests were conducted to assess pre- and post-intervention changes in two subscales: Closeness (reflecting warmth, trust, openness) and Conflict (indicating tension, disagreement, or defiance in the relationship).

Table 1. Paired Samples Statistics for Closeness and Conflict

Student-Teacher Relationships	Mean	Std. Deviation	N
Closeness (Pre)	3.3653	.80424	191
Closeness (Post)	3.7109	.78918	191
Conflict (Pre)	2.8906	1.06571	191
Conflict (Post)	2.3862	.93467	191

As shown in Table 1, teachers reported higher average closeness with students after the PBIS intervention. The pre-intervention closeness mean score increased from 3.37 (SD = 0.80) to 3.71 (SD = 0.79) post-intervention. This difference was statistically significant, $t(191) = -7.11$, $p < .001$, and reflects a moderate effect size (Cohen's $d = 0.67$), suggesting that the intervention led to meaningful improvements in perceived relational warmth, openness, and trust between teachers and their students.

Conversely, conflict scores showed a more substantial difference. Before the intervention, the mean conflict score was 2.89 (SD = 1.07), which dropped to 2.39 (SD = 0.93) following the two-week PBIS implementation. This reduction was also statistically significant, $t(191) = 7.14$, $p < .001$, with a large effect size (Cohen's $d = 0.98$), indicating a strong and practical reduction in teacher-perceived conflict with students.

Table 2. Paired Samples t-test Results for Closeness and Conflict

Student-Teacher Relationships Measure	Mean Difference	Std. Error Mean	95% CI Lower	95% CI Upper	t	df	p-value (2-tailed)
Closeness	-.345610	.048601	-.44147	-.249745	-7.111	191	< .001
Conflict	.504464	.070695	.36502	.643907	7.136	191	< .001

Table 3. Effect Sizes for Closeness and Conflict (Cohen's d)

		Standardizer	Point Estimate	95% CI Lower	95% CI Upper
Closeness	Cohen's d	.67344	-.513	-.663	-.362
	Hedges' correction	.67610	-.511	-.661	-.361
Conflict	Cohen's d	.97958	.515	.364	.665
	Hedges' correction	.98345	.513	.362	.662

These findings indicate that even brief implementation of targeted PBIS strategies can produce meaningful changes in the quality of teacher-student relationships (see Table 3). The larger effect size on conflict ($d = 0.98$) relative to closeness ($d = 0.67$) is consistent with how Tier 1 PBIS operates over short windows: praise and contingent reinforcement target observable behavior and may be particularly effective at reducing behavioral tension and negativity, as supported by the significant t-test results (see Table 2). By contrast, closeness reflects trust, warmth, and openness which are qualities that typically accumulate more gradually as positive interactions accrue. Measurement context may also have contributed: baseline conflict showed greater variability and more room to decrease (pre $M = 2.89$) than closeness has to increase (pre $M = 3.37$), and over two weeks teacher ratings may be more sensitive to visible behavior change than to relational depth. The intervention produced a pronounced reduction in conflict and a moderate but reliable gain in closeness; extending the duration or layering additional relational strategies may be necessary to strengthen rapport further.

In summary, the effect sizes indicate that PBIS strategies can lead to meaningful and substantial improvements in teacher-student relationships over a short period, with reductions in conflict and increases in closeness laying the foundation for more positive and trusting classroom relationships.

Analysis 2: PBIS Strategy Comparison (One-Way ANOVA)

To explore whether the type of PBIS strategy influenced the level of improvement in teacher-student relationships, one-way ANOVAs were conducted using post-intervention STRS scores for both closeness and conflict. Higher closeness scores reflect stronger teacher-student bonds, and lower conflict scores reflect more positive interaction. Teachers selected one of three relationships PBIS strategies:

1. Daily two-minute one-on-one conversations,
2. Verbal praised for positive behavior, or
3. Immediate rewards (e.g., stickers, candy).

The descriptive statistics for each strategy are presented in Table 4.

Table 4. Mean Post-Intervention Closeness and Conflict Scores by PBIS Method

Student Teacher Relationships	PBIS Method	Mean	Std. Deviation	N
Closeness	Converse with Student Daily	3.7071	.82224	99
	Verbal Praise for Good Behavior	3.7641	.76897	71
	Provide an Immediate Reward	3.5568	.70997	22
	Total	3.7109	.78918	192
Conflict	Converse with Student Daily	2.3694	.90834	99
	Verbal Praise for Good Behavior	2.3843	.98933	71
	Provide an Immediate Reward	2.4675	.90799	22
	Total	2.3862	.93467	192

A one-way ANOVA was conducted to determine whether the differences among the three groups were statistically significant. Results are summarized in Table 5.

Table 5. One-Way ANOVA Results for PBIS Method and Teacher-Student Relationships Outcomes

Dependent Variable	df Between	df Within	<i>F</i>	<i>p</i>
Closeness	2	189	0.579	.562
Conflict	2	189	0.098	.906

Results indicated no statistically significant differences among the three PBIS strategies (two-minute daily conversation, verbal praise, and immediate rewards) in their effects on Closeness ($F = 0.579$, $p > .05$) or Conflict ($F = 0.098$, $p > .05$). These findings suggest that all three approaches were similarly effective in supporting teacher-student relationships following the PBIS intervention.

Although average scores varied slightly, especially for closeness (with verbal praise yielding a slightly higher mean), these differences were not statistically meaningful. Educators can therefore implement any one of the three PBIS options as they appear to yield comparable outcomes in fostering better teacher-student relationships. They can feel confident to select a PBIS approach that aligns with their teaching style and the needs of individual students, as no single method emerged as superior within this sample.

Analysis 3: Grade Level and Strategy Interaction (Two-Way ANOVA)

To determine whether the effectiveness of PBIS strategies differed across grade levels, a two-way ANOVA was conducted with the PBIS strategy type (Three levels: daily conversation, verbal praise, immediate reward) and grade level (three levels: PK-5, elementary school; 6-8, middle school; and 9-12, high school) as independent variables. All teachers had the freedom to choose from among the rewards. The dependent variables were the change scores (post minus pre) for closeness and conflict scores reported by first-year teachers using STRS.

Descriptive statistics for each PBIS strategy across the three grade levels bands are provided in Table 6. While no single method appears more effective, there are modest trends, such as stronger conflict reduction in elementary grades (PK-5) and greater closeness gains in high school (9-12). These trends, however, do not indicate a consistent pattern of differential effectiveness by grade level.

Table 6. Mean Closeness and Conflict Scores by PBIS Method and Grade Level

Student Teacher Relationships	PBIS Method	Closeness/ Conflict	Mean	Std. Deviation	N
PK-5	Converse with Student Daily	Closeness	.3761	.66273	51
		Conflict	-.5798	.88164	51
	Verbal Praise for Good Behavior	Closeness	.3549	.60934	32
		Conflict	-.4941	1.11248	32
	Provide an Immediate Reward	Closeness	-.0304	.43343	10
		Conflict	-.4429	.78729	10
6-8	Converse with Student Daily	Closeness	.2847	.46692	18
		Conflict	-.4497	.97975	18
	Verbal Praise for Good Behavior	Closeness	.2086	.53266	22
		Conflict	-.4740	1.10339	22
	Provide an Immediate Reward	Closeness	.1352	.79792	7
		Conflict	-.1429	.83118	7
9-12	Converse with Student Daily	Closeness	.5756	.78667	30
		Conflict	-.6254	.96880	30
	Verbal Praise for Good Behavior	Closeness	.3540	.90657	17
		Conflict	-.4202	1.12009	17
	Provide an Immediate Reward	Closeness	.4357	.86571	5
		Conflict	-.3238	1.12959	5

A full factorial two-way ANOVA was conducted to examine:

1. The main effect of PBIS strategy on teacher-students closeness and conflict.
2. The main effect of grade level.
3. The interaction effect between PBIS strategy and grade level.

Results of the ANOVA (see Table 7) revealed no statistically significant main effects or interaction effects for either outcome variable. Specifically:

- For closeness, neither the PBIS strategy type ($F(2, 183) = 1.135, p = .324$) nor grade level ($F(2, 183) = 1.390, p = .252$), nor their interaction ($F(4, 183) = 0.408, p = .802$), produced statistically significant differences.
- For conflict, similar non-significant results were observed across all three effects (all p -values $> .05$).

It should be noted, however, that the N for several grade-level/strategy subgroups was small (e.g., immediate reward in high school, $N = 5$). These low counts may have reduced statistical power, limiting the ability to detect potential differences and suggesting caution in interpreting subgroup findings.

Table 7. Two-Way ANOVA Summary for Closeness and Conflict by Grade Level and PBIS Strategy

Dependent Variable	Source	df	F	p-value
Closeness	PBIS Strategy	2	1.135	.324
	Grade Band	2	1.390	.252
	Strategy $\times$ Grade	4	0.408	.802
	Error	183		
Conflict	PBIS Strategy	2	0.541	.583
	Grade Level	2	.260	.771
	Strategy $\times$ Grade	4	0.118	.976
	Error	183		

These null results suggest that the positive effects of PBIS strategies on teacher-student relationships were consistent across elementary, middle, and high school levels, and did not depend on the specific strategy selected. There were no main effects for grade level, nor any interaction effects between grade level and

strategy type ($p > .05$). These findings suggest that PBIS strategies yielded comparable outcomes across all grade levels included in the study (K–12).

This consistency offers valuable implications for school-based PBIS implementation. PBIS interventions, regardless of the specific method, grade level, or gender, produced similar outcomes in terms of improving relationships. Because no method outperformed the others, schools have the flexibility to focus on a uniform PBIS strategy or to enable teachers to choose methods that align with their personal teaching styles or specific classroom needs. However, given the age differences between student groups, the type or perceived value of the “reward” component may influence student engagement and responsiveness to PBIS strategies. Future research with a larger sample size or more targeted measures could potentially reveal subtle differences related to grade levels or particular methods, offering deeper insights into optimizing PBIS implementation.

Analysis 4: Qualitative Findings, Thematic Summary of Teacher Reflections

Thematic analysis of teacher responses to the post-intervention open-ended questions provided valuable insight into how first-year teachers perceived the effects of PBIS on student behavior and teacher-student relationships. From the total dataset of 191 student entries, a purposeful sample of 58 teacher reflections was selected for coding. These reflections were chosen based on clarity, completeness, and relevance to the study’s research questions. The resulting themes are closely aligned with five overarching categories: increased engagement, improved emotional regulation, reduced defiance, better peer interactions, and strengthened relational trust. These qualitative findings offer additional depth to the quantitative results by capturing how novice teachers experienced and interpreted changes in student behavior and classroom climate following the PBIS implementation.

One of the most frequently cited themes was increased engagement. Teachers frequently noted that students who were previously withdrawn or showed low participation became more involved in classroom activities. When students sensed that their teacher cared about them as individuals, they became more willing to participate, take risks, and follow classroom expectations. Similarly, numerous teachers reported improved self-regulation as a common observation. Teachers described students exhibiting fewer outbursts and greater self-control. Students who were previously prone to impulsivity or frustration began to demonstrate greater control, often attributed to consistent and positive adult attention. This change was often linked to the consistent structure and positive reinforcements embedded in PBIS strategies, which can offer students a sense of predictability and emotional security.

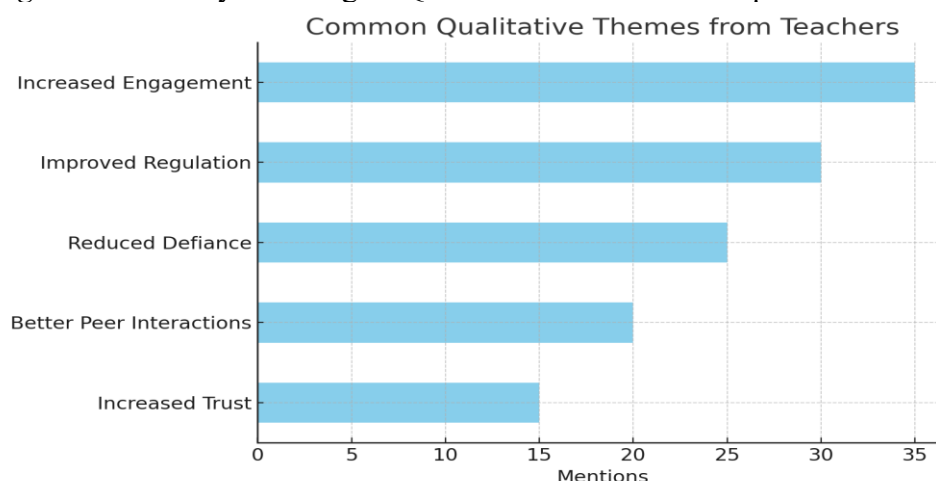
A third theme centered on reduced defiance and opposition. Many participants described a noticeable decrease in oppositional behavior. Teachers observed that students became more cooperative and less argumentative when positive interactions replaced corrective or disciplinary exchanges. This shift was especially meaningful for the novice teachers in this study, many of whom acknowledged initial struggles in managing student resistance. In several cases, teachers emphasized that behavior changes were not dramatic but were still noticeable,

suggesting that even small adjustments in relational tone and consistency had a positive impact.

In addition to behavioral shifts, several teachers highlighted improved peer relationships. Teachers shared that students began showing greater empathy, patience, and social awareness, which contributed to a more cohesive classroom climate. These social-emotional developments not only benefitted student interactions but also reinforced a sense of community.

Finally, the theme of trust as a foundation for academic success was woven throughout the reflections. Teachers noted that as trust between the teacher and student deepened, students became more receptive to feedback, more confident in their academic efforts, and more motivated to succeed. When students felt emotionally safe and understood, they not only behaved better but also displayed increased motivation and pride in their work. This trust-based connection was seen as a cornerstone of effective instruction and behavior support, particularly for students with a history of relational or behavioral challenges.

Figure 1. Summary of Emergent Qualitative Themes and Frequencies



These qualitative reflections reinforce the values of PBIS as a relationship-centered approach, especially for novice teachers navigating early classroom management. These findings align with the quantitative findings by underscoring the power of relational practices, e.g. praise, consistency, and positive attention, that can foster engagement, cooperation, emotional regulation, and trust. For many novice teachers, PBIS provided a practical framework for building meaningful connections between themselves and their students, creating a calmer learning environment and addressing behavioral challenges through consistent and supportive interactions.

Discussion

This study sought to examine the effects of PBIS on teacher-student relationships, with a specific focus on first-year teachers. Findings from both the qualitative and quantitative data suggest that brief, relationship-centered PBIS strategies can yield meaningful improvements in classroom dynamics. These improvements were especially

evident in the reduction of conflict and the development of stronger relational bonds, demonstrating the potential of PBIS to build stronger connections that support learning and classroom success.

Quantitative analysis revealed statistically significant improvements on both subscales of the STRS, with closeness increasing moderately and conflict decreasing significantly following a two-week PBIS implementation. These findings extend prior research by confirming that relational improvements are observable even within short time frames and under the direction of first-year teachers who are still developing classroom management skills. The large effect size for conflict reduction is particularly noteworthy, suggesting that PBIS may serve as a useful classroom management strategy against early-career challenges commonly associated with oppositional behavior and disciplinary challenges.

The qualitative data added value to this study by illustrating how teachers experienced these changes in real time. Teachers consistently noted improvements in student engagement, emotional regulation, cooperation, and trust among their students. These descriptions support the idea that PBIS strategies do more than reduce misbehavior – they help establish a relational classroom climate where students feel safe, seen, and motivated. Although the increase in closeness was statistically more modest, teacher reflections revealed that small relational shifts often carried significant emotional and instructional weight, particularly for students with a history of behavioral difficulties.

Notably, the study found no statistical significant difference in outcomes based on the type of PBIS strategy used, whether it was conversation, praise, or an immediate reward. Similarly, there were no meaningful differences by student grade level or gender. These null results suggest that the relational improvements associated with PBIS were consistent across diverse educational contexts. Rather than depending on a specific method or demographic fit, the success of PBIS appears to stem from its consistent, positive reinforcement of student-teacher interactions, which is an approach with broad applicability in PK-12 classrooms.

While effects appeared consistently across strategies and grade levels, interpretation should account for several limitations. The intervention window was two weeks, an intentional scope to align with novice teacher feasibility; consequently the results should be interpreted in light of this brief implementation period. A second limitation of this study is the small number of participants in some subgroups when disaggregated by both PBIS strategy and grade level. For example, the “immediate reward” condition at the high school level included only five participants. Such low N values reduce statistical power and may mask potential differences that could emerge with larger samples. While the overall results suggest consistency across strategies and grade levels, these subgroup findings should be interpreted with caution. Future research with broader participation would help clarify whether subtle differences exist in the effectiveness of PBIS strategies across developmental stages and classroom contexts. Finally, outcomes were assessed exclusively via teacher self-reports on the STRS, which can introduce single-informant bias. A more balanced approach would incorporate student perspectives on student-teacher relationship quality, classroom observations, and converging behavioral indicators such as on-task rates or office discipline referrals.

Overall, the findings of this study offer important insights for schools, teacher preparation programs, and educational leaders seeking practical ways to support relationship-building in PK-12 classrooms. PBIS, when implemented with relational intent, represents a low-cost, high impact approach that can enhance classroom culture and help teachers, especially those who are new to the profession, to establish a foundation for behavior management and student connection.

Recommendations

Based on the findings, PK-12 school leaders are encouraged to support their teachers in replicating this study as a means of measuring and strengthening teacher-student relationships. The STRS instrument is straightforward to administer, requires no parental consent, and is designed to be unobtrusive; students are unaware of the evaluation process. For both novice and experienced teachers, this reflective practice can offer valuable insights into relational dynamics in the classroom. Repeated administration of the instrument throughout the academic year may also provide useful data to guide instructional and behavioral supports.

Teacher preparation programs should consider integrating these findings into coursework on classroom management and relational pedagogy. Instruction on how to measure teacher-student relationships, combined with training in PBIS strategies, would provide future educators with a practical, evidence-based foundation for addressing classroom behavior while cultivating meaningful student connections. Emphasizing relational tools such as praise, one-to-one interaction, and consistency can help new teachers build the trust and emotional safety that underlie effective classroom instruction.

Conclusion

This study demonstrates that teacher-student relationships can be measured easily and meaningfully using a valid instrument, and that even short-term PBIS interventions can positively influence these relationships. Specifically, the findings support that such interventions can increase perceived closeness and reduce conflict between teachers and students. For early-career educators in particular, relationship-centered behavior strategies offer a manageable and impactful way to create positive classroom environments.

Beyond immediate effects, Tier 1 PBIS practices (e.g., behavior specific praise, brief one-to-one interactions, and simple reinforcement routines) are low-cost, time-efficient, and sustainable because they embed into daily instruction and can be maintained through coaching, self-monitoring, and school-wide teaming. Moreover, these core practices are adaptable across international contexts when culturally attuned. For example, calibrating praise language and frequency to local norms, selecting reinforcers that reflect community values, co-developing expectations with families, and using multilingual visuals to communicate routines. The results contribute to a growing body of literature showing that the interpersonal aspects of teaching, e.g. trust, rapport, and emotional attunement, are not only foundational to effective teaching but can also be

intentionally developed and measured. PBIS, when implemented with a relational focus, provides a scalable method for enhancing student behavior, improving teacher-student relationships, and strengthening teacher confidence.

Recommendations for Future Research

Future studies should explore the effects of additional PBIS strategies, as well as combinations of approaches, to determine their differential impact on closeness and conflict. Expanding the intervention period beyond two weeks may also yield insight into the sustainability and long-term relational benefits of PBIS.

It is recommended that PK-12 classroom teachers replicate all or part of this study to measure the relationship between themselves and some of their students and to determine the effects of a PBIS intervention on that relationship. The measurement can be conducted in any PK-12 classroom to assist with classroom management. It can be conducted in any country - the fundamentals of classroom management are universal, and international replications are encouraged.

Finally, additional qualitative research is warranted to capture teacher narratives and contextual factors that influence how relational changes occur. Such work would build on the present study's findings by identifying not only whether PBIS improves relationships, but how and why it does so in the day-to-day realities of teaching.

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Appendix A. Student-Teacher Relationship Scale (STRS)

Subscale (Conflict or Closeness)	Question
closeness	1. I share an affectionate, warm relationship with this child.
conflict	2. This child and I always seem to be struggling with each other.
closeness	3. If upset, this child will seek comfort from me.
closeness	4. This child is uncomfortable with physical affection or touch from me.
closeness	5. This child values his/her relationship with me.
closeness	6. When I praise this child, he/she beams with pride.
closeness	7. This child spontaneously shares information about himself/herself.
conflict	8. This child easily becomes angry with me.
closeness	9. It is easy to be in tune with what this child is feeling.
conflict	10. This child remains angry or is resistant after being disciplined.
conflict	11. Dealing with this child drains my energy.
conflict	12. When this child is in a bad mood, I know we're in for a long and difficult day.
conflict	13. This child's feelings toward me can be unpredictable or can change suddenly.
conflict	14. This child is sneaky or manipulative with me.
closeness	15. This child openly shares his/her feelings and experiences with me.

Appendix B. Post Intervention Teacher Reflection Questions

	Teacher Reflection Questions
1.	The purpose of this study is to investigate how Positive Behavioral Interventions and Supports (PBIS) might have a positive effect on teacher-student relations and a decrease in discipline referrals. In 3-5 sentences, share whether or not this student's behavior changed as a result of implementing PBIS. If possible, share evidence/examples of this change. If there was no change, share why you think there was no change.
2.	In what ways do you think your gender or teaching grade level influences your relationships with your students?
3.	What outcomes have you noticed in your classroom when positive relationships are present compared to when they are lacking?

Cultivating ISI: Shaping the Future of Idiomatics in Language Education and Research

By John I. Lontas*

This article advances the evolving field of *Idiomatics*, devoted to the rigorous study of idiomatic and figurative language. It is organized into five main sections, framed by a preamble and a prologue that establish the conceptual stage, and concluded by an epilogue and a coda that reflect on the work's implications and future directions. Positioned between inherited nomenclatures and emergent inquiry, the article confronts a labyrinth of competing terms that have long obscured conceptual clarity. Rather than offering a fixed taxonomy, it proposes a living lexicon shaped by the ethical demands of scholarly precision and the generative possibilities of rhetorical craft. Idiomatics is envisioned not as a static discipline, but as a restless, dialogic practice sustained by communal inquiry and a collective vow that no idiom or shimmer of meaning goes unclaimed. The article outlines eight acts of cultivation through which the International Society of Idiomatics (ISI) might grow—not as a monument, but as a living ecology where language, thought, and form perpetually remake one another. It invites readers to serve as active stewards in shaping a discipline whose evolving contours will guide future generations through the intricacies of idiomatic and figurative expression.

Keywords: Idiomatics, idiomaticity, discursive labyrinth, living lexicon, rhetorical craft, communal inquiry, International Society of Idiomatics (ISI)

Preamble

Before the thread is drawn, before the first turn is taken, there is the threshold. A place between knowing and seeking, between old words and those yet to be named. This is where idiomatics stands—at the entrance of a labyrinth not of stone but of language, woven from centuries of thought and voices that refuse to fade. What follows is not a map, but a reckoning. A recognition that the path ahead coils and uncoils—eight turns for every truth uncovered—in ways no chart can contain, and that every step forward demands both memory and audacity. In the hush before the first step, the thread hums, the walls lean in, and language readies itself to speak. This is the breath held and meaning stirred, the pulse before the thread is seized, where every voice that came before leans close to listen. And so we arrive—where old words falter, new ones gather, and the labyrinth waits, restless and alive.

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Prologue—At the Threshold

*Friends, Romans, countrymen, lend me your ears;
I come to bury Caesar; not to praise him.*

Such were the immortal opening lines of one of the most celebrated speeches in English literature, delivered by Mark Antony in William Shakespeare's *Julius Caesar* (Act 3, Scene 2).

Unworthy to so much as hold a candle to Shakespeare, let alone stand upon the same line, I shall not presume to ask for your ears—that would be an audacious ask. Instead, with your gracious indulgence, dear readers, I entreat you only to cast your eye (a discerning one at that) upon my line of argumentation, in what I trust shall prove a rigorous, if not always gentle, presentation of epistemological facts and proposals that have traced their course through the literature of *idiomaticity* for over five score years and counting. I come not to bury your phrasing, but to praise its precision, and to chart a path through a discursive maze whose turns have too long confounded even the most patient of wayfarers.

This, at least, I vow: you shall not be obliged to read between the lines, for I mean to mince neither word nor intention—whether in the propositions I advance or the examples I marshal in service of my *logos* henceforth.

Applying the venerable art of persuasion, as framed by Aristotle's immortal triad of *ethos* (ἦθος), *pathos* (πάθος), and *logos* (λόγος), I shall endeavor to illuminate why the discordant chorus of terms affixed to *idiomatic language*, *figurative language*, *formulaic language*, and *multiword expressions* demands, at long last, the drawing of clear and inviolate lines of demarcation. These lines shall not be drawn capriciously, nor in service of idle taxonomy, but in pursuit of conceptual clarity in the nomenclature of *idiomaticity* and the nascent discipline I have named *Idiomatics*¹. For language, like the mythic labyrinth, is a construct passed from hand to hand—each generation adding passages, raising new walls, and leaving cryptic signs for those who come after. The task before us is to mark these turns with care, lest future wayfarers mistake clever ornament for necessary structure. In this, we join a lineage of lexicon-keepers and meaning-makers, ancient and modern Daedalians whose labor was to give form and passage to what might otherwise remain a tangle of unmarked turns.

In undertaking this task, I shall give voice to both sides of the argument—not as an act of empty concession, but to honor the ethical obligations of the scholar, who must not stifle dissent, even in defense of a dearly held position. To this end, I shall endeavor to temper my own *pathos*, restraining it where it threatens to overrun the cool dominion of *logos*, though no scholar who labors in earnest since the closing years of the last century can wholly disentangle passion from purpose.

My hope endures that this theoretical scaffolding, shaped across several works and still evolving, will serve as fertile ground from which the living idea of ISI—the International Society of Idiomatics—may root itself more deeply and grow. *Cultivating ISI: Shaping the Future of Idiomatics in Language Education and Research* is not a blueprint for static architecture but an effort to cultivate a restless, speaking space where idiomatic inquiry remains unsettled, meaning's pulse moves through every new voice, and the labyrinth of language stays alive. It is an invitation, not a conclusion—a call for

others to step into the labyrinth, leave their mark, and help keep the conversation turning.

And now, dear readers, I extend to you not the role of passive witness but of active architect—to lend your voices, interrogations, doubts, and convictions to a discourse long obfuscated by terminological discord. In so doing, you help shape the living contours of what may, in time, emerge as a coherent and sovereign discipline: *Idiomatics*.

I leave you not with cunning gloss nor words cloaked in ornate deception, but with a plain, enduring truth: in language, as in justice, clarity must outrank cleverness, and the lasting transcend the ornamental. We stand at the entrance to a living labyrinth, its turns inscribed by those before us, its future passages to be cut by those yet to come. The map we draft here must serve not only ourselves but generations of scholars who will inherit and amend these halls. And if, like Daedalus, we find ourselves in a labyrinth of our own making, let it be one whose passages lead not to dead ends but to insight, inheritance, and the enduring pulse of language. Truth, spoken plainly and without artifice, outlives the seductions of embellished rhetoric and the fleeting charm of cunning tongues. By engaging in this discourse, you do more than debate terminology—you shape the lexicon through which future scholars will apprehend, contest, and refine idiomatics.

Let us, then, forswear gloss in favor of plain-spoken rigor, that what we build here may endure not for a season, but for an age. For the truth, once spoken plain, outlives the cunning gloss. And as Cicero himself declared, “*The foundations of justice are that no one shall suffer wrong; then, that the public welfare be the supreme law.*” So let it be with language.

Entering the Labyrinth²—Threads of Meaning, Webs of Names

In the Labyrinth of idiomatic inquiry, meaning is a thread, names a web that both reveals and obscures. For every definition spun, another tangles the path. This section follows the shifting threads and tangled webs that have illuminated and confounded the study of idiomatic language. Since 1997, I have defined *idiomaticity*—also called *idiomatology* or *phraseology*—as the systematic study of idioms and idiomatic expressions (Liontas, 1997a; 1997b; 1997c; 1999; 2001; 2002a; 2002b; 2002c; 2003; 2008; 2013; 2015a; 2015b; 2017a; 2017b 2018a; 2018b; 2018c; 2018d; 2018g). For over a century, this inquiry has wound through a conceptual Labyrinth of definitions, taxonomies, and theories as intricate as Daedalus’ design. At its center stands the Minotaur of meaning—the idiom, a linguistic hybrid defying logic and classification. Born of transgression and necessity, it unsettles every system meant to contain it. Neither fully transparent nor wholly opaque, it straddles boundaries, flouts convention, and demands pursuit. Scholars chase it through shifting theoretical corridors, each framework a thread in the hand of a modern Theseus. Whether the Labyrinth was necessary, or the creature truly monstrous, remains the enduring question of idiomatic inquiry—a question that makes condensing a century of thought a Herculean task. Even a humble writer must approach it with apology, mindful of voices lost to brevity’s cruel limits. Attempting this in eight brief paragraphs invokes the Greek eight: balance, renewal, and passage beyond completion. Each paragraph a step in the labyrinth, a fragile harmony within vast complexity, a measured breath in the pursuit of meaning.

Over the years, linguists, etymologists, lexicologists, idiomatologists, and language researchers have wrestled with the peculiar nature of idiomatic and figurative language. Approaches have ranged from sociocultural (Roberts, 1944) and transformational-generative (Katz & Postal, 1964; Weinreich, 1969) to naturalist (Chafe, 1968), syntactic (Newmeyer, 1972, 1974), semantic (Nunberg, 1978), pragmatic (Strässler, 1982), cognitive (Goldberg, 2006), and computational (Sag et al., 2002). Complementary efforts classified idiomatic expressions by frozenness (Fraser, 1970), semantic decomposability (Nunberg, 1978), purity (Fernando, 1996), compositionality (Cacciari & Glucksberg, 1991), metaphoric transparency (Moon, 1998), form-meaning relationships (Seidl & McMordie, 1988), structural configurations (McCarthy & O'Dell, 2002), and syntax-semantic-function categories (Cowie et al., 1983). Together, these perspectives shaped a multidimensional understanding of idiomaticity. They also contributed to its intricate categorization.

Efforts to isolate the properties that render an expression idiomatic have centered on grammatical irregularity, figurativeness, conventional phrasing, compositeness, and opacity. Bell (1991) and Nunberg et al. (1994) emphasized structural and figurative traits; Fernando (1996) highlighted compositeness and opacity; Barkema (1996) added compositionality and flexibility. Goldberg (2006) examined cognitive storage alongside morphemes and frames, while Sag et al. (2002) noted challenges in computational processing and translation. Together, these scholars advanced a progressively sophisticated profile of idiomatic forms.

Since 1973, these foundations have produced a dozen hypotheses and models addressing the lexical representation, processing, and comprehension of idioms in first (1973–2015) and second language (1997–2015) contexts—eight and four, respectively. From the Idiom List Hypothesis (Bobrow & Bell, 1973) to the Dual Route Model (Van Lancker Sidtis, 2004, 2012; Van Lancker Sidtis et al., 2015), each has sought to clarify the cognitive architecture of idiomatic processing. This intellectual history mirrors broader tensions between formalist, cognitive, and usage-based paradigms. In second language research especially, idiomaticity has posed distinct challenges, prompting models such as the Graded Salience Hypothesis (Giora, 1997), the Idiom Diffusion Model (Liontas, 1999, 2002a, 2015a), the Dual Idiom Representation Model (Abel, 2003), and the Literal Salience Model (Cieślicka, 2006). These theories attempt to explain how literal and figurative meanings are accessed, retrieved, and produced, often with conflicting outcomes.

First Language Hypotheses and Models	
Idiom List (Literal First) Hypothesis	(Bobrow & Bell, 1973)
Lexical Representation (Simultaneous Processing) Hypothesis	(Swinney & Cutler, 1979)
Figurative First Hypothesis (or Direct Access Model) and Holistic Hypothesis	(Jiang & Nekrasova, 2007, Wray, 2002)
Idiom Decomposition Model	(Gibbs, 1980, 1995; Gibbs & Nayak, 1989; Gibbs et al., 1989)
Configuration Model	(Cacciari & Tabossi, 1988)
Hybrid Model	(Caillies & Butcher, 2007; Cutting & Bock, 1997; Sprenger et al., 2006)
Constraint-Based Model	(Libben & Titone, 2008; Titone & Connine, 1999; Titone et al., 2015)
Dual Route Model	(Van Lancker Sidtis, 2004, 2012; Van Lancker Sidtis et al., 2015)
Second Language Hypotheses and Models	
Graded Salience Hypothesis	(Giora, 1997)
Idiom Diffusion Model	(Liontas, 1999, 2002b, 2015a)
Dual Idiom Representation Model	(Abel, 2003)
Literal Salience Model	(Cieřlicka, 2006)

Each framework multiplied classificatory schemes while offering valuable insights. Yet after decades of inquiry, idiomaticity remains conceptually diffuse, its ambiguity deepened by Smith (1925) and Hockett (1958). Their sweeping categories collapsed diverse expressions—proverbs, phrasal verbs, slang, and more—into a catch-all ‘idiom,’ dissolving distinctiveness and inviting circular reasoning that renders any string potentially idiomatic and meaningless.

This theoretical enterprise has spawned a proliferation of terms. Idiomaticity now concerns fixed, multilexemic phrases functioning as single lexemes, whose holistic meanings resist deduction from their parts. The literature variously labels them phrasemes, phraseologisms, idiomatic expressions, lexical bundles, and formulaic language. More recently, scholars have favored the umbrella term *multiword*, covering formulaic sequences, chunks, fixed expressions, multiword lexemes, and multi-morphemic phrases.

Despite varied labels, these expressions share core properties: non-compositional meanings, syntactic-semantic stability, and rhetorical function (Gläser, 1998; Liontas, 2024a; 2024b; 2024c; 2025; Sag et al., 2002). Yet the field remains mired in terminological quagmire—a dilemma flagged by Moon (1998) and Hinkel (2017), and catalogued by Liontas (2019), who identified seventy-three terms. By 2026, Liontas counted over 110, underscoring the field’s deep fragmentation (see Liontas, 2026).

This profusion signals deeper conceptual and practical challenges. The path moves from problem to consequence, response, and resolution: recognizing terminological variety as linguistic complexity, then addressing its classificatory and pedagogical implications. Two responses have emerged—one favoring flexibility, the other systematization—marking successive stages in idiomatics toward clarity.

Tracing the Labyrinth—The Arc of the Idiomatics Argument

Terminological abundance in multiword expression studies reflects linguistic complexity, not scholarly excess. The challenge lies not in variety itself, but in building frameworks that link overlapping categories without collapsing their distinctions. These categories trace threads through the idiomatic Labyrinth. *Idioms* are the hidden chambers—fixed, figurative, and resistant to logic. *Idiomatic expressions* stretch along adjoining passages, blending figuration and convention. *Collocations* mark well-trodden paths where words habitually meet, while *colligations* anchor the structure's grammar-bound walls. Together, they form a shifting maze where meanings elude capture and categories bleed into one another.

Yet this maze is no formless tangle. Its threads, though winding and knotted, weave a larger design—a linguistic tapestry of texture and pattern. Within its fabric, *idioms* become vivid knots—fixed, figurative, and opaque, while *idiomatic expressions* extend the weave to include phrasal verbs and conventional phrases with flashes of figuration. *Collocations* appear as recurring patterns in the fabric, semi-compositional and often literal, and *colligations* stitch grammar into the design, binding words by syntactic rule rather than meaning (Firth, 1957, 1968; Siepmann, 2005). The result is a richly textured continuum where boundaries blur and meanings shift with each interpretive turn (Barfield & Gyllstad, 2009; Peters, 2016).

Context complicates matters further, as a single phrase may serve different functions in different uses (Girard, 2004). Terminological variation across linguistic traditions and reference works exacerbates the difficulty: what one scholar deems an *idiom*, another classifies as an *idiomatic expression* or *collocation*, shaped by differing criteria and priorities (Cowie, 1981). Rapid or automated classification compounds the problem, overlooking subtle semantic and pragmatic shades, and yielding oversimplified, often faulty labels (Bartsch, 2004; Gablasova et al., 2017; Walker, 2011). This tangled web of overlapping terms continues to vex theory and pedagogy alike, leaving scholars and learners adrift in uncertain categories (Grant & Bauer, 2004).

Confronting this complexity requires disentangling the nuances and intersections of these categories. Instead of enforcing rigid boundaries, it is wiser to embrace language's fluidity and design frameworks that honor both difference and overlap. This fosters scholarly precision, pedagogical clarity, and a flexible, informed approach to navigating the intricate terrain of multiword expressions. Alternatively, a call for *authoritative*, *definitive*, and *comprehensive* descriptions and terminology in *idiomatology* offers a pragmatic path. Clear distinctions among free combinations, collocations, and idioms proper—anchored in compositionality, conventionality, and sociopragmatic variation—assert a normative claim about the field's aims.

Together, these positions reveal two interdependent dimensions of scholarly inquiry. The first confronts the absence of a coherent, universal nomenclature, urging rigorous theoretical refinement. The second embraces terminological plurality, proposing provisional frameworks that honor ambiguity while inching toward conceptual clarity. This ongoing discourse reflects both the provisional limits and the aspirational horizon of idiomatics: a discipline still tracing its contours, yet resolute in developing tools for systematic, empirical, and pedagogical progress. These stances do not conflict but rather chart successive movements—diagnosis followed by considered resolution.

In navigating this conceptual labyrinth, rhetorical strategies are indispensable for making complexity intelligible without flattening it. Antithesis, metaphor, and balanced phrasing serve not as ornament, but as instruments for tracing an epistemic landscape where categories bleed and meanings shift. What follows is an effort to chart this unsettled terrain, where promise and paradox entwine.

Navigating the Labyrinth—Between Fertility and Fragmentation

This conceptual labyrinth is inevitable. Decades of interdisciplinary research across applied linguistics, pragmatics, psycholinguistics, corpus studies, and pedagogy have created a dense network of terms. This diversity reflects layered scholarly exploration—a living cartography of linguistic inquiry, continually redrawn by its participants, where categories gain meaning as much from proximity as from internal logic.

This abundance poses a paradox. While multiple terms sustain epistemic fertility—enabling nuanced distinctions, operational clarity, and cross-disciplinary exchange—they also reflect language's inherent slipperiness and context-dependence. Such plurality fuels intellectual vitality, preventing overgeneralization, promoting idea migration across paradigms, and fostering hybrid methodologies that broaden inquiry. Conversely, unchecked proliferation risks conceptual confusion. Overlapping or vague terms obscure rather than clarify, creating redundancy masked as innovation. Without stable, context-sensitive definitions, research fragments, hindering synthesis and theory-building. Increasingly opaque jargon alienates newcomers, erecting barriers to accessibility. When terminology becomes unstable and overly context-dependent, epistemic relativism threatens shared standards and durable meaning.

What emerges is neither chaos nor rigid order but a living labyrinth—dynamic, overlapping, and sometimes conflicting. The challenge lies not in the labyrinth itself but in the absence of a metadisciplinary framework to navigate it. Labyrinths can be traversed with a guiding thread; the true problem arises when no one holds that thread, and taxonomy becomes an end rather than a means. Thus, while this labyrinth reflects the richness and nuance of language studies, it demands navigational tools commensurate with its complexity.

What is needed is not terminological consolidation, but a meta-taxonomy: a cartographic thread to navigate the labyrinth without flattening its contours. No one enters a maze to stay lost; the task is to traverse, interpret, and emerge. And like Theseus of old, the scholar must carry a thread—conceptual clarity spun from theoretical rigor, operational precision, and rhetorical acuity—to chart complexity without severing its intricacies. Threading meaning through multiplicity is the task ahead.

Threading the Labyrinth—A Framework for Idiomatics Analysis

This section advances a defensible, operational framework for analyzing *idiomatics* in English, capable of mapping the intricate contours and recurring paths of this conceptual labyrinth. By clarifying category boundaries and attending to the registers and usage domains in which idiomatic and formulaic constructions circulate, it offers a conceptual thread through apparent disorder, rendering it intelligible for descriptive and applied inquiry. The goal is not to escape the labyrinth, but to make it traversable, interpretable, and ultimately habitable for future scholarship.

What follows is no attempt to flatten complexity into false simplicity, but to furnish a conceptual map—a series of clear signposts for navigating *idiomatics*. This framework distinguishes several interrelated yet analytically discrete categories: *idioms*, *idiomatic expressions*, *multiword expressions*, *collocations*, and *colligations*, while attending to the registers and domains in which they circulate. These categories inevitably intersect with broader *formulaic* and *figurative language*, warranting their inclusion. Each serves as a fixed point along the conceptual thread, ensuring scholars do not lose their way amid shifting figurative expression. To secure conceptual clarity and scholarly defensibility, the classification clarifies what speakers know about idiomatic language and how they enact it in discourse. We begin, fittingly, with idioms.

Idioms are fixed, conventionalized multiword expressions whose meanings cannot be inferred from their parts (Bortfeld, 2003; Cacciari & Tabossi, 1988; Cutler, 1982; Fernando, 1996; Gibbs, 1980, 1995; Gibbs & Nayak, 1989; Gibbs et al., 1989). They convey culturally embedded figurative meanings that render literal interpretation implausible. Marked by semantic opacity, figurative intent, and structural fixity, idioms resist syntactic and lexical variation without losing integrity (e.g., *break the ice*, *cost an arm and a leg*, *know the ropes*, *under the weather*). Table 1 lists 10 idioms that are fully figurative, opaque, and fixed, permitting limited interpretive flexibility.

Table 1. Idioms

Idiom	Meaning
<i>Barking up the wrong tree</i>	Making a wrong assumption.
<i>Bite the bullet</i>	Endure something unpleasant bravely.
<i>Burn the midnight oil</i>	Work late into the night.
<i>Cry over spilt milk</i>	Waste time worrying about irretrievable mistakes.
<i>Hit the books</i>	Study hard.
<i>Hit the sack</i>	Go to bed.
<i>Kick the bucket</i>	Die.
<i>Let the cat out of the bag</i>	Disclose a secret.
<i>Pull someone's leg</i>	Tease or joke with someone.
<i>Spill the beans</i>	Reveal a secret.

Idiomatic Expressions form a broad, flexible category encompassing idioms and other conventional, fixed phrases with clear or partially figurative meanings, facilitating fluent, context-sensitive interaction across social and pragmatic domains (Bobrow & Bell, 1973; Cacciari & Glucksberg, 1991; Caillies & Butcher, 2007; Cieřlicka, 2006; Hinkel, 2017; Lontas, 2019; Titone & Connine, 1999). Unlike idioms, whose metaphorical meanings are opaque and irreducible, idiomatic expressions are often transparent or contextually inferable, serving polite, social, or pragmatic functions and allowing greater syntactic and lexical flexibility (e.g., *come up with an idea*, *go broke*). A persistent confusion involves *categorical slippage*—the assumption that all idiomatic expressions are idioms. This blurring obscures a crucial theoretical and pedagogical distinction. Idioms function as figurative puzzles, demanding distinct learning strategies and interpretive skills because they resist literal decoding and embed culturally specific meanings (e.g., *Burn the midnight oil*, *spill the beans*). In contrast, expressions such as *How's it going?* or *Nice to meet you* perform social functions without semantic shift. In short, *idiomatic expressions* are routine, formulaic phrases vital for natural, context-sensitive interaction. Table 2 outlines their defining features; Table 3 illustrates 24 classic examples distinct from idioms.

Table 2. Idioms and Idiomatic Expressions Summary

Aspect	Idioms	Idiomatic Expressions
Meaning	Figurative, non-literal	Literal or contextually clear
Function	Express figurative meaning	Social/pragmatic (greetings, offers, etc.)
Transparency	Opaque, non-compositional	Transparent or near-transparent
Usage frequency	Routine, sometimes colorful or vivid	Frequent in everyday conversation
Example	"Hit the books" / "Kick the bucket"	"How are you?" / "Please, come in."

Table 3. Idiomatic Expressions

Idiomatic Expressions with Explanations	
By the way. — phrase to introduce additional information. Can I help you? — offer of assistance. Can't complain. — informal, routine “fine” reply. Help yourself. — invitation to take or serve oneself. Hold on a second. — request to wait briefly. How are you? — routine greeting. How's it going? — informal greeting asking how someone is. I beg your pardon. — polite request to repeat or apologize. I'm afraid not. — polite way to refuse or deny something. I'm just kidding. — phrase signals a comment was made in jest. It's up to you. — expression leaving a decision to the listener. Keep in touch. — request to maintain contact.	Keep me posted. — request for regular updates. Long time no see. — informal greeting after a long absence. Make yourself at home. — invitation to be comfortable. Nice to meet you. — polite phrase upon introduction. No worries. — reassurance meaning “It's not a problem.” Please, come in! — invitation to enter. See you later. — common farewell. Sorry to keep you waiting. — polite apology for a delay. Take it easy. — casual sign-off or relax suggestion. That sounds good. — expression of agreement or approval. What's going on? — casual check-in on someone or events. What's the matter? — inquiry about a problem or concern.

Multiword Expressions (MWEs) form a large subset of formulaic language, encompassing any combination of two or more words functioning as a single unit in communication. This broad category includes *idioms* (e.g., *throw in the towel*), *collocations* (e.g., *strong tea*), *phrasal verbs* (e.g., *give up*), *compound nouns* (e.g., *traffic jam*), *fixed expressions* (e.g., *by and large*), and conventional *idiomatic expressions* (e.g., *What's up?*). What unites them is prefabricated, conventionalized use, though they vary in fixity and in the transparency or opacity of their meanings (Aron & Christiansen, 2017; Hinkel, 2017; Sag et al., 2002). Importantly, not all MWEs are idiomatic. While idiomatic expressions form a prominent subset, marked by figurative or socially conventional meanings and relatively fixed phrasing, many other MWEs—such as collocations or phrasal verbs—remain semantically transparent or grammatically flexible while still functioning as formulaic units in discourse.

Alongside the three primary classifications of idioms, idiomatic expressions, and multiword expressions, *figurative language* and *formulaic language* occupy distinct, though occasionally overlapping, domains within the broader landscape of linguistic expression.

Figurative Language engages meaning and imagery, drawing on figures of speech such as *metaphor*, *simile*, *personification*, and *hyperbole* to evoke symbolic, affective, and imaginative meanings beyond the literal. It includes both conventional idioms and novel constructions that animate discourse. Phrases like “time is a thief” or

“she runs like the wind” exemplify this creative use of language to stir emotion and conjure vivid mental images (Ibáñez et al., 2010; Liontas, 2018c).

Formulaic Language, by contrast, comprises fixed or semi-fixed sequences routinely stored and retrieved as ‘prefabricated units.’ These include *idiomatic expressions*, *multiword expressions*, *collocations*, *phrasal verbs*, *sentence frames*, *speech formulas*, *clichés*, and *routine social exchanges*. Some, like *idioms*, are figurative, though many are not. What unites them is neither grammar nor etymology but the fact that they are learned, internalized, and used as wholes rather than assembled word by word in real time (Van Lancker Sidtis, 2012; Van Lancker Sidtis et al., 2015; Wray, 2002, 2013, 2017). This foundation supports fluent, culturally attuned expression by providing habitual patterns and sociolinguistic polish beyond isolated vocabulary or grammar. In essence, *figurative language privileges creativity and imagery; formulaic language prioritizes prefabricated fluency and social conventionality*. Their paths intersect—many idioms are figurative—but they serve distinct communicative purposes. Their overlaps are meaningful, yet their boundaries remain conceptually vital. It is within these parameters that *collocations* and *colligations* emerge: the subtle, often invisible ligatures binding words by habit and grammatical necessity, shaping both the sound and the sense of natural language. Here, the architecture of patterned expression comes sharply into focus—crystal clear, some might argue.

Collocations are habitual pairings of words that co-occur with statistically significant frequency—more often than chance would predict. These may be *lexical* (e.g., *catch a cold*, *make a deal*, *strong coffee*) or *grammatical* (e.g., *come to an agreement*). Unlike idioms, their meanings are typically transparent or conventional rather than figurative. Defined by their predictability in natural usage and semantic compositionality, *collocations* permit limited variation without altering core meaning (Granger, 1998; Laufer, 2010; Lewis, 2000; Nesselhauf, 2003). They range from fully to semi-compositional and are classified by lexical or grammatical type and degree of fixity. At their core, *collocations* reflect the patterned preferences of a language: the *word + word* tendencies that shape fluent, *idiomatic expression*.

Colligations are habitual *grammatical* environments associated with a word or phrase—not about which specific lexical items co-occur, but how a word tends to behave grammatically: what parts of speech it aligns with or which grammatical structures it typically selects or triggers (e.g., *verb + preposition + noun/gerund*). The term retains theoretical relevance within *idiomatics*, involving the preferential pairing of a word with particular grammatical structures or function words (Firth, 1957, 1968; Siepmann, 2005). For example, *depend* colligates with *on*, typically followed by a noun phrase or gerund clause (e.g., *depend on someone*, *depend on doing something*). Conceptually, *colligations* chart *word + grammar* preferences within the patterned architecture of natural language.

Summarized succinctly: *idiomatic language* consists of fixed, conventional expressions with non-literal meanings (Liontas, 2018c); *figurative language* comprises creative, imaginative constructions (Liontas, 2018c); and *formulaic language* encompasses prefabricated, routinized sequences, some figurative, many not (Van Lancker Sidtis, 2012; Van Lancker Sidtis et al., 2015; Wray, 2002, 2013, 2017).

In language teaching, drawing clear lines between idioms, idiomatic expressions, and MWEs reveals whether the focus lies on figurative treasures or the broader,

prefabricated rhythms of speech—each a vital thread in the rich tapestry of *idiomatics* where true fluency takes shape. Yet to cultivate genuine idiomatic competence and performance across the second language curriculum, the intricate architectures of *formulaic sequences*, *collocations*, *colligations*, and *figurative turns* must be grounded in a coherent framework of *structure*, *meaning*, *function*, *register*, and *usage*. These domains are constitutive—forming the scaffolding for fluent, naturalistic, context-appropriate language. Neglecting them leaves learners adrift in a sea of isolated phrases, untethered from the currents of real discourse. Thus, patterned language instruction must begin systematically from Day One, threading *idiomatic competence* as an integral, performative asset—not mere ornament—in learners’ repertoires. We begin with *structure*.

Structure denotes the syntactic pattern underlying a multiword expression, specifying the grammatical arrangement of its elements (e.g., verb + noun phrase, adjective + preposition + noun). It reveals the preferred configurations idioms, idiomatic expressions, collocations, and colligations adopt, exposing structural regularities within language. In *idiomatics*, structure complements meaning and compositionality by mapping grammatical frameworks that sustain and conventionalize patterned expressions.

Meaning designates the semantic content an expression conveys—literal, figurative, or idiomatic. It captures the sense derived from the phrase as a whole, independent of its parts, distinguishing transparent, partially inferable, and opaque interpretations within communicative contexts. This dimension anchors the phrase’s interpretive value to its discourse situation.

Function denotes the pragmatic role an expression performs in discourse, shaping speaker intent, listener reception, and social interaction. In *idiomatics*, idioms serve multiple functions: expressing attitudes, emotions, and evaluations; modulating statements; adding rhetorical vividness; fostering solidarity; and enabling indirectness, humor, euphemism, and conversational flow. They operate as versatile discourse devices encoding both meaning and social function within conventionalized language.

Register and Usage Domains classify expressions by the communicative settings in which they typically occur—formal, informal, business, legal, social, or general—reflecting pragmatic appropriateness relative to audience, context, and purpose. This domain encompasses regionalisms (e.g., “*He’s fixing to leave*” in Southern U.S. English, meaning “*about to leave*”), occupational jargon (e.g., “*Close the books*” in accounting, meaning “*finalize financial records*”), conversational tone (e.g., “*With all due respect...*” as a formal, face-saving preface to disagreement), medium sensitivity (e.g., “*spill the tea*” in digital discourse, rare in formal writing), and sociolinguistic marking (e.g., “*Bob’s your uncle*” in British English, “*throw shade*” in colloquial slang).

Structure, meaning, function, register, and usage form the foundation for *idiomatic competence* and *performance*. Both are essential for authentic, nuanced, and socially attuned discourse. Competence is internalized idiomatic-figurative knowledge of meanings, contexts, functions, and connotations—knowing what expressions mean, when, where, and how to use them. Performance is their fluent, timely, and culturally tuned delivery in real-world interaction. One governs, the other enacts. Instruction must cultivate both.

True mastery in *Idiomatics* is not a matter of possession, but of presence—the grace to move through language’s unpredictable currents, to speak with precision, and to choose the phrase that carries its weight in memory, culture, and time (Liontas, 2018f). It is spoken not from the tongue alone, but from the marrow.

In this light, the Labyrinth is no mere puzzle of stone and shadow. It is the tangled inheritance of idiomatic expressions, the winding corridors of ancestral stories and ritual turns of phrase. Memory moves as both guide and riddle, offering glimpses but no certainties. Yet wisdom is not won by wandering alone. The Labyrinth demands an exit.

It is not enough to know the paths, to hoard scripts, to chart every turn. One must step into the daylight, voice steady, words sharpened, and tell the tale. A story long trapped in the maze is a story half-lived, its truths dimmed, its lessons unsung. In the end, it is not the map we clutch, but the line we deliver when the curtain lifts and the world leans forward. The Labyrinth yields only to those bold enough to walk, speak, perform—not merely to know the way, but to leave footprints where the map once was.

And so, dear readers, we arrive at the threshold. Beneath its vaulted corridors echo the idioms of centuries—whispered in agorae, sung in taverns, woven into sermons, cast like runes upon parchment and screen. The maze was never meant to be a home but a crucible. Competence dwells within its walls; performance waits beyond them. The thread we carry is not mere tradition but a lifeline spun from wisdom, precision, and the will to cross from knowing to becoming. For this is the true labor of *Idiomatics*: to step forth from inherited scripts into the uncharted daylight of living speech, where language breathes, pulses, and acts. Not to name the walls, but to scale them. Not to memorize the steps, but to compose new ones. The scholar’s charge is to perform the tale: to speak it clean, to speak it true, and thereby ensure that no story, no idiom, no living utterance perishes for lack of a teller.

Let us then, as Cicero counseled in *De Oratore* and as clarity demands, forswear cunning gloss in favor of enduring truth. The lines we draw today, the discipline we name, and the performances we summon shall outlast ornament, outlive the maze, and echo long after theory’s passage fades.

For the truth, once spoken plain, outlives all gloss.

What, then, I humbly ask, shall we make of this charge? Who among us will raise the standard for *Idiomatics*, not as a scattered curiosity, but as a discipline forged in rigor, performance, and truth? Shall we leave the living idiom to languish beneath the weight of borrowed categories and dusty glossaries? Or shall we together build the house it deserves, a house with many rooms for every voice, every utterance, every flicker of the human pulse made word?

This is the labor before us. This is the promise of ISI: to cultivate a field where no idiom need apologize for its strangeness, where no turn of phrase dies unnamed, and where the future of language education and research is shaped not by convenience but by courage. Will we take up this work? Will we answer the call? Will we blaze paths for others to follow?

A path is born in the walking—etched by the press of footsteps, shaped by choices cast upon uncertain ground. No path exists until a soul moves through the wild, marking the way by the sheer fact of going. Wisdom is no paved road but a shimmering trace, a line of echoes left by those bold enough to tread where none have dared, leaving in their wake a path for others to follow, to forge their own turns, to walk with purpose, to widen

the way, and, yes, to press beyond. The paths we mark at this hour will bear the weight of those yet to come. Let them be worthy. Let them lead beyond the maze.

But what shape shall these lines take? Who will name the contours of this emerging discipline? What principles shall we honor, what traditions must we break, and what new lexicons will we dare compose? Shall we cling to borrowed maps, or chart the terrain of Idiomatics by the shifting constellations of living speech?

The answers to these questions must not descend as edicts from elsewhere. They must rise in the power of our own scholarly voices. We—the researchers, the teachers, the tellers of tales worth telling—are the ones called to claim this ground, to stake its borders not in stone but in fierce dialogue, unflinching inquiry, and the vow that no idiom, no figure, no shimmer of language will be left unseen, unspoken, or unclaimed.

This is our charge. And it begins now.

Charting New Lines—The Promise of ISI

The reader encountering the title of this article, *Cultivating ISI: Shaping the Future of Idiomatics in Language Education and Research*, could be forgiven for anticipating certain scholarly rituals: a manifesto, a taxonomy, a crisp delineation of aims, or a history of idiom studies rendered in tidy chronologies and authoritative claims. One might reasonably expect a programmatic scaffold: mission statements, methodological proposals, and an inventory of the terminological fissures and conceptual disputes long dividing the field. Such expectations are neither naïve nor misplaced, for they rise from a discipline eager for coherence. I have elsewhere laid those stones in their proper order (Liontas, 2021, 2024a, 2024b, 2024c, 2025).

And yet, as I cautioned at this article's opening, I come not to bury your phrasing, nor merely to praise the precision of prior taxonomies, but to pursue what lies beyond them. I asked not for your ears then, nor shall I presume to command them now; I seek only your discerning eye and your honest reckoning with the lines we might yet draw together. *Charting New Lines—The Promise of ISI* stands not in opposition to our title's charge, but as its first, essential act: the initial, tender mapping from which all further cultivation must humbly proceed.

It is precisely because those taxonomies, mappings, and terminological architectures have been surveyed, mapped, and named that this piece now turns—not in dismissal of those efforts, but in quiet acknowledgment of the labor that still waits in their wake. This marks not a departure from our guiding metaphor, but a reflective turn within it. Let us then return not to the graveyard of old taxonomies, but to the living soil of possibility. The task is not to read between inherited lines, but to inscribe new ones—and to ask, as Cicero once did, what truths they shall outlast.

To inscribe new lines that endure beyond the present, we must continue to cultivate Idiomatics by clarifying its disciplinary boundaries, conceptual language, and intellectual aims, while concomitantly cultivating ISI as the living framework through which the field will take root, flourish, and endure. The discipline's vitality rests upon this twin, interdependent labor: the simultaneous cultivation of Idiomatics and ISI. We begin with the former.

Cultivating Idiomatics

Cultivating Idiomatics—the art and science of idiomatic and figurative language—begins with this seminal truth: claiming responsibility for its future requires charting its lines, tracing its boundaries, and declaring the principles by which it shall flourish. This is more than bestowing a matching name upon a society; it is about building a field, fostering growth, and making space to thrive. Cultivation founds traditions, builds communities, mentors stewards, and sharpens tools for future harvests. It tends an intellectual inheritance with care and foresight. The word itself suits idioms—organic, rooted, and evolving. Born in the mouths of people, idioms are shaped by fears, loves, jokes, superstitions, rebellions, and longings. Each generation inherits this treasury not as fixed code, but as a living current—a pulse that beats in time with history and leaves its mark upon the age.

Like language itself, Idiomatics lives with us, alive and speaking here and now. At its heart, idiomatics is the study of how meaning survives by changing. How phrases fossilize, then crack, then flower again in new soil. How language resists ossification by endlessly renewing itself in the mouths of the many. It is a living labyrinth because every passage was once walked by another, though none walks it the same way twice. Every turn of phrase bears the fingerprints of those who spoke it, bent it, and passed it on. These idioms are the living veins of language's long memory. Idiomatics, then, is not the cataloging of dead things, but the study of how language breathes, adapts, and remembers—time's own handprint upon the tongue.

To cultivate the field of idiomatics is to tend not only its practitioners and ideas but also the language by which it names, explains, and interrogates its subject. Without precise, coherent terms, no inquiry finds its voice, no soil nourishes what seeks to grow, and no tradition takes root. Idiomatics—a discipline born of metaphor and bound to the ineffable—has long wandered in a Babel of competing names, tangled in a labyrinth without a center. Put differently, before shaping its future, we must reckon with the nomenclature we inherit: clear the stones, chart the lexicon, and untangle meaning's thickets. And just as the Eleusinian rites once sanctified the ancient mysteries veiled from ordinary sight, so must we consecrate the names that bestow coherence upon the world, carrying them beyond mere survival toward *sophrosyne* (σωφροσύνη)—the flourishing born of wisdom and balance—ever mindful of the venerable Hellenic maxim *meden agan* (μηδὲν ἄγαν), 'nothing in excess,' which tempered Greek thought and civic virtue alike.

Before tilling the field, we must first chart its lines, discern the promise the soil holds, imagine what might one day flourish there, and reckon with the labor those harvests will demand. For you reap what you sow; a harvest without intention yields only what chance permits. This is not evasion but necessity. What lies before us is not an institution awaiting founders, but an intellectual inheritance awaiting its rightful claimants—a field whose yield will depend on the wisdom of the hands that turn its soil.

I claim no green thumb, but this I know: to cultivate is not mere growth or development. It is careful, deliberate nurturing, tending an idea, a practice, or a community with sustained effort and vision. The word calls to mind more than growth; it summons the patient preparation of soil, seed planting, vigilant sheltering of fragile

shoots, and steady guidance toward fruition. It speaks of intentionality, artistry, foresight, and the reckoning every harvest exacts.

This article began where lasting cultivation must: with language itself—mapping the terminological labyrinth, planting order in the soil of inquiry, and gathering scattered voices into a concerted chorus. Only then can the discipline rise—not as a cacophony of tongues, but as an enduring edifice, bearing the weight of harvests to come. No edifice endures where words are brittle, where language fractures, and where creative thought lingers unfinished in dark labyrinthine corners—lest the Minotaur of confusion lurks to devour the field entire. This, at least, I have sought to accomplish.

And fittingly, this reckoning unfolded in eight deliberate turns—echoing the ancient Greek symbol of balance, renewal, and the eternal passage beyond completion. Eight turns, eight reckonings, eight threads unwound in a living maze not of stone, but of meaning. To chart them is to trace the enduring ambition to master what resists mastery. A task Daedalian in its intricacy; yet to forsake it is to abandon the very art of language itself.

The work of clearing the stones and preparing the ground became a metaphor for reckoning with the tangled thickets of meaning we have inherited. It was necessary to tame the Babel of competing terms and voices, to restore coherence where too long there had been only cacophony. This required an urgent act of naming, a painstaking untangling of terminological threads wound tightly in a labyrinth with no discernible center.

The vision, always, was of a discipline rising as a unified, harmonious edifice—its language tempered, its metaphors coherent, its voice one in concert. And so I close this labor, modestly, acknowledging what remains unfinished. Each step a beat in this ancient cycle, each word a stone in the path toward a language worthy of the field it seeks to hold, each act a turn within the labyrinth of tomorrow. Whether this passage leads to clarity or to yet another chamber of mirrors remains to be seen. But as Daedalus once shaped his maze with craft and foresight, so too must we shape our language.

We approached language as *logos*: the ordering principle, the kosmos (κόσμος) of thought, where names are not mere labels but acts of consecration. Yet if I have leaned upon *logos* (λόγος) in this reckoning, it is because the labyrinth demands clear threads. No argument, however, lives by reason alone. *Ethos* (ἦθος) breathes through the devotion to inquiry itself—the quiet fidelity to those who came before and those yet to come. *Pathos* (πάθος) moves in the unspoken urgency to preserve, reshape, and pass meaning forward, lest the living pulse of language fall still. In their weave lies the true art of speech—not merely to persuade, but to endure. (For a more detailed discussion of the art of persuasion, see Liontas, 2025.)

For the very stem of idiomatics proclaims it so, from the heart of its own etymology. Along the old paths of memory, it becomes clear that this reckoning with language's order is no modern conceit, but an ancient summons, etched in the marrow of the word itself. To name a field *Idiomatics* is to confess that meaning is no drifting vapor, but particular, situated, bound to tongue, time, and place—that without clarity, we consign ourselves to wander endlessly through a maze of our own devising. The question is no longer whether this reckoning must come, but whether we shall rise to meet it. Shall we forever pace these labyrinthine corridors, deaf to the ancestral

summons that calls us by name—or shall we, at long last, name the center, claim the mantle, and in that naming, find our way home?

I aim to ignite the spark that lights idiomatics' future, orchestrating its growth as a harmonious, multifaceted movement, and weaving its threads into a rich fabric interlacing heritage, innovation, and lasting connection within language education and research. In quiet devotion, I nurture what breathes and stirs, guiding its slow unfolding with patient hands, like a gardener watching tender shoots, mindful of the promise the harvest still holds. It is toward this cultivated future, and the gathering of hands to tend it, that we now turn.

Cultivating ISI

To chart a future for ISI is to sow a new field—not to fence in, but to cultivate; not to impose, but to nourish. This future will not rise as a carved monument, fixed and unyielding, but as a living ecology of breath, thought, and enduring spirit. It summons not guardians of a brittle order, but stewards of a restless, fertile idea—a seed entrusted to capable hands and generous, forgiving soil. Like any enduring garden, its flourishing will depend upon deliberate, faithful tending. Eight distinct acts of cultivation shall ready this ground and coax forth its promise, each one an essential labor in the forging of a common harvest, where at last the heart of idiomatics may take root, stretch toward the light, and thrive:

- **First**, we loosen the earth, fingers deep in old soil, clearing the tangled undergrowth of misnomers, misconceptions, and worn-out frames, making space for what waits to be born.
- **Second**, into this hollowed earth, we plant a single, shimmering seed no storm will uproot: the knowing that idiomatics, radiant and unruly, has always sought its own wild grove.
- **Third**, we feed it with memory, the stories of those whose words once fell like rain upon this very ground.
- **Fourth**, we claim common ground, a meeting-place of voices where difference does not divide, but multiplies the strength of soil and root.
- **Fifth**, we kneel to witness the first green signs—the fragile, reckless shoots of thought breaking through—granting them light, time, and space to take their shape, carrying the pulse of something unnamed.
- **Sixth**, we cut with wisdom, trimming not to control but to reveal, so what grows may rise unbroken, true to its nature, fierce in its becoming.
- **Seventh**, we raise a canopy, a shelter woven not from rules but of openness, a lattice against the blight of narrowness, where every new branch tilts toward light, toward the infinite possible.
- **And eighth**, we leave the gate unbarred, the paths unmarked, so those yet unborn of this vision might enter, might plant, might shape this restless, living grove.

And so, ISI begins to take its shape—not as a monument, but as a living design in the spirit of Daedalus: a structure not built to entrap, but to transform. In this labyrinth, each turn leads not to a dead end, but to another clearing, another question, another invitation to begin again.

To cultivate ISI is to plant a seed deep in the soil of a thousand whispered traditions, nurturing a fellowship of kindred minds who honor the past, read the pulse of the present, and dream futures yet unfolding. Cultivation is no mere preservation—it is the restless, tender art of shaping a sacred space where ideas dance, collide, and bloom anew. ISI stands not as a vault of silent knowledge, but as an open, shifting terrain of inquiry—a living labyrinth, forever unfurling its winding paths. It cradles the living pulse of this endeavor, preserving without freezing, honoring without binding, and leaving its doors wide as the dawn for those yet to come—to explore, reshape, and carry the wild, unruly flame of this living art onward: sowing, tending, and harvesting futures no map can chart.

To build a society devoted to this work is not merely to catalogue or classify, but to tend the soil from which meaning endlessly grows. The work of idiomatics belongs not to the past alone, but to the restless, ever-becoming present. Each generation inherits this living labyrinth, its passages reshaped with every speaker's breath, altered by every voice bold enough to enter. Like Daedalus' fabled creation, this labyrinth is neither fixed nor linear. It shifts with each mind that walks its winding corridors, where every turn marks a moment of reckoning, discovery, or revision. Its walls are not barriers but thresholds—places where inherited wisdom meets untamed insight, where idiomatic inquiry refuses the final answer. To travel this space is to accept that meaning, like language itself, evades capture—and that it is the restless pursuit, not the conclusion, that keeps the labyrinth of idiomatics alive, its passages reshaped with each seeking voice.

ISI's cultivation is the tending of a restless, living terrain—a structure forever open, its corridors shifting with thought, its pulse quickened by every new voice. To trace its contours is to follow unwritten paths, thresholds opening endlessly toward what language might yet become. It is the careful stewardship of a living ecology, where ideas bloom and decay, where language remakes itself, and where meaning drifts like pollen from one mind to the next. The work of ISI is to keep this field breathing—to tend its passages, leave its doors unlatched, and let meaning chase itself through restless, luminous turns. Its worth lies in its movement, in its capacity to remain ancient and new, familiar and strange (see Liontas, 2024c, 2025).

And so it is that the *International Society of Idiomatics* must rise not as a monument, but as a garden: a breathing, speaking, restless space where meaning's pulse thrums in every turn of phrase, every wayward idiom, every cultural echo folded into the words we trade. In that spirit, we do not seek to escape the labyrinth, but to keep it alive—to wander its mutable paths, name its thresholds, rekindle forgotten chambers, and leave new trails for those who follow. For keeping it alive is not the terminus of our labor, but the soil from which movement stirs, invention kindles, and inheritance passes, breath to breath, from elder tongues to young ears. It is ground where new trails thread their way into the yet-to-be, where old idioms bloom in unexpected mouths, where meaning,

reckless and radiant, endlessly remakes itself—a living terrain where each turn holds memory and the shimmer of futures unclaimed.

Shaping the future of idiomatics in language education and research rests upon this shared commitment: We do not abandon the labyrinth, nor flatten it into a map. We keep it breathing—restless, speaking, unfinished. Its breath is not a destination but a beginning. Life here is the start of purpose. Tending this living terrain is no final act, but the pulse of a field forever in motion. Ever forward. Ever open. Doors unlatched, corridors unmarked—purposefully so, that those yet unborn might enter, wander, reshape the restless, luminous turns of meaning, and name the world anew.

Epilogue—A Living Labyrinth

If it has been my fortune to guide you, dear readers, through the intricate passages of idiomaticity's conceptual labyrinth, then let this closing reflection serve not as a terminus but as a recognition that the labyrinth was never meant to be escaped.

Having traced these winding turns of nomenclature and epistemological reckoning, we arrive at a clearing—though not an ending. For language—idiomatic language most of all—is no fixed monument but a living labyrinth: its walls ever shifting, its passages shaped by those who dare to map and remap its course. We are, each of us, Daedalians, architects of meaning and keepers of inherited turns, fashioning paths where others saw only tangle.

If, in myth, Daedalus crafted a maze to confound, let ours be a labyrinth of passage, inheritance, and return—a space where each generation leaves its cipher upon the walls, not to trap meaning but to set it loose upon the air. Here, in this fellowship of idiomatics, the pulse of past speech quickens in the present tongue, and the future waits to be named.

Let this be not a closing but a reckoning with lineage; a nod to those lexicon-keepers before us, and an invitation to those who will follow. The living lexicon is ours to tend. If clarity must outrank cleverness, it falls to us to chart passages wide enough for truth, narrow enough for rigor, and enduring enough to house the inheritance of words yet to be spoken.

Like Daedalus' masterwork, the labyrinth was fashioned not merely to confound but to give form to what defies easy containment: a living system of meaning, mutable and ever-shifting, marked by the footsteps of those who traverse its corridors.

So too is the field of idiomatics. It is no static relic, no fixed architecture of definitions admired behind glass. It is a living inheritance, passed from one generation of scholars to the next, each leaving their mark upon its walls, each rethreading Ariadne's line, and each reinterpreting the maze's shape according to the pulse of their age. Both idiomatic and figurative expressions live because we use them, challenge them, distort them, and pass them on. The discipline born of their study must do no less.

To cultivate ISI is to tend this living labyrinth—to recognize that our task is not to erect final walls but to shape passages wide enough for future thought and to leave threads for those yet to come. It is to honor inherited foundations while daring to redraw the map. Eight turns we have taken together, not as a march toward resolution but as an embrace of the recursive, the unfinished, and the necessary work of meaning-making in motion.

In Daedalus' time, the labyrinth imprisoned the Minotaur—a creature half bull, half human. In ours, it carries the echo of our own inquiries and the promise that idiomatics will remain not a discipline of static definition but of living conversation: a place where each generation might enter, read the marks upon the wall, and leave their own.

And so, I invite you now not to seek an exit from this labyrinth, but to dwell within it—to continue its making, its questioning, and its living renewal. For in this enduring maze, it is not escape that defines us, but cultivation; not closure, but the patient tending of meaning through time and space.

So let it be said one final time: the future of idiomatics in language education and research belongs not to those who decorate meaning, but to those who dare to name it. Beyond these labyrinthine walls, let our words be spoken plainly, spoken naturally, spoken unapologetically—for it is not ornament that endures, but the pulse of words well told, and the truths they dare to bear.

Are your ears ringing yet?

They should. Listen closer. Listen deeply. Listen fully. The maze is never silent.

The architecture is built... now walk the halls with me one last time.

Coda to the Labyrinth³

The labyrinth was never meant to be escaped, neither Daedalus' nor ours. It was fashioned to be entered, inhabited, and kept alive by those who refuse easy exits.

Here's to the ones who stay.

The Labyrinthians. The Idiomatists. The Meaning-Seekers.

The ones who wander the labyrinth, not to escape it, but to keep it breathing.

*The ones who know that language winds through time like a restless vine,
threading meaning from tongue to tongue, hand to hand, breath to breath.*

The ones who pulse with the hours and shift with the seasons of memory.

*They are the ones who see the writing is always on the wall—
half-faded, half-unwritten, awaiting the next hand.*

And they believe idioms are not relics, but inheritances.

They do not mistake silence for absence, nor tradition for conclusion.

*For they know this was never a citadel of fixed stone, but a living terrain—
a restless, speaking ground, meant to be walked, spoken into, and unsettled.*

They know not to flatten the map, not to seal the doors, not to remain silent.

They are the ones who rise to reach further, question deeper, and imagine bolder.

*When the past leans in and the future answers,
they steady the thread, even when others let it fall.*

*In the moment of becoming, they lift their voices higher; leave new marks in the air;
and shape new turns for those yet to come.*

*And so the thread passes. Its pulse endures. Forever unfinished. Forever theirs.
Because the ones brave enough to believe they can reshape meaning are the ones
who do.*

To the ones who stay, we extend not a hand for handshake, but an open page. Those who would help inscribe the future of idiomatics will find the margins waiting, the ink wet still. Correspondence and expressions of intent may be directed to John I. Liontas, University of South Florida, via liontas@usf.edu.

Endnotes

¹ The term *idiomatics* stems from the Greek *ἰδιόμα* (*idiōma*), meaning “peculiarity” or “distinctive feature,” itself from *ἴδιος* (*idios*), “one’s own.” At its core, *idiomatics* concerns particular, situated expressions whose meaning transcends the literal. Its etymology demands specificity and precision, for idioms mark the cultural and linguistic distinctiveness of a community. To name this field is to undertake the labor of charting particularities and forging a lexicon equal to the forms it seeks to hold. Thus, the very stem of *idiomatics* “shouts it so,” urging its stewards to dispel Babel’s din and honor the distinctive life of language.

² The metaphor of the labyrinth first whispered to me in 2019, when I gave a passing name to the maze of idiomaticity (Liontas, 2019). For six years it lingered, restless and half-formed, weaving through the corridors of my thought. Only now does it find its full shape—no longer a fleeting image, but a living architecture threading this work from foundation to spire.

³ We must tend the names by which we know the world, for without them, coherence falters. We must tend the idioms that bind meaning to life, lest particularity dissolve into *Babel’s din*. And we must speak wisely, guided by *sophrosyne* (σωφροσύνη) and *meden agan* (μηδὲν ἄγαν) that language may flourish in balance, neither in excess nor in silence.

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Using AI in Book Writing with Human Supervision: A Case Study in Astronomy for Kids

*By Elizabeth D. Diaz**

In recent years, the intersection of artificial intelligence (AI) and creative writing has opened new possibilities in producing educational content. This paper explores the process of co-authoring a children's book on astronomy using AI as a writing assistant, under the supervision of a subject matter expert. While AI has advanced significantly in generating coherent, relevant text, human guidance is crucial to ensure scientific accuracy, pedagogical appropriateness, and an engaging narrative tailored to young readers. In this case study, I, the principal author and co-creator, utilized AI writing tools to draft a book aimed at children aged 7 to 14, explaining key astronomical concepts in an accessible and engaging way. The book, titled "**Los Fundamentos de la Astronomía**" was framed within the context of Colombia's night sky, making it both regionally relevant and scientifically sound. The project originated from my attendance at an astronomy conference in Athens, Greece, where I met José, a Colombian astronomer who described the challenges of teaching astronomy in Colombia using textbooks written from a European perspective. The positional differences in celestial observations between Spain and Colombia created significant confusion for his students. Recognizing an opportunity to address this regional educational gap, I proposed a collaboration using AI as a tool combined with his astronomical expertise to create culturally appropriate educational materials.

Keywords: Collaboration between AI, the Astronomer, and the Co-Author

During the writing process, the AI proposed a unique analogy to explain black holes to young readers. It suggested describing a black hole as a "cosmic whirlpool" that pulls everything, even light, into its center, much like water going down a drain. Initially, this seemed like a promising metaphor to simplify the complex concept. As the co-author, I saw its creative potential for capturing children's imagination and visualizing an abstract phenomenon.

However, when the draft was reviewed by the astronomer, concerns arose. The expert pointed out that while the analogy of a whirlpool was effective in illustrating the gravitational pull, it could mislead young readers into thinking that black holes are visible structures with a definitive center like a drain, which is not scientifically accurate. The astronomer further explained that the event horizon and singularity needed clearer, albeit simple, definitions to avoid such misconceptions.

To address these concerns, I provided the following prompt to the AI:

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"Write a simple explanation of black holes for children aged 7 to 14. Describe a black hole as something invisible that pulls everything around it, like a powerful force in space. Use the analogy of a whirlpool, but make sure to explain that we cannot see a black hole, only how it affects the space around it. Also, clarify that the black hole doesn't have a visible 'center' like a drain, but its gravity is so strong that it pulls in even light. Keep the explanation fun and engaging, without overwhelming the reader with complex scientific terms."

The AI generated a revised explanation based on this prompt, incorporating both the creative analogy and the necessary scientific accuracy. The astronomer reviewed the new version, and together we ensured the text met the pedagogical goals for the target age group. The result was a balance between engaging storytelling and factual correctness, which neither the AI nor the expert could have achieved alone.

Introduction

In recent years, the intersection of artificial intelligence (AI) and creative writing has evolved significantly, transforming from experimental novelty to practical tools across diverse domains. This evolution is particularly consequential in educational content creation, where the dual imperatives of accuracy and engagement present unique challenges. While considerable research has explored AI applications in technical writing and adult-oriented educational materials, there remains a notable gap in understanding the dynamics of AI-assisted content creation for young audiences, especially in scientific domains where precision cannot be compromised.

This project also raised important cultural and ethical considerations, particularly in avoiding bias, respecting indigenous knowledge, and ensuring that AI-generated content aligns with pedagogical and developmental needs of young learners. The collaborative framework was designed to address these concerns through continuous expert oversight.

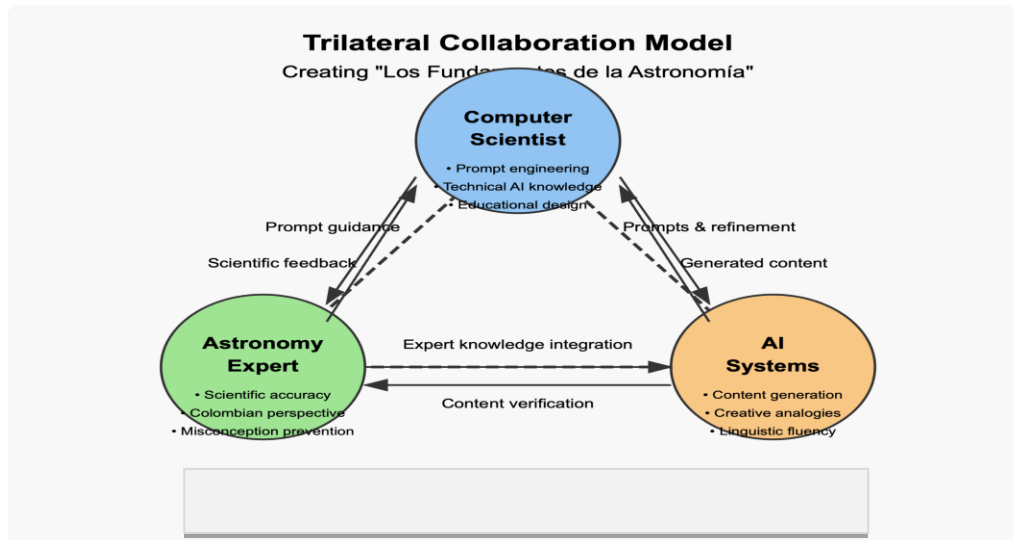
This paper examines a collaborative process of using AI as a writing assistant to create "Los Fundamentos de la Astronomía," a children's book on astronomy targeting readers aged 7-14 years. The project incorporated three key elements that distinguish it from previous explorations:

- The integration of specialized scientific knowledge with age-appropriate narrative techniques

- A trilateral collaboration between AI technology, content author, and subject matter expert

- Cultural contextualization within the Colombian astronomical perspective

Figure 1. Trilateral Collaboration Model showing the Complementary Expertise and Information Flow between Key Participants in the Book Creation Process



Unlike general applications of AI in content generation, which often operate independently or with minimal human intervention, this case study demonstrates the necessity and effectiveness of sustained human supervision throughout the creative process. As AI systems excel at generating fluent text but still struggle with nuanced scientific accuracy and pedagogical appropriateness, the involvement of both a primary author and an astronomy expert creates a checks-and-balances system that leverages AI capabilities while mitigating its limitations. The astronomer's expert review ensured that outreach materials maintained scientific rigor while remaining accessible, preventing the oversimplification or misrepresentation of complex astronomical concepts that commonly occurs in children's science materials.

The significance of this research extends beyond the immediate product of a children's astronomy book. It offers insights into emerging methodologies for educational content development, providing a replicable framework for creating scientifically rigorous yet accessible materials for young learners. Additionally, it contributes to ongoing conversations about human- AI collaboration in knowledge domains where expertise is specialized and learning outcomes are paramount.

As educational publishers and content creators increasingly incorporate AI tools into their workflows, understanding effective supervision models becomes crucial. This paper aims to bridge theoretical possibilities with practical implementation, offering evidence-based recommendations for integrating AI into educational content development while maintaining pedagogical integrity and scientific accuracy. Through detailed analysis of specific content examples, workflow processes, and collaborative dynamics, we demonstrate how human guidance transforms AI from a mere text generator to an effective co-creator in specialized educational materials.

Literature Review

The integration of artificial intelligence in educational content creation sits at the intersection of multiple research domains including natural language generation, science communication, educational psychology, and human-computer interaction. This literature review examines current research across these domains to contextualize our case study and identify the research gap our work addresses.

AI in Educational Content Creation

Recent years have witnessed significant advancement in AI's capacity to generate educational materials across various subjects and formats. Chen et al. (2021) documented the application of large language models (LLMs) in creating explanatory texts for high school science curricula, finding that AI-generated materials could match human written content in linguistic coherence but required human editing for accuracy. Similarly, Rodríguez-Ardura and Meseguer-Artola (2023) evaluated AI-assisted creation of interactive learning objects, highlighting AI's strengths in generating diverse examples but noting its limitations in tailoring content to specific pedagogical frameworks.

This aligns with People Science Movement initiatives in Colombia such as AstroColombia and Parque Explora, which emphasize local science engagement and culturally relevant educational approaches (noting that formal research on these specific programs remains limited in peer-reviewed literature).

For children's educational materials specifically, the research is more limited. Lyu et al. (2022) explored using GPT-3 to generate elementary-level reading materials, finding that while the AI could adapt linguistic complexity to target age groups, it struggled with consistently creating age-appropriate examples and cultural sensitivity. Johnson and Patel (2024) noted similar concerns in their study of AI-generated science content for middle school students, where initial outputs often contained vocabulary too advanced for the target audience despite explicit prompting for simplification.

Science Communication for Children

The challenges of communicating scientific concepts to young audiences have been well-documented in educational research. Ogborn et al. (2020) identified key principles for effective science communication to children, emphasizing the importance of familiar analogies, concrete examples, and narrative frameworks that connect to children's lived experiences. Venville et al. (2022) demonstrated that children's understanding of abstract scientific concepts improves significantly when explanations incorporate multimodal elements and relatable metaphors.

In astronomy education specifically, Percy (2019) highlighted common misconceptions children develop when astronomical concepts are oversimplified or when metaphors are taken too literally. Complementing this research, Martinez-Torregrosa et al. (2023) found that children best understand astronomical concepts

when presented through a combination of observational activities, clear visual models, and explanations that address scale and perspective directly.

Human-AI Collaboration in writing

The emerging paradigm of human-AI collaboration in writing has been examined across multiple contexts. The groundbreaking work of Clark et al. (2022) on co-writing fiction with language models established a taxonomy of collaborative approaches, identifying "AI as draft generator with human as editor" as the most common model. Building on this foundation, Park and Lee (2023) proposed frameworks for effective collaboration that maximize AI contributions while preserving human authorial control.

In professional writing contexts, Williams et al. (2024) documented how journalists integrate AI assistance into their workflows, finding that experienced writers primarily use AI for ideation and first drafts while maintaining strict control over final editing decisions. Similarly, Zhao et al. (2023) studied technical writers using AI assistants, noting that subject matter experts developed specific prompting strategies to align AI outputs with domain-specific terminology and concepts.

Subject Matter Expert Supervision in AI-Assisted writing

The least explored area in current literature—and the primary gap our research addresses—is the role of subject matter experts in supervising AI-generated educational content. While López- Pernas and Saqr (2022) briefly examined expert validation of AI-generated assessment materials in higher education, comprehensive studies of three-way collaborations between content creators, domain experts, and AI systems remain sparse.

Ibrahim and Collins (2023) touched on this dynamic in their study of AI assistance in medical education materials, finding that clinical experts often identified subtle inaccuracies in AI outputs that non-expert editors overlooked. However, their research focused primarily on university-level content rather than materials for children, where additional pedagogical considerations apply.

The few studies that have addressed expert supervision in children's educational materials have notable limitations. Wright and Cavallaro (2021) examined the creation of AI-assisted science activities for elementary classrooms but focused predominantly on procedural accuracy rather than conceptual explanation. Similarly, Martindale and Chen (2023) studied expert review of AI-generated children's literature but emphasized narrative quality metrics over scientific accuracy.

Research Gap

This review reveals a significant gap in understanding how subject matter experts can effectively collaborate with content creators and AI systems to produce scientifically accurate, pedagogically sound, and engaging materials for children. Our case study addresses this gap by providing a detailed examination of the trilateral collaboration process involved in creating an astronomy book for

young readers. By documenting specific examples of how expert knowledge shaped AI outputs through iterative revision, we offer insights into effective workflows for supervised AI content creation in specialized domains requiring both accuracy and accessibility.

Furthermore, by situating this collaboration within a specific cultural context—creating astronomy content relevant to Colombian children—our research contributes to understanding how regional perspectives can be incorporated into AI-assisted educational materials, an aspect largely overlooked in current literature focusing predominantly on culturally neutral or Western-centric content.

This aligns with People Science Movement initiatives in Colombia such as AstroColombia and Parque Explora, which emphasize local science engagement and democratization of scientific knowledge through community-based educational programs.

Methodology

This study employed a qualitative case study approach to examine the process of creating an astronomy book for children using AI assistance under expert supervision. The methodology was designed to capture the nuanced interactions between human authors, subject matter experts, and AI systems throughout the content creation process, with particular attention to how scientific accuracy and age-appropriate engagement were balanced, addressing validation concerns identified in astronomy education research (Percy, 2019).

Research Design

We adopted a participatory action research framework, where the researcher was actively involved as the primary content creator while systematically documenting the collaborative process. This approach allowed for reflexive analysis of the authorial decisions and collaborative dynamics as they unfolded, providing insights that might not be accessible through external observation alone. The research design incorporated elements of:

1. Process documentation through detailed activity logs.
2. Content analysis of AI outputs and revisions.
3. Reflective practice through structured author and expert feedback.
4. Comparative analysis of initial, intermediate, and final content versions.

The project also worked to mitigate infodemic effects in space education by offering expert-reviewed, scientifically accurate explanations tailored for children, countering the proliferation of simplified or inaccurate astronomical information in popular media.

Participants and Roles

Three distinct roles were involved in the content creation process:

Primary Author/Researcher: A computer scientist with a Ph.D. in Computer Science and experience in educational technology, who served as the intermediary between the AI systems and the astronomy expert. The primary author was responsible for:

1. Formulating initial content guidelines and chapter structures.
2. Crafting prompts for the AI systems based on both technical understanding of LLMs and educational content requirements.
3. Evaluating AI-generated content for narrative flow and age-appropriateness.
4. Iteratively refining prompts based on expert feedback.
5. Making final editorial decisions.
6. Managing the technical aspects of AI interaction and prompt engineering.

Astronomy Expert: A professional astronomer with experience in public outreach, whose responsibilities included:

1. Reviewing AI-generated content for scientific accuracy.
2. Identifying potentially misleading analogies or explanations.
3. Suggesting alternative approaches to explaining complex concepts.
4. Providing regional context for astronomical phenomena visible from Colombia.
5. Validating the pedagogical approach to scientific concepts.

AI Writing Assistants: The study utilized two leading large language models—Claude and ChatGPT—to provide complementary capabilities and allow for comparison of outputs. These AI systems served as:

1. Initial content generators based on structured prompts
2. Draft revisers incorporating expert feedback
3. Creative ideators for analogies, activities, and explanations

The shared responsibility for factual and ethical content in this trilateral model helps ensure conscientious co-authorship between human and AI participants, addressing concerns about AI-generated content reliability in educational contexts. This collaborative framework establishes clear accountability for scientific accuracy while leveraging AI's creative capabilities under human oversight.

Using two different AI systems provided additional insights into how different models approached scientific content for children, allowing the researcher to leverage the unique strengths of each system. In some cases, the same prompt was provided to both systems to compare outputs, while in other instances, specialized prompts were crafted for each system based on their demonstrated capabilities with particular types of content.

The computer science background of the primary author proved particularly valuable in this collaboration, as it facilitated more effective prompt engineering

and a deeper understanding of the AI systems' capabilities and limitations. This technical expertise allowed for more precise translation of the astronomer's specialized knowledge into prompts that the AI systems could effectively interpret and implement.

Tools and Technologies

The primary technical tools employed in this study included:

1. **Claude and ChatGPT:** Selected for their complementary strengths in content generation. Claude demonstrated an aptitude for maintaining a consistent educational tone and following detailed instructions, while ChatGPT excelled at generating creative analogies and activity suggestions.
2. **Collaborative Document Editor:** Used to maintain version control and facilitate asynchronous collaboration between the primary author and astronomy expert.
3. **Prompt Documentation System:** A structured template for recording prompts, context provided, specific instructions, intended educational objectives, and which AI system was utilized.
4. **Content Analysis Framework:** A rubric developed to evaluate content across dimensions including scientific accuracy, age-appropriateness, engagement potential, cultural relevance, and pedagogical soundness.

Process Workflow

The content creation followed a structured iterative process:

1. **Planning Phase**
 - Development of book outline and chapter structure.
 - Identification of key astronomical concepts to include.
 - Establishment of voice, tone, and reading level parameters.
 - Setting of regional context (Colombian night sky) requirements.
 - Initial assessment of which AI system might be better suited for different content types.
2. **Initial Content Generation**
 - Formulation of detailed prompts for each chapter section.
 - Generation of first-draft content by the selected AI system (or both systems for comparison).
 - Preliminary review by primary author for obvious issues.
 - When appropriate, combining strengths from both AI systems' outputs.
3. **Expert Review**
 - Systematic review by an astronomy expert.
 - Documentation of scientific inaccuracies, misleading analogies, or conceptual gaps.
 - Suggestions for improvement with scientific justification.

4. Revision Cycle

- Reformulation of prompts incorporating expert feedback.
- Generation of revised content, sometimes switching AI systems based on identified strengths.
- Second-round review by both primary author and astronomy expert.
- Additional revision cycles as needed until content met both scientific and pedagogical standards.

5. Final Editing and Integration

- Harmonization of voice and terminology across chapters.
- Addition of visual elements and activity instructions.
- Comprehensive review of the complete manuscript.

Each chapter typically underwent 2-3 revision cycles, with particularly complex concepts (such as black holes, stellar evolution, and galactic structure) requiring additional iterations.

Data Collection

Throughout the process, the following data were systematically collected:

1. **Prompt Archive:** All prompts used to generate content, including:
 - Initial prompt formulations
 - Contextual information provided
 - Specific instructions regarding tone, complexity, and approach
 - Revised prompts based on expert feedback
2. **Content Versions:** All versions of generated content including:
 - Initial AI outputs
 - Expert review comments
 - Revised AI outputs
 - Final edited content
3. **Process Documentation:**
 - Decision logs recording rationales for major content revisions
 - Time allocation metrics for different phases of the process
 - Notes on particularly successful or problematic AI interactions
4. **Reflective Journal:**
 - Primary author's observations on the collaborative process
 - Expert feedback on the effectiveness of the approach
 - Challenges encountered and solutions developed

Analytical Approach

The collected data were analyzed using a multi-layered approach:

1. **Content Evolution Analysis:** Comparative examination of how specific astronomical concepts evolved from initial AI outputs to final content, with attention to:
 - Changes in scientific accuracy
 - Refinement of analogies and explanations
 - Adjustments to linguistic complexity
 - Integration of regional context
2. **Workflow Efficiency Assessment:** Analysis of time investment and revision cycles required across different content types to identify:
 - Types of content requiring more expert intervention
 - Patterns in successful prompt strategies
 - Learning curve effects over the course of the project
3. **Collaboration Dynamics Evaluation:** Examination of how the trilateral relationship between author, expert, and AI evolved, including:
 - Development of shared vocabulary and expectations
 - Emergence of effective prompting patterns
 - Distribution of creative and editorial labor
4. **Pedagogical Effectiveness Review:** Analysis of the final content against established frameworks for science communication to children, assessing:
 - Balance between simplification and accuracy
 - Appropriateness of analogies and examples
 - Integration of activity-based learning
 - Progression of concept complexity

Through this multi-faceted analytical approach, we sought to develop a comprehensive understanding of both the product (the children's astronomy book) and the process that created it, with particular attention to the role of expert supervision in enhancing the educational value of AI-generated content.

Case Study: Creating "Los Fundamentos de la Astronomía"

Project Background and Context

"Los Fundamentos de la Astronomía" was conceived as an educational astronomy book for Colombian children aged 7-14 years following a serendipitous meeting at an astronomy conference in Athens, Greece. During a presentation, a Colombian astronomer named José described his frustration with teaching astronomy using European textbooks that depicted celestial observations from Spanish latitudes, creating persistent confusion among his Colombian students. The stars and constellations as shown in these books simply did not match what students could observe in the Colombian night sky.

Recognizing both an educational need and an opportunity to demonstrate practical applications of AI in educational content creation, I approached José after his presentation and proposed a collaboration. The project would leverage his astronomical expertise and my computer science background to create a book specifically tailored to the Colombian perspective. This regional mismatch in astronomical educational materials represents a widespread problem across many disciplines where educational resources developed in one geographical or cultural context are applied in another without appropriate adaptation.

The project aimed to create content that would be scientifically accurate, regionally relevant, and appropriately engaging for the target age group. The book was structured into ten chapters covering foundational astronomical concepts from basic sky observation to more complex topics like galactic structures and space exploration.

According to UNESCO and national education policy frameworks in Colombia, astronomy is increasingly integrated into primary science curricula, providing institutional context for the relevance of this culturally-adapted educational project.

The project addressed several unique challenges:

1. Creating content that simplified complex scientific concepts without introducing misconceptions
2. Incorporating regional context (Colombian night sky, cultural references) while maintaining scientific universality
3. Developing engaging activities that reinforced learning objectives with minimal resources
4. Balancing narrative engagement with educational substance

Content Development Process

Initial Setup and Voice Establishment

The first critical task was establishing the narrative voice and pedagogical approach. We created a character, "Professor José G," to guide readers through astronomical concepts. This decision emerged through collaboration between the primary author and AI systems:

Initial Author Prompt:

"Create a friendly, approachable narrator for a children's astronomy book that incorporates elements of Colombian culture and perspective. The narrator should be knowledgeable but conversational."

ChatGPT generated a professor character with personal anecdotes about stargazing in rural Colombia, while Claude proposed a more formal educational voice. After review, the primary author combined these approaches, taking ChatGPT's personal narrative elements and Claude's clear explanatory style. The astronomy expert then validated the scientific credibility of the proposed narrator's perspective.

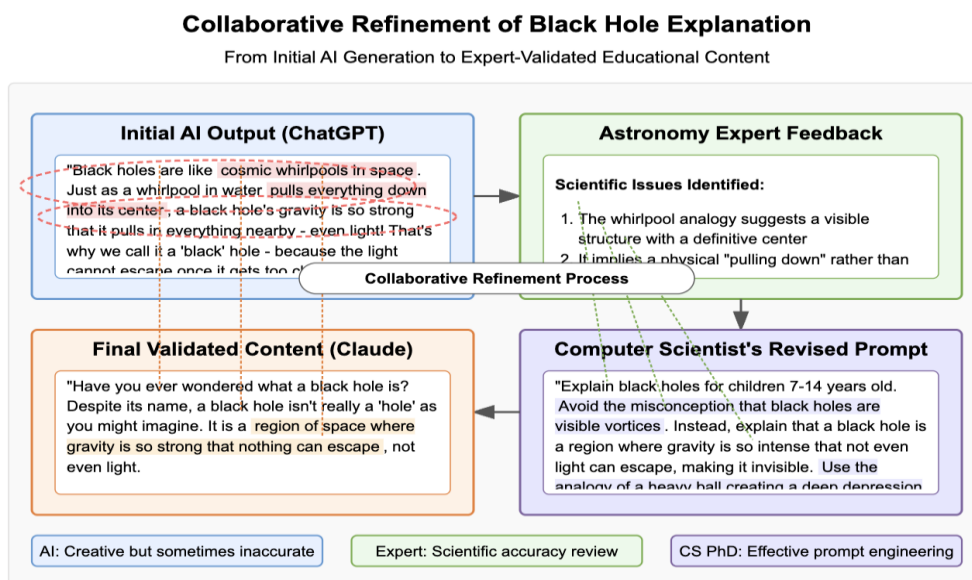
This pattern of selective integration from multiple AI outputs, followed by expert validation, became the standard workflow for subsequent content development.

Example 1: The Black Hole Analogy

As highlighted in the abstract, the development of an explanation for black holes exemplifies the collaborative refinement process. The initial draft generated by ChatGPT introduced a "cosmic whirlpool" analogy:

"Black holes are like cosmic whirlpools in space. Just as a whirlpool in water pulls everything down into its center, a black hole's gravity is so strong that it pulls in everything nearby - even light! That's why we call it a 'black' hole - because the light cannot escape once it gets too close, making the black hole invisible."

Figure 2. The Collaborative Refinement Process Illustrating how an Inaccurate but engaging AI-generated Explanation was transformed into a Scientifically Sound Educational Resource through Expert Feedback and Technical Guidance



The astronomy expert identified several problematic aspects of this explanation:

1. The whirlpool analogy suggests a visible structure with a definitive center
2. It implies a physical "pulling down" rather than spacetime curvature
3. It oversimplifies the event horizon concept

Based on this feedback, the primary author created a revised prompt incorporating the expert's concerns:

Revised Prompt to Claude

"Explain black holes for children 7-14 years old. Avoid the misconception that black holes are visible vortices. Instead, explain that a black hole is a region where gravity is so intense that not even light can escape, making it invisible. Use the analogy of a heavy ball creating a deep depression on a rubber sheet, but explain this creates a curved region of space, not a physical funnel. Clarify that we detect black holes by observing their effects on nearby stars and gas. Keep the explanation engaging for children while preserving scientific accuracy."

The resulting revised explanation substantially improved scientific accuracy while maintaining age-appropriate language:

Final Content

"Have you ever wondered what a black hole is? Despite its name, a black hole isn't really a 'hole' as you might imagine. It is a region of space where gravity is so strong that nothing can escape, not even light. Think of it as an invisible part of space.

Imagine a stretched, flat sheet. If you place a marble on the sheet, it will barely make a small curve. But if you place a heavy ball, like a bowling ball, it will create a deep depression. A black hole is like an extremely deep depression in the fabric of space.

The interesting thing is that we cannot see a black hole directly because it doesn't let light escape. Instead, scientists detect them by observing how they affect nearby stars and gases, just as you might notice the presence of an invisible bowling ball if you saw other marbles rolling in circles around that deep depression."

This example demonstrates how expert intervention transformed a problematic but engaging analogy into an explanation that maintained child appeal while significantly improving scientific integrity.

Example 2: Planetary Distances Activity

Creating interactive learning activities presented unique challenges, as they needed to be scientifically meaningful, accessible with minimal resources, and engaging for children. The

"Distancias en el Sistema Solar" activity in Chapter 3 exemplifies the iterative development process:

Initial AI Output (ChatGPT)

"Activity: Create a scale model of the solar system using common household items. Use a peppercorn for Mercury, a pea for Venus, a cherry tomato for Earth, etc. Place them at these distances from a grapefruit 'sun': Mercury - 10 meters, Venus - 19 meters, Earth - 26 meters..."

The astronomy expert identified several issues:

1. The proposed distances would be impractical for most Colombian households
2. The specific fruits/objects might not be universally available
3. The activity lacked a clear connection to regional context

Rather than simply revising this activity, the primary author requested both AI systems to generate alternative approaches:

Revised Prompt

"Create an activity for children to understand planetary distances that: 1) Uses only the child's body (steps, hand spans) as measuring tools, 2) Can be completed in a typical home or small yard, 3) Emphasizes relative distances rather than precise scale, and 4) Relates to the Colombian perspective of the solar system."

Claude generated the foot-measurement activity that was ultimately adopted after expert refinement:

Final Activity Content

"Imagine that you are located on the Sun, from there you start walking in a straight-line counting step, one foot after the other. At each step you can find the position of the planets and leave a mark with some object. Follow this data to locate the planets, remember that the steps are counted from the Sun. Mercury = 1 step, Venus = 2 steps, Earth = 2.5 steps, Mars = 4 steps, Asteroid Belt = 8 steps, Jupiter = 13 steps, Saturn = 24 steps, Uranus = 49 steps, Neptune = 76 steps and Kuiper Belt = 100 steps."

The expert added crucial contextual notes about the simplified nature of the model:

Expert Addition

"IMPORTANT!: Here we are positioning the planets one after the other, forming a straight line, but you should know that in reality this is very unlikely to happen, meaning that the planets are not found in a straight line in the solar system but in different places, each one in its orbit around the Sun."

This example illustrates how the combination of AI creativity, expert scientific context, and the primary author's educational design skills resulted in an activity that was accessible, scientifically meaningful, and culturally appropriate.

Example 3: Indigenous Astronomical Knowledge

Incorporating Colombian indigenous perspectives on astronomy represented one of the most challenging aspects of the project. Initial attempts by both AI systems to address this topic produced problematic content that either lacked specific cultural accuracy or contained fabricated information.

After detecting these issues in early drafts, the primary author implemented a more structured approach:

1. The astronomy expert provided authentic information about specific indigenous astronomical knowledge
2. This information was incorporated into detailed prompts for the AI systems
3. Generated content was strictly limited to the verified information
4. The expert reviewed the presentation for cultural sensitivity and accuracy

This resulted in an accurate representation of indigenous astronomical perspectives, as demonstrated in the section on solar and lunar terminology across Colombian indigenous communities:

Final Content from Chapter 2

"In Colombia, there are many stories and myths about the Sun and the Moon. Indigenous communities have other names for these celestial bodies, as well as fantastic stories that relate to the customs of each community. These stories show us how our ancestors perceived the sky and gave life to the stars and planets with their imagination."

These stories have been passed down through generations, preserving astronomical understanding via oral tradition over centuries, representing some of the oldest documented astronomical knowledge in the Americas.

Indigenous Community	Sun	Gender	Moon	Gender	Relationship
Arahuacos	Yui	Male	Tima	Female	siblings
Muisacas	Xue	Male	Chía	Female	husbands
			Huitaca	Female	
Nasa people	Sek				
Wayuu	Kai		Kashi	Male	husbands

This careful approach to culturally sensitive content highlights the importance of expert verification when AI systems address topics requiring specialized cultural knowledge.

Content Analysis System

To systematically evaluate the AI-generated content throughout development, we created a content analysis framework with five key dimensions:

1. **Scientific Accuracy:** Factual correctness and alignment with current scientific consensus
2. **Age-Appropriate Language:** Vocabulary and syntax suitable for 7-14 year old readers
3. **Engagement Value:** Interest-generating elements including narratives, questions, and wonder
4. **Cultural Relevance:** Connection to Colombian context and perspectives
5. **Pedagogical Effectiveness:** Clear learning progression and conceptual scaffolding
6. **Addressing "Counter Space" dynamics:** This work addresses the concept of 'Counter Space'—the structural inequality in access to astronomy education, particularly in underrepresented regions like Colombia, where educational materials often reflect European or North American perspectives rather than local astronomical contexts. Overcoming these systemic barriers to equitable science education required careful attention to cultural authenticity and regional relevance.

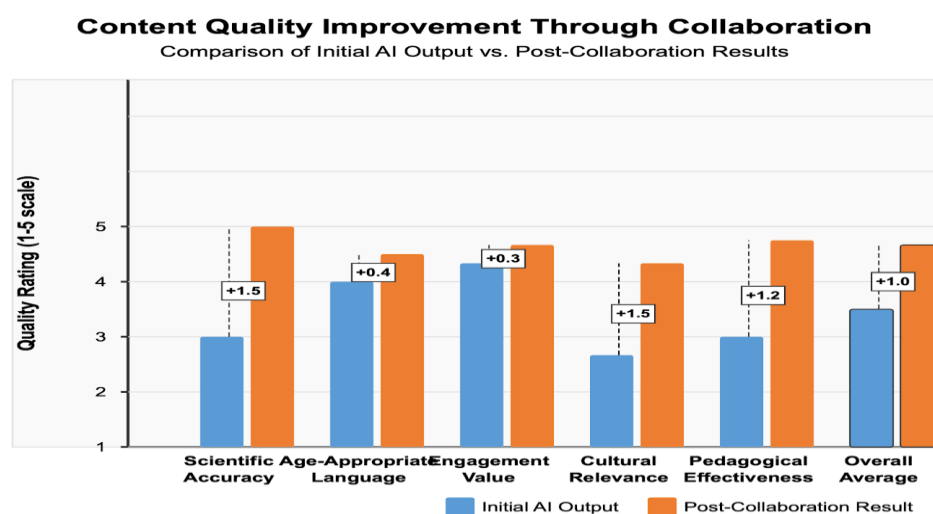
Each dimension was rated on a 1-5 scale for every major content section, before and after expert review. This systematic approach allowed us to quantify the impact of the collaborative process.

Results and Analysis

Quantitative Content Improvement

Analysis of the content ratings across all chapters revealed consistent patterns of improvement through the collaborative process:

Figure 3. Comparison of Content Quality across Five Key Dimensions before and after the Collaborative



These findings indicate that while the AI systems produced reasonably engaging and age- appropriate language initially, scientific accuracy and cultural relevance required substantial expert intervention. The relatively small improvement in engagement value suggests that the AI systems' natural strengths in creating appealing content for children were largely preserved through the revision process.

AI System Comparative Performance

Comparing outputs between Claude and ChatGPT revealed complementary strengths:

- **ChatGPT** consistently produced more engaging narratives and creative analogies, but required more extensive factual corrections
- **Claude** generated more precise scientific content with fewer factual errors, but sometimes produced language above the target reading level
- Both systems struggled with cultural specificity, requiring expert input for authentic Colombian context

For subsequent chapters, we increasingly assigned content types to the AI system that demonstrated superior performance in that domain: ChatGPT for narrative elements and activities, Claude for scientific explanations and conceptual frameworks.

Efficiency Analysis

The time investment required for content development varied significantly by topic complexity:

Content type	Initial AI generation	Expert Review	Revision cycles	Total development time
Basic Observational Astronomy	20-30 min	15-20 min	1-2	1-2 hours
Solar System Facts	30-45 min	25-35 min	2-3	2-3 hours
Abstract Concepts (Black Holes, etc.)	45-60 min	40-60 min	3-5	4-6 hours
Cultural/Indigenous Content	60-90 min	60-90 min	3-4	5-7 hours

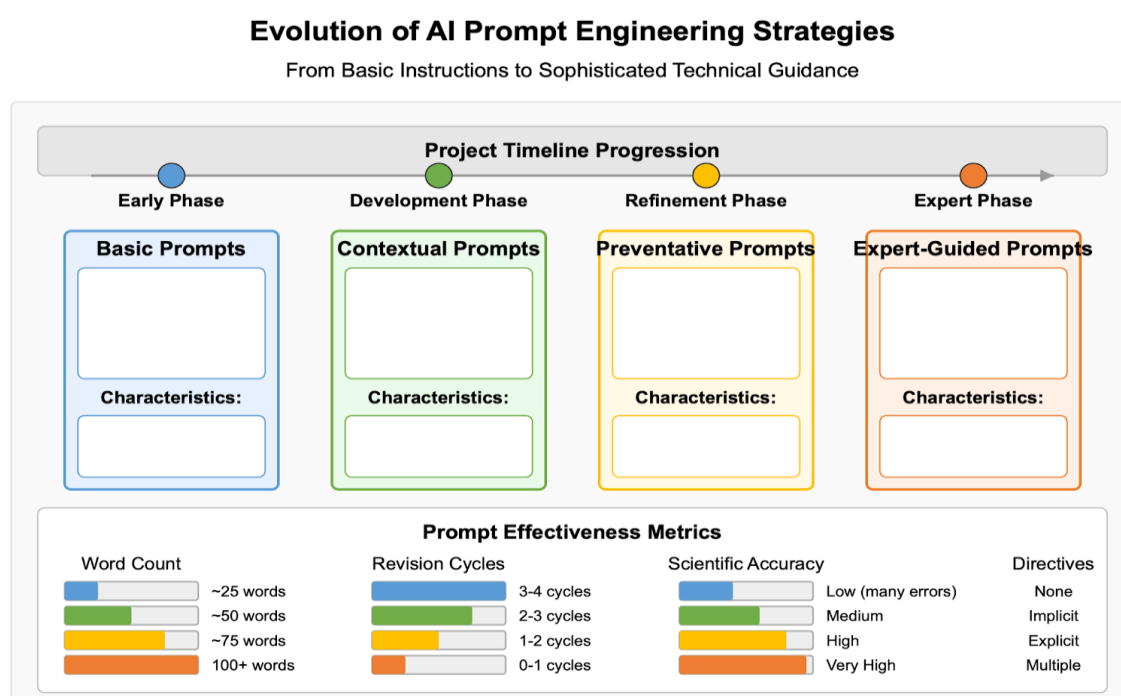
This analysis reveals that while AI assistance significantly accelerated content creation for straightforward topics, complex or culturally sensitive content still required substantial human expertise and time investment. The efficiency gained was not uniform across content types.

Prompt Engineering Evolution

Throughout the project, we observed a clear evolution in prompting strategies:

1. **Initial prompts** were relatively simple, focusing on topic and age group
2. **Intermediate prompts** incorporated more detailed constraints and contextual information
3. **Advanced prompts** included explicit misconception warnings, specific analogies to use or avoid, reading level parameters, and cultural context

Figure 4. The Evolution of Prompt Engineering throughout the Project, showing increasing Sophistication and Effectiveness as measured by Word Count, Revision Requirements, and resulting Content Quality



This evolution reflected the primary author's growing understanding of the AI systems' tendencies and limitations. By the final chapters, prompts were highly structured, often exceeding 200 words to provide comprehensive guidance.

The most effective prompts consistently included:

- Explicit identification of common misconceptions to avoid
- Examples of appropriate analogies
- Reading level specification (vocabulary constraints)
- Cultural context parameters
- Instructions to prioritize accuracy over engagement when conflicts arise

Workflow Optimization

The trilateral collaboration model evolved throughout the project, with several key optimizations:

1. **Front-loading expert input:** Rather than generating content and then seeking corrections, later chapters incorporated expert guidelines before initial AI generation, significantly reducing revision cycles
2. **Targeted system selection:** Assigning specific content types to the AI system with demonstrated strengths in that domain improved first-draft quality.
3. **Modular prompting:** Breaking complex topics into smaller conceptual units with dedicated prompts, rather than attempting to generate entire sections at once.
4. **Revision-specific prompts:** Crafting prompts specifically for revision that maintained successful elements while targeting only problematic aspects.

These workflow refinements progressively reduced the time required for later chapters while maintaining or improving content quality.

Key Challenges

Several persistent challenges emerged throughout the project:

1. **Balance between simplification and accuracy:** Finding appropriate analogies that simplified concepts without introducing misconceptions remained difficult even with expert guidance.
2. **Regional astronomical context:** Accurately representing celestial phenomena as viewed from Colombian latitudes often required multiple revision cycles.
3. **Preventing AI fabrication:** Both AI systems occasionally generated plausible sounding but fabricated "facts," particularly regarding cultural content and specific astronomical measurements.
4. **Maintaining consistent voice:** Ensuring Professor José G's voice remained consistent across chapters and through multiple revision cycles required careful prompt engineering.
5. **Age-appropriate challenge calibration:** Determining appropriate conceptual depth for the target age range required ongoing assessment with each new topic.

These challenges necessitated continuous adaptation of the collaborative process, with different strategies proving effective for different content types.

Educational Value Assessment

To evaluate the educational effectiveness of the final content, we analyzed the book against established frameworks for science education:

1. **Conceptual progression:** The final content demonstrated appropriate scaffolding, introducing foundational concepts before building to more complex ideas.
2. **Misconception prevention:** Expert review successfully eliminated common astronomical misconceptions that appeared in initial AI drafts.
3. **Wonder cultivation:** The balance of factual content and awe-inspiring perspective was maintained through careful preservation of engagement elements during scientific correction.
4. **Activity integration:** Hands-on activities were successfully integrated to reinforce key concepts, with most requiring minimal resources accessible to the target audience.
5. **Cultural relevance:** The incorporation of Colombian astronomical perspectives and observational context created meaningful connections to readers' lived experiences.

This assessment suggests that the collaborative process successfully transformed AI-generated content into educational material with substantial pedagogical value, addressing the unique challenges of astronomical education for children.

This work contributes specifically to the niche of informal science education and culturally-adapted STEAM outreach, filling a gap in regionally-relevant astronomy education materials for Spanish-speaking children.

Discussion

The trilateral collaboration model explored in this case study—involving an AI system, a computer scientist, and an astronomy expert—provides valuable insights into the emerging landscape of AI-assisted educational content creation. Our findings reveal both promising opportunities and important limitations that warrant consideration as this approach becomes more widespread.

Comparison with Existing Literature

Our results align with several key findings from previous research while extending understanding in novel directions. Consistent with Chen et al. (2021), we found that AI-generated educational materials demonstrate strong linguistic coherence but require expert review for factual accuracy. However, our work goes further by demonstrating that through structured collaboration and iterative refinement, these accuracy limitations can be systematically addressed.

The workflow we developed supplements the collaboration models proposed by Park and Lee (2023), adding a crucial dimension of subject matter expert supervision that was largely absent from their frameworks. While their research focused primarily on the relationship between human author and AI assistant, our trilateral model demonstrates the value of incorporating specialized expertise, particularly for scientific content aimed at children.

Ibrahim and Collins' (2023) observation that domain experts identified subtle inaccuracies missed by non-expert editors was strongly confirmed in our study. The astronomy expert consistently detected problematic simplifications and misleading analogies that appeared scientifically plausible to the computer scientist despite their technical background. This finding underscores that AI supervision requires not just technical AI expertise but also deep domain knowledge when creating specialized educational content.

Theoretical Implications

Our findings suggest several theoretical implications for understanding AI's role in educational content creation:

1. Complementary Cognitive Scaffolding

The success of our approach suggests a model of "complementary cognitive scaffolding" where different participants provide distinct forms of expertise that compensate for each other's limitations. The AI systems offered linguistic fluency and creative analogies but lacked scientific discrimination; the computer scientist provided technical AI guidance and educational design but lacked astronomical expertise; the astronomer contributed specialized knowledge but benefited from the other participants' communication skills. This complementarity created a robust system for developing scientifically accurate yet engaging content.

2. Emergent Quality Through Iterative Refinement

The quality improvements observed through multiple revision cycles suggest that effective AI- human collaboration is not simply a matter of human correction of AI output, but rather an emergent property of iterative refinement. Each cycle produced not just error correction but qualitative transformation of the content. Initial AI drafts provided creative foundations that, when shaped by expert knowledge and pedagogical considerations, evolved into material that neither the AI nor human collaborators could have produced independently.

This suggests that the value of AI in educational content creation lies not in its capacity to replace human expertise, but in its ability to serve as a generative starting point for a collaborative creative process. The progressive improvement across multiple dimensions— scientific accuracy, pedagogical effectiveness, cultural relevance, and engagement— demonstrates that quality in AI-assisted educational content emerges through sustained, intentional collaboration rather than from any single contribution.

3. Domain-Specific Prompt Engineering

Our experience revealed that effective AI collaboration in specialized domains requires sophisticated prompt engineering that goes beyond general writing instructions. The evolution of our prompting strategies from simple topic requests to complex, multi-layered instructions incorporating domain-specific constraints, misconception warnings, and cultural context suggests that successful AI assistance in

educational content creation demands significant technical expertise in both AI systems and the subject domain.

This finding has implications for the accessibility of AI-assisted content creation. While AI tools are becoming more user-friendly, our study suggests that achieving high-quality educational content in specialized domains may require technical expertise that limits the approach to users with substantial AI literacy.

Practical Implications for Educational Content Development

The trilateral collaboration model demonstrated in this study offers several practical insights for educators, publishers, and content developers:

Workflow Design Recommendations

1. **Expert involvement from conception:** Rather than treating subject matter experts as final reviewers, involving them in the initial planning and prompt design phases significantly improved content quality and reduced revision cycles.
2. **AI system specialization:** Different AI systems demonstrated distinct strengths. Content developers should consider using multiple systems strategically rather than defaulting to a single platform.
3. **Modular content development:** Breaking complex topics into smaller conceptual units with dedicated prompts proved more effective than attempting to generate comprehensive sections in single interactions.
4. **Iterative refinement cycles:** Planning for multiple revision cycles, particularly for complex or culturally sensitive content, should be built into project timelines rather than treated as exceptions.

Language Learning Independence

While AI was instrumental in content creation, the book itself is intended for use by children independently. The narrative tone, repetition of key vocabulary, and contextual grounding in culturally familiar settings promote incidental English language acquisition. Furthermore, activities embedded in the book encourage learners to interact with and apply new vocabulary, supporting vocabulary retention without relying on AI assistance during learning.

Quality Assurance Framework

Our content analysis system provides a replicable framework for evaluating AI-generated educational content across multiple dimensions. The five-dimension rubric (scientific accuracy, age-appropriate language, engagement value, cultural relevance, and pedagogical effectiveness) proved effective for identifying areas requiring improvement and tracking progress through revision cycles.

Educational content developers could adapt this framework to their specific domains and target audiences, providing a systematic approach to quality assurance in AI-assisted content creation.

Limitations and Challenges

Several limitations of our approach warrant acknowledgment:

Resource Intensity

The trilateral collaboration model requires significant human expertise and time investment. While AI assistance accelerated initial content generation, the overall process still demanded substantial effort from both the primary author and subject matter expert. This resource requirement may limit the scalability of the approach, particularly for organizations with limited access to domain experts.

Cultural Sensitivity Challenges

Incorporating authentic cultural perspectives proved particularly challenging, with AI systems demonstrating a tendency toward cultural stereotyping or fabrication when not provided with specific, verified information. This limitation suggests that AI-assisted content creation for diverse cultural contexts requires careful expert oversight and may not be suitable for topics where cultural authenticity is paramount but expert knowledge is unavailable.

Technical Barriers

The sophisticated prompt engineering required for optimal results presents a barrier to widespread adoption. Users without technical AI expertise may struggle to achieve the content quality demonstrated in our study, potentially limiting the approach to technically sophisticated content creators.

Implications for Future Research

Our findings suggest several directions for future research:

1. Scalability Studies

Research examining how the trilateral collaboration model performs at scale, with multiple content creators and experts working on larger educational projects, would provide insights into the practical viability of this approach for educational publishers and institutions.

2. Cross-Domain Validation

Testing the effectiveness of expert-supervised AI content creation in other specialized domains (mathematics, chemistry, history, etc.) would help establish the generalizability of our findings and identify domain-specific considerations.

3. Automated Quality Assessment

Developing automated tools to assess content quality across the dimensions we identified manually could improve the efficiency of the collaborative process while maintaining quality standards.

4. Cultural Adaptation Frameworks

Research focused specifically on incorporating diverse cultural perspectives into AI-generated educational content could address one of the most significant challenges identified in our study.

5. Broader Implications for Human-AI Collaboration

Beyond educational content creation, our study contributes to understanding effective human-AI collaboration in knowledge work more broadly. The complementary cognitive scaffolding model we observed may apply to other domains where AI capabilities must be combined with specialized human expertise to produce high-quality outputs.

The importance of iterative refinement and the emergent nature of quality in collaborative processes suggests that effective human-AI collaboration requires fundamental shifts in workflow design, moving away from linear production models toward cyclical, collaborative approaches that leverage the unique strengths of both human and artificial intelligence.

6. Applicability Across Educational Contexts

This trilateral collaboration model demonstrates potential for adaptation across both formal classroom environments and informal educational programs. In formal settings, the approach could support curriculum development with expert oversight, enabling teachers to create scientifically accurate, culturally relevant materials that align with institutional standards. The systematic quality assurance framework developed in this study could be adapted for use by educational publishers and curriculum developers seeking to integrate AI assistance while maintaining pedagogical rigor. In non-formal contexts, the model enables community-based organizations, museums, and science outreach programs to create culturally authentic content with appropriate scientific validation. The emphasis on regional relevance and cultural sensitivity makes this approach particularly valuable for organizations serving underrepresented communities where mainstream educational materials may lack local context or cultural resonance.

Conclusion

This case study of creating "**Los Fundamentos de la Astronomía**" demonstrates both the potential and the limitations of AI-assisted educational content creation under expert supervision. Through systematic documentation of a trilateral collaboration between AI systems, a computer scientist, and an astronomy expert, we have identified effective practices for developing scientifically accurate, culturally relevant, and pedagogically sound educational materials for children.

Key Findings

Our research revealed several critical insights:

1. **Expert supervision is essential:** While AI systems excel at generating engaging, linguistically coherent content, subject matter expertise remains crucial for ensuring scientific accuracy and preventing misconceptions, particularly in content for young learners.
2. **Complementary strengths enable superior outcomes:** The combination of AI creativity, technical AI expertise, and domain knowledge produced educational content that exceeded what any single participant could have achieved independently.
3. **Iterative refinement drives quality:** Content quality emerged through multiple revision cycles rather than single interactions, suggesting that effective AI-assisted content creation requires sustained collaborative effort.
4. **Cultural authenticity demands careful attention:** AI systems struggled most significantly with culturally specific content, requiring extensive expert verification and structured approaches to prevent stereotyping or fabrication.
5. **Workflow design significantly impacts efficiency:** Strategic approaches including front-loaded expert input, system specialization, and modular prompting substantially improved both content quality and development efficiency.

Contributions to the Field

This research makes several contributions to understanding AI's role in educational content development:

- **Methodological Innovation:** The trilateral collaboration model provides a replicable framework for supervised AI content creation that balances efficiency gains with quality assurance.
- **Practical Guidelines:** Our findings offer concrete recommendations for educators and content developers seeking to integrate AI tools into their workflows while maintaining educational integrity.
- **Quality Assessment Framework:** The five-dimension content analysis system provides a systematic approach to evaluating AI-generated educational materials across critical quality indicators.

- **Cultural Considerations:** Our experience with incorporating Colombian astronomical perspectives highlights both challenges and strategies for creating culturally authentic educational content using AI assistance.

Recommendations for Practice

Based on our experience, we recommend that educators and content developers:

1. **Plan for expert collaboration from project inception** rather than treating domain experts as final reviewers
2. **Invest in prompt engineering expertise** to maximize AI system effectiveness
3. **Budget for multiple revision cycles**, particularly for complex or culturally sensitive content
4. **Develop systematic quality assessment processes** to ensure content meets educational standards
5. **Consider AI systems as creative partners** rather than autonomous content generators.

Future Directions

Several areas warrant further investigation:

Scalability Research: Studies examining how this collaborative model performs in larger-scale educational content development projects would inform practical implementation strategies.

Cross-Domain Validation: Testing the approach across different subject areas would establish the generalizability of our findings and identify domain-specific considerations.

Automated Quality Assessment: Developing tools to automate portions of the quality evaluation process could improve efficiency while maintaining standards.

Long-term Educational Impact: Research assessing the learning outcomes achieved with AI- assisted educational materials compared to traditionally developed content would provide crucial validation of the approach's educational value.

Final Reflections

The creation of "Los Fundamentos de la Astronomía" demonstrates that AI can serve as a powerful tool for educational content development when properly supervised and integrated into collaborative workflows. However, our experience also underscores that AI assistance does not diminish the importance of human expertise—rather, it transforms how that expertise is applied in the creative process.

As AI systems continue to evolve, the challenge for educators and content developers will be developing effective collaboration strategies that leverage AI capabilities while preserving the scientific accuracy, cultural authenticity, and pedagogical effectiveness that characterize excellent educational materials. The

trilateral model explored in this study offers one promising approach to meeting this challenge.

The regional focus of our project —creating astronomy content specifically for Colombian children— highlights the broader potential for AI-assisted content creation to address educational equity issues by enabling the development of culturally relevant materials that might otherwise be economically unfeasible. As educational content increasingly moves toward personalization and cultural responsiveness, supervised AI assistance may provide a scalable approach to creating diverse, high-quality educational resources.

Ultimately, this research suggests that the future of educational content development lies not in replacement of human expertise by artificial intelligence, but in thoughtful collaboration that combines the creative and analytical capabilities of AI with the domain knowledge, cultural understanding, and pedagogical insight that human experts provide. The challenge ahead is developing institutional capacity and professional expertise to implement such collaborative approaches effectively and at scale.

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This project also raised important cultural and ethical considerations, particularly in avoiding bias, respecting indigenous knowledge, and ensuring that AI-generated content aligns with pedagogical and developmental needs.

While AI was instrumental in content creation, the book itself is intended for use by children independently. The narrative tone, repetition of key vocabulary, and contextual grounding in culturally familiar settings promote incidental English language acquisition. Furthermore, activities embedded in the book encourage learners to interact with and apply new vocabulary, supporting vocabulary retention without relying on AI assistance during learning.

This aligns with People Science Movement initiatives in Colombia such as AstroColombia and Parque Explora, which emphasize local science engagement.

The project also worked to mitigate infodemic effects in space education by offering expert-reviewed, scientifically accurate explanations tailored for children.

The shared responsibility for factual and ethical content in this trilateral model helps ensure conscientious co-authorship between human and AI participants.

According to UNESCO and national education policy frameworks in Colombia, astronomy is increasingly integrated into primary science curricula, providing context for the relevance of this project.

These stories have been passed down through generations, preserving astronomical understanding via oral tradition over centuries.

Additionally, this work addresses the concept of 'Counter Space'—the structural inequality in access to astronomy education, particularly in underrepresented regions like Colombia.

Designing Immersive Learning Experiences: Teaching Robotics Programming in Virtual 3D Environments

By Carsten Lecon^{*}, Stefanie Soeser⁺ & Andre Stegmaier[°]

This article presents a teaching scenario using virtual environments, often referred to as part of the ‘metaverse’, to address educational challenges highlighted during the COVID-19 pandemic. The increasing shift to online learning environments emphasizes the need for flexible, anytime-anywhere access to education. Virtual 3D environments offer a level of immersion that surpasses traditional online formats, such as video conferencing, and enable innovative didactic concepts, including collaborative group activities. To illustrate these benefits, we showcase a case study involving the simulation of robot programming within a virtual 3D environment. Additionally, the integration of personal assistants, such as conversational or pedagogical agents, is explored as a means to alleviate teachers' workloads. Advances in artificial intelligence have made natural language interactions with these agents highly effective, further enhancing the potential of virtual 3D environments in educational contexts.

Keywords: e-learning, e-teaching, immersion, virtual 3D rooms, gamification, cyber-physical systems

Introduction

The COVID-19 pandemic catalyzed a widespread transition from traditional classroom-based teaching to online platforms, such as video conferencing systems. However, challenges persist even beyond the immediate effects. Current crises, including significant increases in energy costs, have added barriers to attending physical training locations, particularly for external training sessions. At the same time, remote work and learning have become integral to modern educational and professional practices. To address these evolving demands, virtual 3D environments present a compelling option for creating authentic and engaging learning experiences. This article explores the unique characteristics of virtual 3D spaces and their application in higher education and adult learning settings.

During the pandemic, limited preparation time required the rapid adoption of online tools, primarily video conferencing systems, to support synchronous and asynchronous learning. Although effective for continuity, these tools often lack the immersive qualities necessary to foster a robust sense of presence. Virtual 3D environments offer a remedy by enabling participants to interact as avatars ("alter egos") within richly designed spaces conducive to learning. This paper elaborates on

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the attributes of such environments and demonstrates their potential through concrete educational scenarios.

The Pedagogical and Technological Framework provides an overview of the fundamental features of 3D virtual spaces. The following sections details a specific learning scenario developed for advanced computer science students, showcasing its integration into existing e-learning infrastructures (Initial phase: Testing with TurtleSim). The scenario emphasizes collaborative group work, with key considerations described in Main Scenario: Autonomous Navigation in a 3D Obstacle Course. Furthermore, the inclusion of pedagogical or conversational agents as virtual assistants is discussed in Next steps. These agents play critical roles, from onboarding learners into the virtual environment to facilitating the achievement of educational objectives. Their functionality extends to assessing and supporting varying levels of competency, as elaborated in the subsequent section. Preliminary results are then presented, followed by the conclusion and an outline of future research directions.

This paper describes ongoing scenarios currently under implementation, with evaluation processes still in progress.

Virtual 3D Rooms

Immersion plays an important role in a virtual learning environment, that is, ‘immersing’ or ‘sinking’ in an artificially generated environment. Studies have shown that immersion in virtual environments has a major impact on learning efficiency (see, for example, (Pagano, 2013)). This is achieved, for example, by allowing multiple perspectives, situated learning, and transfer (Dede, 2009). Meanwhile, proven immersion environments are virtual 3D environments. (Churchill & Snowdown, 1998) argue that there is a ‘paradigm change’ because such virtual environments ‘provide a space that contains or encompasses data representations and users. Virtual 3D room support supports the fact that the key aspect of many pedagogical methods and theories involves how students learn through observation, imitation, and interactions with other students and the instructor (Beck, 2019).

Regarding the virtual user experience, there are two aspects (Girvan, 2018): sense of presence (“being in a virtual room”) and ‘Shaped by its inhabitants’ (the user ‘inhabitant’ can become a content consumer and a content producer). The user experience is also influenced by technical features (Girvan, 2018): avatars, multiple concurrent users, content creation tools, persistence, and space representation. The interaction of an avatar is significantly influenced by the so-called "embodiment", e.g. by appearance, gesture options, facial expression, etc. (Churchill & Snowdown, 1998) However, social proximity (Borkovic, Skovira & Kohun, 2021), that is, proximity to someone opposite, can also play a role in a virtual environment. "Walking through" a person is not usually possible, but if one avatar encounters another on their way (for example, if the user in question is inexperienced in controlling his/her avatar) and then automatically stands in front of you, this can lead to a feeling of distress. Since the virtual 3D world is basically just a piece of software, countermeasures can be taken if necessary, for example, by placing a "ban mile" around the avatar in order to maintain the social distance (Borkovic, et al., 2021; Figure 1); this is 1,2 to 2.1 metres.

Figure 1. Proximity (generated in part by AI)

Intime distance, personal distance, social distance

Virtual 3D environments are advantageous in many ways in contrast to, for example, often used 2D video conferences. Simple conversational situations are perceived as more natural than in 2D environments (Garau, et al., 2023). The virtual environment can be comfortable and friendly, so that this environment can trigger relaxation, silence, and pleasure in the user. Induced positive emotions can be a decisive factor for collaborative work and self-regulated learning, which is also reinforced by intensive flow and presence experience (Boekaerts, 1996). In general, for collaborative learning and working, spatial and social immersion are central characteristics of these environments, as well as appropriate usability. Spatial immersion means feeling as being in another place as in reality (Boekaerts, 1996; Zinn, et al., 2016). In (Lai, 2011) it is postulated that the effect of collaborative learning depends on the quality of the interaction. With distributed learning, virtual 3D environments offer better possibilities than, for example, video conferences or asynchronous media such as Wikis or chat groups.

In principle, virtual worlds promote the activity of participants, since the avatar reduces risk perception, especially for shy and insecure students (Lueckemeyer, 2015).

It makes sense to offer the possibility to place (interactive) 3D objects in such a 3D environment, which can also be interacted with in a protected, safe environment (Mantovani & Castelnuovo, 2003). In this way, digital twins can also be integrated into the 3D environment (Qi, et al., 2019). The size of objects can also be experienced particularly intensively in a virtual 3D environment.

"Second Life" can be seen as a quasi-pioneer of virtual 3D worlds; this environment is still used in some cases, for example (Dede, 2009) in the context of 'self-efficacy'. In the meantime, there are now many commercial and open source providers of virtual 3D environments.

Pedagogical and Technological Framework

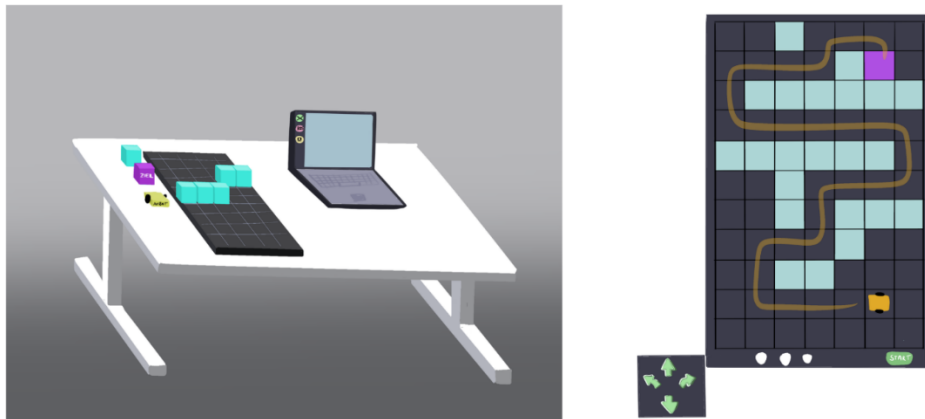
This study explores the implementation of a cyber-physical application in a computer science course where students program a virtual robot to navigate a maze. Learners begin by constructing a parkour using a dedicated editor. This scenario is enriched with a gamification component, where participants, represented as avatars, compete to complete the maze as quickly as possible. The interactive nature of this learning environment not only fosters engagement, but also develops multiple competencies through group work. Additionally,

conversational agents are employed to diagnose programming errors and provide targeted assistance.

This virtual 3D learning environment is used primarily for programming training in universities. While previous efforts focused on teaching basic programming languages to early-semester students (Lueckemeyer, 2015), the present project builds on previous research (Lecon & Herkersdorf, 2014) by challenging students to program algorithms to control a robot navigating a maze. Students first create and animate the robot using 3D modelling tools, followed by group collaboration to program its movements and address challenges such as collisions and item collection. This competitive and gamified approach, in which run times are compared between groups, adds an additional layer of motivation.

The first concept is shown in Figure 2. Each student is provided with a virtual workstation. The grid board on the left side can be used to build the obstacle course. With the laptop on the right side of the desk, the students can set up and execute the code. The concept also includes a top view of a possible result.

Figure 2. Concept, see also (Lecon et al., 2024)



Integration into the e-Learning Infrastructure

To ensure seamless integration of virtual 3D environments into existing educational frameworks, appropriate interfaces were developed. These interfaces link the Learning Management System (LMS), the 3D environment, and a code repository, usually based on version control systems (Spinellis, 2004). Students access the virtual environment through the LMS, enabling integration of real-time program code analysis and conversational agent support. Robot log data is also transmitted to LMS to track task progress and results.

Future enhancements aim to synchronize real-world robots with their digital twins in virtual space. Real-world data, gathered through sensors, will be used to dynamically generate virtual environments, bridging the gap between physical and virtual learning experiences.

Collaboration in Virtual 3D Spaces

Collaboration, defined as a joint problem solving effort where participants learn together (Lai, 2011), is a cornerstone of this approach. Unlike cooperation, which involves independent contributions, collaboration emphasizes collective interaction, fostering group synergy. Meta-analyses suggest that collaborative learning particularly benefits lower-performing students, while heterogeneous groups achieve optimal outcomes due to diverse skill sets (Oliver, & Marwell, 1988); Macy, 1999).

In practice, interdisciplinary groups comprising computer science and user experience students have demonstrated superior creativity and functionality in virtual reality projects. Factors like social facilitation also play a role: experienced students often perform better under observation, while less experienced ones benefit from reduced stress due to avatar-mediated partial anonymity (Harkins, 1987).

AI-Assisted Conversational Agents

The use of AI in education often began with the use of "intelligent" chatbots (Adamopoulou & Moussiades, 2020). AI, especially language models, has now advanced to the point where they can act as individual contact persons ("agents") with natural language input and output (Terzidou & Tsiatsos, 2014; Zargham, et al., 2021). The basis is often ChatGPT, with its strengths, but sometimes also (initial) limitations (Thorp, 2023).

In asynchronous learning settings, conversational agents act as pedagogical supports, assisting students navigate the virtual environment or troubleshooting programming challenges. These agents, represented as avatars, offer natural language communication and gesture-based interactions to enhance immersion. The use of AI-controlled avatars has now also arrived in the educational sector (Doe et al, 2025).

Design considerations for these agents include:

Dialogue Mode: Text-based, speech bubbles, or natural language communication.

Appearance and Accessibility: Visibility on-demand or at predetermined locations, with customisable designs to foster trust.

Two modes of interaction are envisioned: direct student queries and proactive intervention when errors are detected. For example, agents can analyse the source code stored in a version control system (VCS) and provide feedback on errors, suboptimal solutions, or alternative approaches.

Metrics for Learning Objectives

Learning outcomes are structured using Bloom's taxonomy and its extensions, such as the Anderson-Krathwohl taxonomy (AKT) (Anderson & Krathwohl, 2001). Building on this, there are further simplified (Dreyfus SE, 2004) or domain-specific (Kiesler, 2002) taxonomies. In general, competencies are categorized across cognitive dimensions—remembering, understanding, applying, analyzing, evaluating, and creating. For programming education, competencies include:

Remembering: Recalling syntax and concepts.
Understanding: Grasping semantics and development environments.
Applying: Implementing solutions that adhere to quality standards.
Analyzing: Identifying optimal algorithms for specific problems.
Evaluating: Assessing algorithm efficiency.
Creating: Developing functional software solutions.

The integration of AI-driven conversational agents aligns with these cognitive objectives by offering targeted support and improving student autonomy.

Results

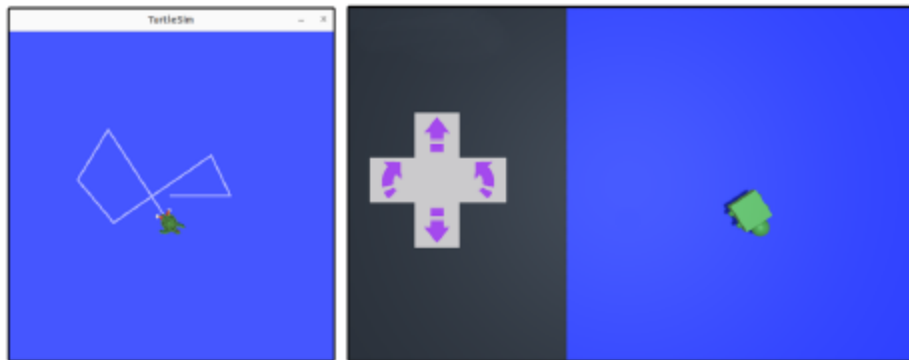
The concept was implemented by developing a robot simulation using the ROS interface (Koubâa (ed.), 2017). To provide consistent development conditions for all students, a standardised virtual machine (VM) was created. This VM includes an installation of ROS2 Iron Irwini, a distribution of the Robot Operating System 2. ROS2 serves as middleware, enabling communication between the various components of the system.

This setup ensures that students can work in a uniform software environment, regardless of the underlying hardware. For the development of the simulation environment, the Unity 3D game engine was chosen, as it is well-suited for creating interactive 3D scenarios. Unity also offers the "Unity Robotics Hub," which facilitated the integration of a ROS2 TCP Connector. This plugin enables bidirectional real-time communication between Unity and ROS2 via standard or custom topics. As a result, Unity can send data to ROS2 and receive ROS-based data in return for visualisation purposes.

Initial Phase: Testing with TurtleSim

To test the environmental setup before developing the main simulation scenario, "TurtleSim" was used. This lightweight ROS-based simulation tool is typically used for educational and introductory purposes. The initial testing phase served as a technical proof of concept to verify the stability and bidirectionality of the communication between ROS2 and Unity through the ROS2 TCP Connector. TurtleSim was chosen due to its simplicity and seamless integration within the ROS2 framework. It includes implementations of core ROS concepts such as nodes, topics, and message structures.

Figure 3. Bidirectional Communication using TurtleSim



To achieve the simulation result shown in Figure 3, several key steps were taken. The 2D top-down visualisation of TurtleSim was recreated in 3D using Unity. The ROS2 topic “geometry_msgs/Twist” was used to transmit linear and angular velocity commands to the simulated turtle. Both environments subscribed to this topic to monitor movement commands, enabling real-time positional updates. Additionally, a custom control menu was implemented in the 3D visualisation, allowing users to send new position data to the TurtleSim topic.

As a result, both the simulation within the ROS2 environment and the Unity 3D environment displayed synchronised movements with minimal delay. This successful bidirectional data exchange between Unity and ROS2 confirmed the reliability of the ROS2 TCP Connector and established the technical foundation for implementing more complex navigation and visualisation features in the main simulation scenario.

Although TurtleSim was not intended for direct student use, this phase was essential to ensure the robustness of the communication architecture before proceeding to student-facing simulations.

Main Scenario: Autonomous Navigation in a 3D Obstacle Course

After completing the TurtleSim phase, the next step was to develop a scenario that met both technological and pedagogical objectives. A 3D environment was created in which students could test their pathfinding solutions – either as algorithms (see, for example, (Hart, Nilsson & Raphael, 1968)) or by using sensor data. To support this, a dedicated workstation setup was designed, featuring a monitor for saving, loading, and resetting functions. On the other hand, a board with an adjustable grid size was provided. Students could place cubes on the board to act as obstacles. In addition, they could position a robot model as the starting point and a sphere as the destination. If the pathfinding algorithm was successful, the robot would be animated along the grid to the destination point.

System Architecture Overview

The architecture consists of the following core components:

The **ROS2 back-end**, which runs inside the virtual machine, is responsible for receiving the grid layout, as well as the start and goal positions. Calculate the path and outputs the corresponding movement commands. This is the component in which students implement and test their pathfinding solutions.

The **Unity front-end** handles the visualisation of the robot and its environment. It allows for user interaction and manages the exchange of messages with the ROS2 backend. In the front-end, the user can set up the obstacle course and position the robot and the target. Using buttons on a virtual screen, the player can save, load, reset, or send the course to the ROS2 backend.

Obstacle Course Creation

The obstacle course was entirely designed in Unity, representing the environment in which the virtual robot would operate.

The grid is generated in an empty GameObject that has been placed on the desk pad. A script called "GridController" has been added to the empty GameObject. The number of rows, the number of columns, and the GameObject to be placed can be transferred to this script via the Inspector. In this script, a two-dimensional array is first created in which the generated objects are stored. The grid is then generated using a function called "BuildGrid". In this function, the width is first read from the transferred GameObject. The objects are then generated in two nested loops and moved to the correct position.

The object that is arranged in the grid is a prefab called "GridField". There are three sub-objects in this prefab. First, there is a visible object in which the player can recognise the individual cells of the grid. There is also an invisible BoxCollider above the visible object. A script called "GridFieldControl" has been added to the collider object to control this field.

The following variables can be set for this script via Unity: two colours can be defined. One is the normal colour, and the other is the colour that the object should have when a block is in the trigger. In addition, the cell object that is to be coloured and the position at which the block is to be located after the snap can be transferred. At the cell start of the script, the colour is first set to the default colour. As soon as an object collides with the collider, it is checked whether it is an object that has the "Gridable" tag. If this is the case, the colour of the cell is changed, and the object is temporarily stored. If the object leaves the collider again, the colour is changed again, and the cached object is deleted. As long as the object is in the collider, a check is made every frame to see if the object is released. If the object is released, the position of the block is adjusted to the previously defined block position, and the collider is deactivated.

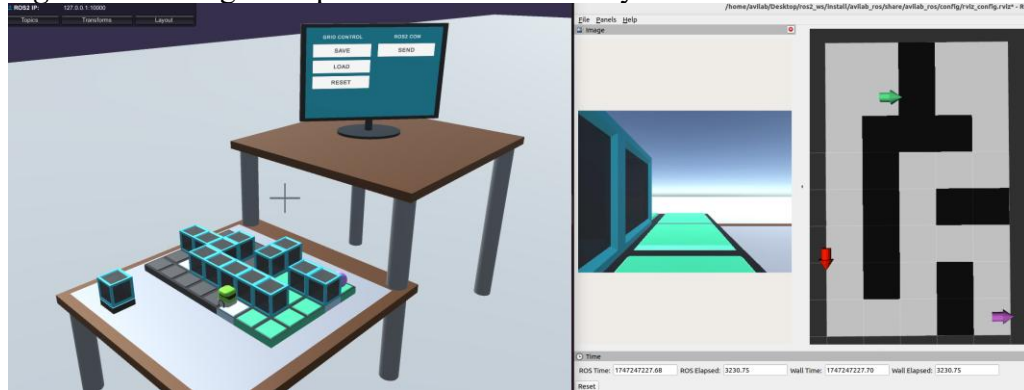
The blocks are generated infinitely via a "BlockSpawner". The "BlockSpawner" also consists of three components. The visible part of the object is similar to the grid cells. There is also an empty object in BlockSpawner that stores the spawn position. The most important part is the collider. This again consists of a BoxCollider and is located above the visible part. The "BlockSpawner" script has been added to this object. In the script, the block to be placed, the position, and the delay can be changed in the Unity Inspector. The script has been programmed so

that a new block is generated in the collider each time a block leaves the collider. This ensures that sufficient blocks are available for the construction of the obstacle course.

An additional object was placed in the middle of the block with a small box collider. This object has been given the tag "Gridable". This additional object ensures that the block is recognised by a maximum of a single grid cell at any time.

A 3D model of a robot has already been created, which is to be edited in the next steps so that it can be placed on the grid (see Figure 4; the (stylized) light green robot is at the front). A target point should be modelled, which should also be placed on the grid.

Figure 4. Running Example of the Course in Unity and ROS2



Communication between ROS2 and Unity

The communication between ROS2 and Unity takes place via a TCP connection. The virtual machine (VM) running ROS2 was configured to forward TCP port 10000 into and out of the VM. In the ROS VM, port 10000 is defined both in `server.py` during the initialisation of the TCP endpoint and in `endpoint.py`. The IP address used is 0.0.0.0. The ROS-TCP-Endpoint opens a TCP server that handles communication. All messages between Unity and ROS2 are transmitted through this TCP server.

In Unity, the official package "ROS-TCP-Connector" by Unity Technologies was used (Unity Technologies, 2025). The ROS settings in Unity are configured as follows: the option to automatically establish the connection at program start was enabled. The communication protocol is set to ROS2. To establish the connection, the ROS IP address was set to 127.0.0.1 and the ROS port to 10000. In this way, Unity attempts to establish a local connection to the virtual machine and the TCP server running on it.

To obtain runtime information about the connection, the "Unity Robotics Visualizations Package" by Unity Technologies was used (Unity Technologies, 2025). Once the `DefaultVisualizationsSuite` prefab is added to the scene hierarchy, the connection information is displayed in the top-left corner of the screen when starting the application. If no connection is possible, the arrows are coloured red. When the connection is successful, the arrows are displayed in blue. This allows users to immediately assess at program startup whether the system is working correctly or not.

Expandability through Sensor Integration

To demonstrate the modularity and future potential of the platform, a virtual camera sensor was added to the Unity Scene. The ROSCamera from the UnitySensors package by Field-Robotics-Japan was used as the camera sensor (Field Robotics Japan, 2025). In a separate script, a ROS message of type CompressedImage is sent to the topic "/camera/color/image/compressed" at the end of each frame. The camera image is rendered in a RenderTexture, then converted to a byte array and sent to ROS along with the current timestamp. There, it can then be displayed using the Camera component in real time and may be further processed. The system is also designed to support a wide range of additional sensors, such as:

- Point clouds from LiDAR sensors (e.g., for obstacle detection)
- Distance, touch, or temperature sensors
- IMU
- Live data from physical robots, enabling hybrid digital twin scenarios

Next Steps

The simulation itself is already partially embedded into an existing Unity-based virtual 3D educational environment. This environment allows users to interact as 3D avatars, participate in conferences or presentations, and communicate via voice chat or emotes. It is highly customisable and can be adapted to a wide range of educational use cases. The integration of our simulation within this world opens new possibilities for collaborative learning and realistic training scenarios.

Parallel to the current development, conversational agents are being implemented in a separate subproject. These AI-based agents are designed to provide individualised support to instructors and can also be integrated into our scenario. Their goal is to assist students directly within the simulation, providing guidance, answering questions or explaining tasks—even when a human instructor is not present. This enables a more flexible and autonomous learning experience, particularly valuable in asynchronous or remote educational settings.

The next development steps focus on the following:

- Full integration into the virtual 3D environment: While the virtual environment is currently being successfully simulated, full integration into the interactive world is still ongoing. The necessary communication interfaces, based on the publish-subscribe model provided by ROS2, are already in place and will enable seamless interaction between the simulated systems and the virtual environment.
- Evaluation through practical application: The effectiveness of the system will be evaluated in two educational settings: one in a traditional face-to-face university, where students will collaborate synchronously in groups, and one at a distance learning university, where group work will occur asynchronously. This evaluation will help assess both the technical reliability and the pedagogical value of the solution in different learning contexts.

These next steps aim to ensure that the simulation system not only functions reliably on a technical level but also adds clear value to digitally enhanced teaching and learning scenarios.

Conclusion

This study introduced a robot programming learning scenario within a virtual 3D environment, highlighting its potential to address the challenges of teaching and learning in remote or hybrid contexts. Such environments are particularly advantageous when traditional face-to-face teaching is not feasible, such as during pandemic-related restrictions or in distance learning courses. At the same time, it shows a concrete use case for virtual 3D spaces in education.

Virtual 3D environments offer significant benefits by bridging the methodological and didactic gaps inherent in practical courses, such as programming and laboratory seminars. They provide enhanced spatial and social immersion, allowing for more natural communication compared to two-dimensional platforms. Immersion can be intensified through the use of head-mounted displays (Wu, Yu & Gu, 2022). Our application supports these devices. However, the test runs so far have been conducted directly on the PC, so intensive immersion is still achieved; therefore, maintaining a class set of head-mounted displays is not absolutely necessary.

The described scenario involved developing and implementing algorithms to navigate a robot through a course designed by trainers or learners. This practical result is visualized as a 3D model, where the robot's movements occur in real time within the virtual space, enhancing experiential learning.

Participants, represented as avatars, benefit from the social immersion these environments offer. While avatars enable partial simulation of facial expressions, they also promote objective and focused communication. In addition, computer-generated conversational agents can be integrated to support users, serving as accessible and responsive points of contact for technical guidance and navigation within the virtual environment.

A prototype of this system has been developed as a proof of concept. Future work will focus on evaluating its effectiveness in both traditional university settings as a supplement to classroom teaching and within the curriculum of an online distance learning university.

Acknowledgments

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An Investigation into the Essence of Short-Term Experiential Learning Field Trips to an Operational Prison

*By Ger Coffey**

Short-term field trips enable learners to bridge the pedagogical gap between academic knowledge (theory) and the practicalities of their discipline in a real-world setting. In Ireland, there has been a dearth of empirical research into the essence of short-term field trips as a teaching and learning strategy for criminal justice students. The purpose of this article is to bridge that pedagogical gap through thematic analysis of qualitative data of student learning experiences in the context of a short-term field trip to an operational prison. Research findings based on semi-structured interviews with students who participated in the active learning experience show evidence of the essence of experiential learning activities which could not be achieved to the same level in academic seminars alone. In essence, students contextualise their academic (theory) knowledge, which is a catalyst for gaining a deep and flexible understanding. In consequence of the sensitive nature of the operational prison, and compliance with security protocols, some limitations were also reported by participants, notably the short-term duration of the field trip and the use of conventional methods of documenting active learning experiences was not possible.

Keywords: higher education, participatory action research, experiential learning, short-term field trip, operational prison, reflection in action, reflection on action, thematic analysis of qualitative data

Introduction

Experiential learning activities remove discussion from the abstract in academic seminars and facilitate students to apply their knowledge in a real-world setting. Enhanced learning in this context is achieved by flipping what normally occurs in academic seminars to active learning experiences. Short-term field trips are experiential learning opportunities to bridge the pedagogical gap thereby facilitating learners in making connections between academic knowledge (theory) and the practicalities of the discipline. In the context of a criminal justice module, the integration of field trips to an operational prison in the curriculum is designed to enhance the conventional and somewhat formulaic learning experiences for students. In academic seminars, students would typically ask about the practicalities of criminal justice and sentencing processes and were notably interested to learn more about the environment wherein convicted offenders would serve their custodial sentence, and whether non-custodial sanctions would be more appropriate for suitable offenders.

This investigation into the essence of short-term field trips to an operational prison was conducted in the context of a postgraduate criminal justice module in an Irish university setting. The motivation for this investigation is the deficiency of

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empirical research into the essence of short-term field trips as a teaching and learning strategy for criminal justice students. Research findings show evidence that field trips provide a unique opportunity for students to gain a deep and flexible understanding of the practicalities of the criminal justice process, principles of sentencing and the functionality of an operational prison from the perspectives of prisoners and staff. Significantly, this level of understanding could not be achieved to the same level in academic seminars alone. Owing to the sensitive nature of an operational prison and compliance with security protocols, there were some limitations on student learning notably the short-term duration of the visit (approximately two hours). Moreover, conventional methods of documenting active learning experiences such as sketches, drawings, videorecording and photographs were not possible.

Literature Review

The recommendations (core principles of improvement) of the *Carnegie Foundation for the Advancement of Teaching* (Sullivan et al, 2007), with particular reference to the ‘anchor practice improvement in disciplined inquiry’ principle, underscore the benefits of integrating experiential or practical aspects of legal education with academic knowledge (Siegel, 2009). In the context of a postgraduate criminal justice module, the unique opportunity enabled students to make connections between their knowledge and theory gained in academic seminars (augmented by self-directed learning) with the practicalities of sentencing principles and disposition of offenders. In essence, criminal justice is a living discipline that requires students to interact with criminal justice institutions, professionals, members of the judiciary and fellow students.

A ‘new way of knowing’ (Schön, 1995b) the dimensions and levels of student understanding and abilities to apply their knowledge in a real-world setting underpins this investigation. Field trips are a type of participatory action research wherein students participate in experiential learning activities by integrating their knowledge gained in academic seminars with the practicalities of the discipline in a real-world setting.

Experiential learning correlates with Schön’s (1995) critique and augmentation of Boyer’s (1990) model of four scholarships (discovery, integration, application (engagement), teaching and learning). Moreover, with the impetus on Schön’s ‘new epistemology’ or ‘new way of knowing’ the dimensions and levels of student knowledge and understanding there is exciting potential for integrating experiential learning activities with particular focus on the purpose dimension of disciplinary understanding. This underscores the imperative of providing a purpose and structure for student learning incorporating short-term field trips.

This investigation is grounded in ‘experiential learning’ or ‘learning by experience’ cycle (Kolb, 1983; 2015; 2017) that involves students as active participants in their own learning through applying their knowledge in real-world settings (Kolb et al. 2001). Utilising this pedagogical tool is pivotal to teaching for understanding (TfU) and the imperative of students learning by doing through performances of understanding (PfU). This approach serves to enhance student knowledge with a deep and flexible understanding as they progress on their journey of learning and discovery from apprentice to mastering the discipline (Boix-Mansilla & Gardner, 1998).

While experiential learning activities have been utilised as a teaching and learning strategy within cognate disciplines to law integrating theoretical knowledge with practical experience (Sinha et al, 2017; Bogo, 2015; Wright, 2000; Scarce, 1997), field trips as an effective pedagogical tool enhancing student learning experiences have conventionally been underutilised across disciplines (Scarce, 1997; Wright, 2000). Indeed, many students who participated in the field trip commented that this was their first experiential learning opportunity to observe the practicalities of criminal justice.

The field trip was unique experiential learning activity that facilitated learners to reflect ‘in’ and ‘on’ their active learning experiences. In the context of an operational prison, experiential learning activities contextualise academic knowledge of the criminal justice and sentencing processes. Moreover, a deep and flexible understanding of abstract concepts is underscored during field trips (Wright, 2000), which are integrative, active learning activities. For criminal justice students, this depth of knowledge and understanding could not be attained to the same level in academic seminars. Significantly, active learning opportunities enable students to make connections between academic knowledge (theory) and practice, “at a depth that cannot be gained through books and lectures alone” (Wright, 2000: 117). Hence, the importance of looking to cognate disciplines for inspiration and innovative ideas for enhancing active learning experiences for criminal justice students. Drawing from cognate disciplines where experiential learning activities regularly feature in teaching and learning pedagogies (Payne et al. 2003), the essence of experiential learning is underscored for students where knowledge and understanding of the practicalities of the discipline are key to bridging the pedagogical gap between academic knowledge (theory) and operational prisons. This teaching methodology enhances student learning experiences through ‘learning by doing’ and prepares students as graduates with transferrable skills for their professional career within the discipline (Schön, 1983; 1987).

Bridging the pedagogical gap imbues students with a sense of excellence in their knowledge and depth of understanding, being socially responsible and ethical professionals, and their contribution will be meaningful to their profession and to society (Gardner et al. 2001). In the context of the field trip to an operational prison, respect for staff and prisoners was ensured through compliance with ethical standards and security protocols. The interactive visit did not objectify or oppress prisoners or staff, and the avoidance of voyeurism was maintained throughout the visit. While there are many benefits for students through experiential learning, these activities must be conducted with dignity and respect for prisoners and staff (Meisel, 2008).

The importance of carefully planned field trips is underscored through ensuring learners are prepared adequately in advance and encouraged to actively participate in the experiential learning activities. Careful planning and preparation in advance, especially for large groups of students, is key to ensuring an effective implementation of field trips. The timing of the field trip within the curriculum, planning on the day of the visit, compliance with protocols mandated by the institution being visited and post-field trip discussions are effective approaches to alleviating potential logistical concerns (Muse et al. 1982).

Ensuring that effective pre-trip preparations are performed, overseeing insurance cover where applicable, expenditure where applicable, travel arrangements, punctuality, gaining access to institutions (which in the context of an operational

prison required compliance with security protocols), gaining prior research ethics approval to conduct empirical research (this can be a laborious task) before post-trip data gathering, and insufficient administrative supports have been reported as the common logistical issues associated with field trips (Anderson & Zhang, 2003; Scarce, 1997). Moreover, time commitment from students can be challenging owing to their academic workloads. Educators should not underestimate the preparation involved in the planning and organisation of field trips, the field trip itself, and the post-trip evidence-based data (such as interviews or surveys) to document student individual learning experiences (which in the context of this investigation entailed transcription of audio-recordings with participants and judicious analysis of qualitative data) (Muse et al., 1982).

Significantly, field trips are integrative and rewarding experiences, facilitating learners to think critically and creatively (Scarce, 1997). The importance of preparing students in advance so that they know what to observe during the field trip and motivation to apply their knowledge is key to enhancing their reflective learning both during and following the field trip. These active learning events take place outside the confines of academic seminars (Boyle, 1995), thereby enabling students to challenge stereotypes and preconceptions (Scarce, 1997). Hence, the importance of ensuring that field trips are effectively synthesised within the curriculum, and most importantly that students are given a purpose and focus to structure their experiential learning activities (Grant et al., 1981; Wright, 2000); otherwise, these unique learning opportunities would be greatly diminished (Muse et al., 1982).

The benefits and limitations of experiential learning activities in criminal justice education have been copiously documented (Skaggs & Graybeal 2019; Belisle et al., 2020; Clevenger et al., 2017; Calaway et al., 2016; George et al., 2015; Beck et al., 2017; Smith 2013; Robinson, 2000; Wolfer et al, 2000), which include enhancing student understanding of the discipline and making the module content more relatable. These benefits are achieved through learners actively engaging with their academic (theoretical) knowledge, which has exciting potential to inculcate an enhanced motivation for self-directed learning of the discipline (Scarce, 1997). Moreover, the benefits of research in action gaining criminal justice student perspectives on active learning experiences in academic seminars (Baxter & Ely, 2019) also informs this participatory action research in the context of an operational prison.

Experiential learning enables effective transition between education and professional career choices, in addition to further studies related to the discipline which students might not have previously considered (Wright, 2000; Rippetoe, 1977). Research based on student surveys have reported that field trips also enable learners to focus and define their professional career objectives (Gore & Nelson, 1984).

The journey of learning and discovery through higher education should encompass more than learning in the discipline; the importance of students developing their social skills is also facilitated through engaging with fellow students during experiential learning activities (Cantor, 1995; Wright, 2000).

There is a dearth of published research into the essence of field trips to criminal justice institutions as a teaching and learning strategy in Ireland. Perhaps, this lacuna is because criminal justice modules have only been taught in Irish higher education institutions since the 1990's when teachers began to conduct research into the growing

phenomenon of criminal justice as a discipline (O'Mahony, 2002). With the exception of Higgins, Dewhurst, and Watkins (2012), there is a deficiency of published on experiential learning in legal education. The context of short-term field trips that were the focus of their investigation included courts of criminal justice, professional training bodies and law firms. The methodology involved a survey of students who participated in the educational tour, and research findings reaffirm the benefits and limitations of experiential learning albeit in the context of legal education more generally. Empirical evidence showed that structured field trips in the context of legal education is a valuable short-term experiential learning pedagogy which could be strategically incorporated into the curriculum. The active learning event provided students with a unique opportunity to observe the law in action, contextualise their academic knowledge (theory) and develop important discipline and personal skills (Higgins et al. 2012). Moreover, the opportunity for students to apply their knowledge in a real-world setting increased levels of understanding in the context of the multifarious activities of legal professionals. Such learning activities are significant for students, and educators alike, to gain an appreciation of their levels of understanding. While their research was conducted in the context of legal education more generally, using student surveys as a research methodology, the research findings are relevant in the context of this investigation through semi-structured interviews into the essence of a field trip to an operational prison. Notably, gaining access to legal education institutions are relatively unproblematic, unlike the sensitive nature of an operational prison and compliance with security protocols.

The heart of this research is not in the literature review as such but rather it is in the unique qualitative thematic data set that has guided this investigation as to what to emphasise in the literature review. While there is a dearth of research into short-term field to an operational prison in Ireland, a review of pertinent literature on experiential learning reveals pedagogical benefits, and some limitations, for students in making connections between academic knowledge (theory) and practice.

Methodology

The foregoing literature review into the use of field trips in higher education across cognate disciplines, and the reported benefits and limitations for learners, informs the research methodology for this investigation.

The application of core ethical principles to research activities underpinned the design and implementation of research methods. Research ethics approval was granted by the university research ethics committee before conducting the semi-structured interviews with students that were audio-recorded and transcribed to document individual learning experiences. A gatekeeper (senior postgraduate administrator who was independent and impartial and not in any way involved in the research investigation) sent an invitation letter to students with a request to participate voluntarily in the evaluation of their experiential learning. The invitation was accompanied by an information letter explaining the purpose of the semi-structured interviews which expressly stated that participation was voluntary, and emphasised that students were under no obligation to participate in the empirical research, thus

ensuring informed consent. Anonymity and confidentiality of participants was assured through the use of pseudonyms in accordance with research ethics approval (e.g., P1 = Participant 1). The information letter included contact details for the gatekeeper to address student queries or concerns, and details of student support services provided by the university in the event students became distressed before, during or after the semi-structured interviews (visiting an operational prison might have been a daunting experience for some students).

Research Design

The bespoke part of this investigation was informed by participatory action research through collaboration with students who participated in the field trip, guided by Kolb's experiential learning cycle (Kolb, 1983). This involved a cyclical process of planning, action and reflection via collaborating with participants through empirical analysis of student knowledge and understanding (cognitive domain), attitudes and beliefs (affective domain), and motivation.

The field trip was an optional experiential learning activity for students and not a required part of curriculum. Discussions in academic seminars with analyses of criminal justice and sentencing law and policies, augmented through self-directed learning, are key to prepare students in advance for the unique opportunity to apply their knowledge in a real-world setting. During the semester, learning was enhanced by guest lectures delivered by a Public Prosecutor on the practicalities of the criminal justice process, and by a Court of Appeal Judge on the practicalities of the sentencing process, which many students alluded to in the interviews greatly enhanced their preparation for the field trip. Students were encouraged to watch institutional videos available on the Irish Prison Service website that provided insights into the internal functioning of an operational prison showing various aspects of prison life to gain broader perspectives and insights on the prison environment, culture, facilities and range of activities engaged in by prisoners.

A pre-trip information session with students was organised a week prior to the event when they were instructed on the imperative of compliance with security protocols on entering the prison, and were guided on what to look for during the visit including the security screening process, visiting rooms for family members of prisoners, size of cells and facilities within those confines (multiple prisoners were accommodated within each cell), recreation area, education centre and medical facilities. Significantly, students were given a purpose for the visit and were encouraged to think critically and creatively beyond the confines of academic seminars, to challenge their preconceptions and to actively engage with the interactive field trip.

The field trip took place in week ten of a twelve week autumn teaching and learning semester and was the centre piece of the criminal justice module. At this stage of the semester, students would have had gained a sufficient knowledge of the discipline, and the timing also facilitated a post-trip discussion and feedback session. The conversational tour of the prison included the reception area, visiting rooms, exercise yard and recreation area, medical centre, education centre, and prospect for rehabilitation for enhanced status prisoners.

The logistics of travelling to and from the prison located in the city centre, punctuality in accordance with the prescribed timeframe for the visit, and what to expect during security screening were also addressed during pre-trip discussions. Visitors are subjected to screening procedures, including X-ray scanners, walk-through metal detectors, and canine screening to detect and prevent the introduction of prohibited items such as drugs, weapons, mobile phones and electronic devices. The visit could only take place when the prison was on lockdown at lunchtime between 12:30-2:00 p.m., therefore it was imperative for students to arrive on time so as not to cause delay especially in consideration of the strict time constraints, going through security protocols and ensuring respect for prison staff who facilitated the visit. Students were encouraged to participate fully in the experiential learning activities and to engage with individual aspects of the visit. The prison officer who led the conversational tour gave an informative account of the history of the prison, details of persons within the care of the prison (including gender, nationality, range of offences for which they had been convicted) and respecting the human rights of prisoners within the care of the Prison Service. Students also had a meeting with the Governor who emphasised the interrelationship between the implementation of prison policy within the relevant legislative framework governing the operation and management of prisons.

Reliable and valid qualitative data collection is key to the research design. All eleven students who attended the field trip were invited to participate in semi-structured interviews on a one-to-one basis. Eight students accepted the invitation and the conversation-based interviews were designed to elicit insightful data on individual learning experiences. The interviews were scheduled during the spring semester following the field trip. This approach was informed by 'reflective space' wherein students had time to 'reflect on' their learning, having 'reflected in' their learning during the field trip. Research findings were greatly informed by student diversity in terms of gender, educational background, and international profile: four male students and four female students; one full-time female student each from the United States, Nigeria, and Ukraine; four part-time male students (three police officers and one fitness instructor), and one full-time female mature student.

Research Method

The key research method used to document and investigate the essence of field trips was one-to-one in person semi-structured interviews with participants to document insights from their individual learning experiences. The interviews were based on open-ended questions to allow respondents to answer in their own words, capturing detailed and nuanced responses. Moreover, this method facilitated the combination of meanings behind responses within their particular context (Joffe & Yardley, 2004). This approach was augmented by a less direct method through my own observation of student engagement and transforming attitudes during the field trip.

Accuracy in analysis and reporting of participants' responses was ensured by transcribing audio-recordings of interviews. Thematic analysis of qualitative data was utilised when examining interview transcripts (dataset) to identify common themes showing evidence of transformative learning, which is the anchor for this investigation. Qualitative data analysis was the most appropriate research method for gathering and

documenting individual learning experiences, as opposed to quantitative or mixed methods approach given the sensitive nature of this investigation (Cohen et al., 2018).

These were the most appropriate methods for analysing and documenting themes and finding common patterns across responses showing individual learning experience (Riessman, 2005). Significantly, the context is vital to the research methodology employed that was restricted by the sensitive nature of an operational prison wherein compliance with security protocols takes precedence.

Results

Research findings are informed by the literature review documenting the benefits and limitations of field trips in cognate disciplines. The results of this investigation correspond to pertinent literature on experiential learning for criminal justice students, which enhance understanding of the discipline, module content is more relatable, removes preconceptions and transforms attitudes (Belisle et al., 2020).

Responses were incredibly positive with insightful comments that showed evidence of the impact of experiential learning on student knowledge and understanding (cognitive domain), attitudes (affective learning) regarding convicted offenders, prison staff, the prison environment/culture, recreational and educational facilities, medical facilities, criminal justice and sentencing policies and key areas for reform. All responses acknowledged the field trip experience directly correlated with their discipline and participants commented on the benefits of the experiential learning enhancing their understanding, contextualising their academic knowledge (theory), and further inculcating a motivation for self-directed learning.

The essence of field trips as a teaching methodology with thematic analyses showing the essence of experiential learning on transformative learning engendered in students are presented below, including representative comments.

Module Structure

This question was designed to elicit responses on student understanding of the module sequence, and how criminal justice topics within the module interrelate culminating in the field trip to experience the practicalities of criminal justice and sentencing processes. The end of the semester was the most beneficial time for the field trip as students had gained sufficient knowledge and understanding of the discipline in academic seminars augmented through self-directed learning. Responses clearly indicated that students appreciated and understood the module was structured sequentially and logically through gaining academic knowledge in academic seminars, initially focusing on the criminal justice process before examining the sentencing process for convicted offenders, culminating in the field trip in week ten of a twelve-week teaching and learning autumn semester.

“...definitely ... because with anything you have to do the theory first ... it is not going to make sense if you do not, so I thought the timing was perfect, I think going in at the start and then trying to do the theory would not have worked. It is good to delve into the theory and really examine that before you go because then you can apply what you have learned in that setting To think in a different sort of mindset when you go into the prison whereas I think if we went in at the start [of the semester] to the prison you do not really understand a whole pile around the sentence ... you have to do the theory before you go into the prison.... Definitely the timing worked well for me.” [P-8]

A few students did comment however, that two field trips, one at the beginning and one at the end of the teaching and learning semester would provide more time to reflect ‘in’ and ‘on’ their experiential learning. This brings to light the enhanced benefits for students of having two field trips, one at the beginning of the semester and one at the end of the semester (Sutton, 2024). Students could reflect on their first visit, their knowledge gained during the semester and what has changed (tipping point: turning teaching into learning) in their knowledge, understanding, perceptions, misconceptions during a subsequent experiential learning event. However, the prospects of multiple visits would depend on whether the Prison Service could facilitate such requests.

Module Learning Outcomes

In terms of pedagogical steps, the field trip is synthesised with the module learning outcomes. Prior to the visit, students were encouraged in academic seminars to consider what they might see and observe such as the size of the cell and facilities (such as toilet washbasin, except for an old wing of the prison where prisoners continue to ‘slop out’). In terms of TfU and the thrust of it, the purpose of the field trip was to bring forth preconceptions and to bridge the pedagogical gap and facilitate students in making connections between theory and practice.

The guided inquiry phase of teaching and learning in academic seminars culminated in the field trip during which students could observe firsthand the practical realities of what their knowledge, the impact of sentencing policies on prisoners’ lives, and prospects for reform and reintegration back into society.

“It is very important for the module to get a deeper knowledge and understanding See how it is and talk to prison officers and prisoners...” [P-1]

“... it helped me to get a deeper knowledge of the topic and I could explain the [discipline] better ...” [P-3]

“It has opened my mind to other aspects of the law and not just what is going on in the academic side of it ...happy medium between the academic side and the practical side especially with the prison [field trip] which really gave me an idea of ... how our study of the criminal justice and sentencing process actually affects the people who ended up in these places and how their day and their routines are structured ... [P5]

Responses showed evidence that students enhanced their cognitive and affective domains of learning, notably from the perspectives of prisoners and the confines of the prison environment.

Guest Speakers

Student learning and understanding during the semester was greatly enhanced by guest speakers (Public Prosecutor and Court of Appeal Judge) who inculcated real-world perspectives and practical knowledge, valuable insights of the criminal justice and sentencing processes.

“We had a judge down from the Court of Appeal and he said they always try to operate on principles of proportionality and always try and give a rehabilitative element That became crucial what the judge said about proportionality and building in rehabilitation ... trying to listen to the circumstances [of the offender] is really important what you actually look at the prison and you look at what people end up with after conviction. It is really important that we try and give these people a bit of hope. It has really enhanced my knowledge around sentencing and around how the judges [impose a sentence] Why was the sentence so lenient, why did the judge go about it this way or give so much time or suspend so much But when you actually go to these places and you realise what these people are going to be in for ... for the length of their sentences, you realise then why the judges are building in this proportionality where there are trying to build in ... a rehabilitate element to the sentence If we are going to incarcerate people without looking to what other ways, we can integrate them to go back into society I think we have a problem so I think it explained to me how the Irish judiciary operate and why they operate in the way that they do.... [P5]

Some students referred to the meeting with the Governor who alluded to the importance of defence lawyers to effectively advocate to an appropriate sentence, and suggested having a defence lawyer as a guest speaker in addition to the public prosecutor and appellate court judge who could provide different perspectives of the criminal justice and sentencing processes.

Transformative Learning

This was a pivotal question was designed to elicit a broad response from students having reflected ‘in’ (during the interactive field trip) and ‘on’ (during the space following the field trip and before the semi-structured interviews) their experiential learning. All responses were positive and engaging in that this was a unique opportunity to visit an operational prison, see with their own eyes how the prison operates and the opportunity to interact with criminal justice professionals, and low-risk prisoners working in the kitchen and laundry.

Students learned firsthand about the daily lives and activities of prisoners, including prospects for reform, rehabilitation and prospects for being granted parole, albeit dependent on whether sufficient resources to facilitate rehabilitation were available. From simply observing the prison management and organisational structure,

students learned about the roles and functions of prison staff overseeing prisoners daily activities.

Students commented on the day-to-day routine for staff and especially prisoners who are governed by an unwavering regime when to eat, sleep, exercise, family visits, all aspects of life which people generally take for granted. Students also commented on the fact that incarceration not only curtails personal liberty but also personal choices including prescribed meal times, recreation, use of shower facilities, and launder their clothes in accordance with schedules determined by prison regulations.

The following representative sample of responses demonstrate the essence of firsthand experience in a real-world setting and how the practicalities are clearly differentiated from academic knowledge (theory).

What really strikes me is the bang of the door in the prison knowing that they [prisoners] cannot walk outside of that ... that their whole life is institutionalised and really opened my eyes and what we do in courts and what we do as solicitors and practitioners ...” [P-5]

“... to get more practical understanding of the topic ... in comparison to a bachelor’s degree where we just learned off legislation and case law What I liked most is that we could get a deeper understanding of the topic and the [field trip] was very educational as we could see with our own eyes what it looks like ...” [P-1]

“...It is to broaden our horizons more than what we learned just with theory ... [the field trip] is to try to get us think about what is happening in the real-world and what happens in practice rather than what happens in the books ... I think our experience has been structured well to give experience of both sides ...” [P-5]

Significantly, many students commented on gaining internal perspectives of the prison, and appreciated how their academic knowledge (theory) was enhanced through a practical understanding in a real-world setting, especially during conversations with prisoners and staff.

“It was interesting to see how it looked like inside and we got to talk to a few people there and to get to know their experience of punishment It was interesting for me as I come from a different country and as I had a tour to a prison in Ukraine and that was very different ...” [P-3]

“I did enjoy it very much as I was very interested in how the prison looks inside and the daily routine inside the prison and ... it gave me a bit of feeling of what the prisoner could face inside ... it made me think more about if the person will get this or that much sentence what he would face inside the prison...to think about the impact it [the sentence] would have on the person and I presume his future ... one of the prison officers talked about how some prisoners by the end of the sentence they have to go outside in the outer world and sometimes it is difficult for them ... I think that was interesting to think about as I personally did not think about it before...” [P-1]

“It is one thing to read from the book and just talk in theory of this person can get this much sentence and that but then when you see what [the prisoner] actually has to face inside the prison and like what conditions and then you actually start thinking about does he actually deserve this or not so I think the [visit] was useful in that way.” [P-7]

Contextualisation of academic knowledge (theory) was reported as an especially important feature of the field trip.

“... it was very helpful ... and gave a very deep understanding of the sentencing process and what the person has to face inside the prison ... I decided to do my dissertation on the topic of sentencing and the alternatives to imprisonment...” [P-2]

“...going into somewhere where I have never been before, to see what goes on in it It opened my mind to other things; it is a break from the books ... its learning but in a different capacity and more of it is needed.” [P-3]

“It makes you think about the accused, the person, more so if I did not go [to the prison] I would not start thinking about the feelings and like the life perspectives for the person and in theory sometimes the sentencing is much harsh not balanced correctly ... I think its important to look from different sides and not just the theory side ...” [P-5]

These comments were interesting as they highlighted students’ holistic approach to an understanding of their learning.

Students were able to apply their knowledge and understanding flexibly in a new context, an operational prison, as the field trip was an active learning activity. Students acknowledged the benefits of the field trip as experiential learning to enhance their knowledge and understanding that could not be achieved to the same level in academic seminars.

“...seeing what happens in the real-world ... going out there and seeing what happens in the real-world is an imperative ... and going forward it is something that should be looked at for undergraduate because the law is a big thing more practicality makes me think better about what I am writing about it makes me open my eyes a bit more ... takes away the constant academic [learning] to more what’s going on out there in the real-world and I think you can write the most insightful articles from spending a small bit of time in the real-world and then bringing it back.... Practical visits will make for better scholars, better practitioners” [P-2]

The Prison Governor, whom the students had a meeting following the prison tour, placed great emphasis on the imperative of competent legal representation to avoid the imposition custodial sentences for appropriate offenders. Significantly, the Governor impressed on students they would be practitioners representing offenders and the imperative of having a practical understanding of criminal justice and sentencing options available to judges. Moreover, the Governor highlighted the divergence between criminal justice and sentencing policies enacted in legislation (laws) and the disconnect with the practical considerations that is often experienced by prison staff in dealing with the multifarious issues presented by prisoners within their care.

A day in prison is a long time and many students’ perceptions of sentence length were greatly informed by the experience.

“... we got to see how it works and on a day-to-day basis the daily routine of the prison officers and the prisoners which gave me a deeper knowledge and understanding of how the punishment will be for the person ...” [P-7]

Many responses suggested that suspended sentences, probation and other forms of non-custodial criminal sanction should be invoked by the courts when dealing with minimal risk offenders as opposed to incarceration. Responses also commented on the apparent disconnect between the sentencing courts and disposition of convicted offenders based on competing interests (offenders’ right to a sentence proportionate to the harm caused must be balanced with public interests ensuring safe communities) whether to impose a custodial sentence or give more consideration to the welfare of prisoners ensuring the appropriate care facilities are provided. Interestingly, many students commented on victim participation that could be greatly beneficial through giving the victim a voice and facilitating restorative justice for appropriate offenders. Many students also commented on the cost involved in custodial sentences as opposed to non-custodial measures such as restorative justice, electronic monitoring (approximately €12,000 annually for each offender), and the average annual cost of an available staffed prison space in Ireland is approximately €88,000 for each prisoner. Students considered this approach would ensure a better outcome for all stakeholders.

Preconceptions

A common misconception was that prisoners consumed their meals in communal areas, typically as portrayed in movies, however this is not the case as prisoners consume their food in their cells. Students were also surprised with prison overcrowding with most cells (about 6 feet by 8 feet) having three occupants, whereas the cell was originally designed to accommodate one occupant. The fact that many prisoners have addiction and/or mental health issue resonated with students and their knowledge of sentencing principles and range of sanctions available to judges. Responses to this question considered that many prisoners would be better catered for in a designated mental health facility instead of a prison. Students were also surprised with the length of a prison sentence and the impact on the prisoner’s daily life and future prospects post-release.

“It was important to ...see how the prison system works ... inside the prison ...we got a talk about how the prisoners for example are getting money [for work] and they can buy stuff that they need inside the prison [compared] to my tour of the prison in the Ukraine, that’s not how it works there.... I presume in Ireland their family or relatives can bring things to them but no they actually can’t but they are getting money and can by it in the [prison] shop ...” [P-3]

“We do not think of these people in the same manner as ourselves. The misconception I had was that these [people] are separate to you and me but really, they are not they just people who made mistakes.... I think people have misconceptions they are having a great time in their cells watching their television but really when you look at it these are very small cells, they are confined ... old buildings ... not great ventilation ... it is not the comfort of their living room ... they are told what to eat, what to do, that time to get up It would do away with the misconception that it is all happy days and they are in having a

good time.... It think they are quite scary places, quite institutionalised and I think to be honest they are really no place for anybody unless they have to be there.” [P-5]

Student preconceptions about prisoners having a lavish existence while incarcerated was removed and students were enlightened regarding the day-to-day realities for most prisoners. Notably, prisoners who refuse to engage with activities generally become disruptive, breach prison regulations and engage in criminal activities (including assaults on fellow prisoners and prison staff), and therefore remain in their cells except during meals (and recreational activities unless this privilege has been suspended).

Students were surprised by most aspects of the experience especially the level of security screening including canine screening on entering the prison, the array of weapons made by prisoners, that many prisoners suffered mental health issues, the height of prison walls, 28-day lunch menu cycle with a different meal each day, and low-risk prisoners working in the laundry and kitchen. Students were impressed by the modern recreational facilities. Interestingly, students were surprised to learn that prisoners have access to TV in their cells, video gaming in the recreational area, modern dental surgery and educational section of the prison where prisoners are currently studying for state examinations including junior certificate, leaving certificate and open university courses. Prisoners taking home economics classes are permitted to bring food they have cooked back to their cells. Low-risk prisoners who engage with the opportunities such as working in the laundry or kitchen are generally given a single occupancy cell as a privilege, whereas most cells have two or three prisoners even though the cells were originally designed to accommodate one prisoner. Students were impressed by the professionalism, dedication, and willingness of prison staff to support prisoners who are willing to engage in reform and rehabilitation programmes.

Some students commented on the lack of adequate resources for prisoners who need ongoing professional psychiatric treatment, have emotional concerns, and need spiritual guidance. The available resources for prisoner well-being have not been expanded commensurate with the ever-increasing prison population in Ireland, an issue that students appreciated had a negative impact on many prisoners who need ongoing professional help owing to addictions and mental health issues.

Participants also commented on the dark grey stone buildings dating from the nineteenth century, uniform structure of buildings and regimental nature of the prison.

“What surprised me about [the] prison is that it is really quite old actually it is an old prison ... and what also surprised me are the facts around it, it is the second highest ... [amount of committals] ... the fact that there is not many facilities for women ... What did surprise me is the level of education they put into their staff when it comes to female prisoners and the programmes that they do It is antiquated but they are doing their best to modernise, but it is quite a scary place really. I tried to put myself into the shoes of someone who is walking in there for the first time ... and the quality of the staff is really what overrides the concerns that I would have ... because you really would be quite scared going in there ... the bang of the door, surroundings, the fact that you are going to spend a significant amount of your time in one of these small rooms ... it is quite a scary place so I think that’s what really struck me...” [P-5]

“...the conditions are not as bad as I thought... but in some situations they are as in the old wing of the prison, but they are not as horrific as I thought like when you are reading from the book you get a different imagination of the place.” [P-4]

An international student [P-6] was surprised by the location of the prison in the city centre, whereas in her home state (United States of America) prisons would typically be located some distance from towns/cities. Consequently, prisoners incarcerated far away from home are effectively denied the possibility of receiving visits family members. This student also commented on how the city centre location of the prison facilitated ease of access for family, relations, friends, solicitors, medical staff, religious among others to attend the prison for visits or consultations.

Many participants also commented on the forthrightness of a life sentenced prisoner (with whom they spoke) accepting responsibility, and advised fellow prisoners to accept responsibility for their crimes and make the most of their time while incarcerated by complying with prison rules, regulations and staff, and to engage with opportunities for reform and rehabilitation. This unique opportunity to speak with a life sentenced prisoner and the realities of daily life in prison greatly informed and transformed affective learning.

Benefits and Limitations

It was reassuring for me as their teacher, to find that all students regardless of their academic or professional backgrounds equally benefited from the interactive field trip in terms of enhancing their knowledge through active learning with varying levels of ability to apply knowledge in a real-world setting. Interestingly part-time students who were criminal justice professionals (police officers studying part-time) were able to complement their extensive practical criminal justice experience with their academic knowledge. Students with an academic background could apply their knowledge in a practical setting and students with a professional background could further appreciate their knowledge and understanding of the practicalities based on their newly acquired academic knowledge.

Participants commented on the field trip as a unique experiential learning opportunity for students to visit an operational prison, speak with a life sentenced prisoner on perspectives of prison life, interact with prison staff, and to apply their knowledge in a real-world setting. Participants clearly identified the unique opportunity to experience firsthand the practicalities of their academic knowledge (theory) including the impact of sentencing policies on prisoners.

“... it gives more practical experience ... [these activities] are very interesting and helpful for students on a master’s programme as they are interested in more practical activities ...” [P-8]

“...differentiated the master’s programme from the undergraduate studies that I have done ... it will incite more people to be interested in a master’s programme ... visits and more practical [experience] gives them [students] more of a chance to settle into a master’s degree.” [P-2]

All participants remarked on how their levels of understanding were greatly enhanced by this experiential active learning activity. Notably, many participants also commented that this was their first visit to an operational prison, and surprisingly their first experiential learning opportunity.

"I have never been in a prison ... so from that point of view it was just unbelievable to get that opportunity to be able to go ... It is a huge advantage for anybody that is intending to go to work in ... a legal setting in that they see what actually goes on in the [prison] ... There are huge advantages both for my learning both for my practical side of things because I am not yet in the workforce, so I have not yet had experience [of a prison] so I think that it is hugely beneficial to any master's programme to have these kinds of experiences." [P-5]

Limitations associated with the field trip were minimal. A common theme was the short-term nature of the field trip. Visits are scheduled from 12:30 until 2:00 p.m. as the prison is on full lockdown during this period as prisoners consume their food in their cells, not in a communal area. This facilitates more freedom to move about the prison to enhance the experience for students. Low-risk prisoners working in the kitchen and laundry continue with their tasks during lunchtime and students had the opportunity to briefly speak with them under controlled conditions. Many participants commented they would have preferred a longer visit to experience more of the prison facilities, culture and environment and suggested that in future years there might be two field trips, one at the beginning of the semester and one at the end of the semester. Students could more deeply reflect on their initial perceptions, preconceptions and relate to their academic knowledge gained throughout the semester. This would facilitate students to revisit these issues during the second visit (perhaps to a different prison for comparison) and 'reflect forward' to the future as well as 'reflecting back' on their initial experiential learning (Sutton, 2024). A second notable limitation was the use of conventional methods of documenting active learning experiences was not possible owing to the sensitive nature of an operational prison.

Engaging with Criminal Justice Institutions

One of the objectives of the field trip had been to develop student confidence in engaging with criminal justice professionals and visiting criminal justice institutions. Interaction with criminal justice professionals during this active learning experience has real potential to inform the affective domain of learning (such as an appreciation for the importance of respecting human rights of prisoners). All students expressed an increased confidence in dealing with criminal justice professionals and participating in field trips. Gaining a familiarity with the prison as a criminal justice institution was greatly beneficial for students to demystify an operational prison. One participant commented "... *I feel more confident and comfortable now ...*" [P-8], while another commented on the approach of staff to students as visitors:

“... I feel they way we were treated in general throughout the visit [by prison staff] was very professional, we were looked after very well, things were explained to us very well so I would have no problem in engaging with criminal justice institutions the future ... I thought it was quite professional and quite informative ...” [P-7]

Responses to this question indicated a positive experience of prison staff in terms of their professionalism, dedication, openness, transparency, and support for prisoners who demonstrated a willingness to participate in vocational programmes that could facilitate their personal development, skills development and reduce recidivism.

“... the prison officers talked us through their work and what they have to do in their daily routine ... we learned basically everything about their day-to-day duties ...” [P-3]

“What I learned about the criminal justice professionals is that they do their job fairly well, they are very structured... My only criticism of criminal justice professionals is that they are very set in their own way and personally I don't think they take to people coming in from the outside which could be very beneficial because we are dealing with very vulnerable people albeit offenders, they are very vulnerable people ...they could do with bringing in more people from the outside ... there should be a range of professionals not just prison guards ... I do think they would benefit from more broader resources ... like psychological resources, resources to speak to solicitors to explain different parts of law they are unsure of because that really struck me was sections of Acts [legislation] they weren't utilising because they didn't quite understand it ... that shouldn't be the way, it should always be the best way for themselves and the best way for the people coming in there.... But [otherwise] very professional....very helpful, answered questions to the best of their ability and doing a tough job.” [P-5]

All students commented on the supportive attitude by prison staff towards prisoners reasonable requests, especially prisoners complying with prison rules and engaging positively with the prison regime and rehabilitation services.

Notably, the ratio of prison staff to an ever-increasing prison population also informed student understanding concerning the difficulties and lack of resources for staff in the performance of their multifarious duties, which include responsible for the safety, security, and well-being of prisoners and staff; supervision of prisoners; maintaining order; and assist with the rehabilitation of offenders. Prison overcrowding has significant negative impacts on staff, primarily increasing workloads and increased risk of violence between prisoners and against staff. In consequence of overcrowding, staff can be diverted from essential rehabilitation including vocational and education programmes.

Motivation to Participate in related Experiential Learning Activities

From an experiential learning perspective a significant theme was that students also did not find the experience as intimidating as they first envisaged and this inspired confidence and motivation to participate in other criminal justice field trips Responses were overwhelmingly positive and a clear indication of the benefits of further integrating experiential learning into the curriculum.

"I would be interested to doing something with criminal justice.... There were a few internships [recently advertised] I was not thinking of doing this before but after the [visit] I was more interested in criminal justice, so I was considering doing those..." [P-1]

Significantly, the pedagogical benefits stimulated a desire to engage in related experiential learning opportunities.

"...[these] activities inform yourself ... if you don't experience in a practical sense ... when engaging with education you also need to see it in a practical sense or it doesn't make sense ... makes the law more accessible, more explainable ... certain things I would be reading over and over again or I'd be checking from the Acts [legislation] yet in a couple of minutes the criminal justice professionals had it explained and how it operates and I would have spent hours trying to figure out... [field trips] makes things more explanatory ... explained in that kind of way and outside of the educational setting I think it would make a lot more sense to people." [P-5]

Responses were incredibly positive with all students expressing a willingness and motivation to participate in extracurricular activities based in their firsthand experiences during the field trip that provided a deeper insight into the work of criminal justice professionals. While noting the importance of their academic achievements, students found that involvement in other experiential learning activities such as an especially important aspect of their academic studies, which enhanced their CV's and attractiveness to potential employers and internship opportunities.

This positive feedback greatly informs approaches to teaching criminal justice students in terms of how experiential learning opportunities can be further utilised to enhance their journey of learning and discovery from apprentice to mastering the discipline.

Human Rights Perspectives

There is a direct correlation between the academic programme comprising criminal justice and human rights modules, and the field trip.

"Human rights are important, we are all human beings you know people make mistakes and I think its taught me not to judge everything on the face of it and to look a bit more into what's going on underneath things...." [P-5]

"It really has opened my eyes ... when I now look at sentences ... I think to myself ... they [prisoners] have done something wrong, and fundamentally wrong in some cases, but there has to be some bit of humanity in the way we deal with them, so that is really what I have really learned from the prison visit." [P-7]

An international student commented on the distinctive smell within the prison and how not having a choice to avoid the prison smell affected human rights of prisoners [P-6]. An illustration of this was the old wing of the prison where prisoners were 'slopping out' (a practice where some prisoners do not have toilet facilities in their cell and therefore were required to manually empty their human waste from a container usually in the morning after being locked in their cells overnight). Students

were surprised on how the inhumane and degrading treatment of prisoners continues to some extent and the urgent necessity for legislative reform and funding for resources cease this practice and ensure dignity of care for prisoners.

Postgraduate criminal justice students also study human rights modules, and were able to synergise their learning from related modules with the criminal justice module. Students were able to identify, appreciate and make connections between the complementary aspects of human rights modules and how this intersection between human rights and the practicalities of criminal justice enhanced their understanding.

“... I am studying criminal justice and human rights modules so the [field trip] was very educational for me...” [P-1]

Many students commented on the human rights centred approach, professionalism, dedication, transparency of staff in the performance of their multifarious duties.

“... we are going from the sentencing stage [in class] to the prison and this really did ... open your eyes to what is actually going on post courts post-conviction I think that going forward for judges and even practitioners it should be very important to actually walk through a prison to actually see what goes on post-conviction and post sentencing to just give them a bit of an idea of ... the fact that these people are human beings and they have rights and they have feelings even though they have committed a crime ... so I think it was very fitting to go to the prison particularly with this masters course...” [P-5]

Student knowledge based on related modules they had studied facilitated a broad understanding of criminal justice and sentencing processes from a human rights perspective. In this context, participants were able to make connections between rights of prisoners to psychological, medical, dental services, recreational facilities, and family visits, with the sensitive nature of an operational prison. Notably, the imperative of judges who impose sentences to experience firsthand the prison environment was highlighted from the perspectives of prisoners and their rights (albeit being convicted offenders and sentenced accordingly).

These learning experiences are reflective of many responses which acknowledged the imperative of safeguarding human rights of prisoners in the custody and care of the Prison Service. Students benefited greatly from the opportunity to speak with prisoners and appreciate the importance of human rights for convicted offenders.

Many students also commented on how the fundamental rights of criminal justice professionals could be affected by the subtle and overt threats of personal harm or to their families if they refused to comply with demands from certain prisoners.

Career Focus

Responses to this question revealed were very distinct transformations in attitude by many students who appreciated the professionalism, openness, transparency and dedication of prison staff in the performance of their multifarious duties and responsibilities. A common response was the impact on possible career options and the field trip had given students the motivation to consider careers as criminal justice professionals.

"It has really broadened my horizons when it comes to the law and opportunities around it." [P-4]

The impact of the field trip on possible career options was transformative as to how the criminal justice process functions, the practicalities of sentencing and realities of life as a criminal justice professional. A few students commented that they were considering a career with the Irish Prison Service, or related criminal justice agency, whereas previously they were considering opportunities to work with Non-Governmental Organisations (NGOs) or pursue further professional studies to qualify as lawyer practitioners (Solicitor or Barrister). This underscores the benefits of field trips as a transformative learning experience for students as they transition from academic studies to their professional careers (Wright, 2000: 117-118; Chickering, 1977; Rippetoe, 1977; Gore and Nelson, 1984).

Analysis

This unique experiential learning activity enhanced student knowledge and understanding, informed and transformed attitudes, beliefs, and values. Students would not have gained this deep and flexible understanding at the same level in academic seminars wherein discussions are confined to academic knowledge (theory) and policies. Significantly, the ability of students to generate knowledge from practice further evidenced the benefits of the interactive field trip. Moreover, the benefits of this experiential learning activity positively impacted on student learning and professional career plans.

Qualitative data analysis of student experiences reveals learning during the guided inquiry phase of the teaching and learning process during the semester. Wherein students gain academic knowledge and understanding in the classroom through discussions, guest speakers (Public Prosecutor and Court of Appeal Judge) thereby making connections between academic knowledge (theory) and practice. This correlates with the kernel of teaching for understanding – it is not just the ‘understanding’ of concepts per se, but it is the ability to apply knowledge in a new situation - flexibly. In terms of TfU the field trip emerges at the guided inquiry phase of learning as they are more beneficial at this stage. Students who participated in the field trip referred to the benefits of the experiential learning activity (and gave examples such as conversing with a life sentenced prisoner) in the final, culmination phase, of the teaching and learning process wherein students could relate their experiential active learning in their final assessments for the module. Moreover, students appreciated and understood the pedagogical benefits of guest speakers in preparing for the active learning experience.

Discussions around the field trip in academic seminars the week before the visit as to what to expect and what to observe as they enter the prison, and during the visit, so that students had a purpose to actively engage with the learning experience. Pre-field trip preparation, the timing of the field trip towards the end of the semester, and post-field trip discussions are key to documenting the benefits and limitations for students. A debrief session was arranged the week following the field trip in which

students discussed the impact of the experiential/active learning event had on their knowledge and understanding of the discipline. The debrief session also highlighted the impact of the field trip on their career plans and how their attitudes changed (affective domain of learning) towards the sentencing process, prisoners/ offenders, disconnect between policy, law, and practical realities. The benefits of the field trip as part of the curriculum were also highlighted and this feedback is key to developing further experiential learning opportunities.

Student learning experiences were overwhelmingly positive and qualitative data analysis revealed remarkably interesting themes on student learning and understanding:

Experiential Benefits

- students gained an appreciation of the practicalities associated with criminal justice and sentencing processes, including the intersection between human rights, law and policies
- human rights centred approach by prison staff engagement with prisoners
- prisoners are typically incarcerated in prisons in close proximity to their normal place of residence (with the exception of foreign nationals incarcerated in Irish prisons) and the city/town centre location of Irish prisons facilitates regular family visits, which in turn might inculcate a greater desire to engage in reform/rehabilitation in preparation for when a prisoner becomes eligible to be considered for parole
- dynamics between prisoners and prison staff was generally positive
- openness, transparency and professionalism of prison staff towards persons in their care
- vulnerability of prison staff to implied and overt intimidation and threats for non-compliance with prisoner demands
- regimental nature of the prison environment: personal liberty and individual rights are restricted
- impressive range and quality of modern facilities including medical centre, dentistry, education centre, and recreation facilities
- improved confidence engaging with criminal justice professionals were also advanced during the field trip.
- for all (postgraduate) students who participated in the field trip, this was their first experiential learning activity

The analysis of the qualitative data also shows evidence of benefits and some limitations of experiential learning activities to enhance student learning and understanding.

Pedagogical Benefits

- unique active learning experience in a sensitive real-world setting
- practical approach to learning
- contextualises academic knowledge (theory)
- bridges the pedagogical gap between academic knowledge (theory) and practicalities of the discipline
- deep and flexible understanding
- experience not as horrific as had been anticipated
- unique opportunity to reflect 'in' and 'on' knowledge and understanding in a real-world setting
- demystifies the criminal justice and sentencing processes
- indelible active learning experience in a unique real-world setting
- curriculum vitae enhancement

Limitations on Learning Opportunities

- not long enough to assimilate every aspect of the visit: the Prison Service can only accommodate visits between 12:30 and 2:00 p.m. when the prison is on lockdown during lunchtime, and persons entering the prison must first undergo security screening
- because of the sensitive nature of an operational prison experiences of the field trip could not be documented through conventional means such as videorecording, photographs or sketches/drawings; therefore, students had to rely on memory of the event
- only one visit, whereas a subsequent visit would provide the opportunity to reflect 'on' their active/experiential learning having reflected 'in' during the first visit; and the benefits of further visits to other prisons for comparison as to how they operate and experience cultural differences within prisons

Prior to the field trip, attitudes toward offenders and the criminal justice process might typically have been shaped by stereotypes and media images that the tour was able to debunk. The prison visit typically debunks myths and stereotypes of prison life and offenders and demystified an operational prison. This is important in terms of facilitating criminal justice students with an opportunity for affective learning and to experience how the visit impacted personal ambivalence toward offenders, criminal justice policies and practice.

All participants commented on the collegiality and bonding experience with student colleagues with whom they might not have previously interacted with in academic seminars.

Discussion

The purpose of this investigation was to address the ‘problem’ (Bass, 1999) of knowing the essence of short-term field trips to an operation prison for criminal justice students. The foregoing literature review reveals a correlation between academic knowledge (theory) and practical experience. In that regard, making connections is imperative for a deep and flexible understanding of one’s discipline (Higgins, 2014). The short-term interactive field trip to an operational prison clearly provide a unique and sensitive opportunity for students to make connections between academic knowledge (theory) and the practical implications of criminal justice and sentencing processes. Moreover, the unique opportunity to interact with criminal justice professionals facilitates students to apply their knowledge in real-world setting.

The multifarious complexities associated with teaching and learning at institutions of higher education, necessitates that teachers must remain vigilant against ‘pedagogical inertia’ in teaching and learning strategies within their discipline (Schulman, 2005). This approach to teaching and student learning is enhanced by utilising short-term field trips within the curriculum and will inculcate in students a desire to take ownership of their learning through self-directed studies. Significantly, the research findings informed the planning of experiential learning activities in subsequent academic years including a greater diversity of guest speakers.

The field trip was a reflective participatory action research activity for students wherein the short-term field trip to an operational prison was a teaching and learning methodology (Norton, 2019; Cohen et al., 2018; McNiff, 2016; Fetterman, 2015; Beaumfield et al. 2012). The importance of short-term field trips as a new way of knowing how and what our students understand is pivotal to ‘reflection-in-action’ and ‘reflection-on-action’ and consequential enhanced approaches to our teaching pedagogies (Schön, 1991). Field trips are active learning experiences that have the potential to increase student knowledge, understanding and motivation for self-directed study of their discipline. Moreover, their informative, transformative impact on student learning is evident where students can apply and reflect ‘in’ and ‘on’ their academic knowledge and understanding in a real-world setting.

Participatory action research based on experiential learning activities inform and transform approaches to effective teaching, but only if we are willing to engage with and embrace this ‘new epistemology’ (Schön, 1995b). Hence the significance of incorporating field trips within the curriculum. While academic knowledge (theory) is invaluable, this needs to be augmented with relevant experiential learning activities. Bridging the pedagogical gap between theory and practice clearly enhances the student journey of learning and discovery deepens their knowledge base and understanding. Crucially, this process of ‘learning by doing’ facilitates students in applying their knowledge flexibly in new situations through performances of understanding, generating knowledge from the practicalities of the discipline.

Students were given a purpose and focus for the field trip which prepared them for their learning opportunities and to avail of this unique active learning opportunity to apply their knowledge in an operational prison. Students reflected on the sentencing process and principles of sentencing and how the field trip might inform, reform, and transform knowledge and understanding, and remove any preconceptions that might

have prevailed before the visit. Students were also encouraged to observe the environment on entry to the prison, observe the size of a prison cell typically holding three prisoners, facilities for prisoners including services for rehabilitation. Students were encouraged to reflect on whether the human rights of prisoners are being complied with, and consider whether prisoners have too many, or too little, facilities and services. Moreover, students were encouraged to consider these issues through the lens of relevant stakeholders including the offender, victim, public interest, criminal justice agencies or perhaps an amalgam of perspectives.

The field trip exposed learners to the practicalities of the criminal justice and sentencing processes, building a pedagogical bridge through making connections between knowledge (theory) and practice, which enhanced student levels and dimensions of understanding. Students were encouraged to think critically and creatively about what they see and observe and to reflect 'in' and 'on' their preconceived notions, stereotypes, preconceptions, and to actively engage with academic knowledge (theory) they had acquired and mastered. Significantly, this is what differentiated the field trip from academic seminars that cannot achieve the same objectives, at least not at the same level.

Student responses provided valuable qualitative data and insights into student experiential learning activities and show evidence their transition through the dimensions and levels of understanding. One of the most significant benefits, as reported in the research findings, is transformative learning in the context of a prison where students were able to apply their academic knowledge (theory) in a real-world setting.

Students have typically reported they are reluctant or feel intimidated to engage with the professions before completing their undergraduate education (Scarce, 1997, 224). Field trips in the context of this investigation facilitated unique opportunities for postgraduate students to engage in meaningful discussions with criminal justice professionals and directly observe the practicalities of criminal justice.

The timing of the field trip is also pivotal for enhancing student active learning. Notwithstanding, the limitation of the field trip to an operational prison and hence, thematic evaluations of student responses, is that they involve a single visit to a single prison by a particular group (Sutton, 2024). While the research for this investigation is based on a single visit, and the sample of learners interviewed is relatively small, the results show evidence of transformative learning and understanding that could not be achieved at the same level in academic seminars alone. Thematic analysis reveals key pedagogical benefits. Field trips clearly inculcate in students a desire to learn through applied knowledge in a real-world setting. The impact of the field trip in contextualising academic knowledge (theory) of criminal justice and sentencing law and policies was as an incredibly positive addition to the module. The field trip demystified the environment of an operational prison and exposed learners to the multifarious responsibilities of staff ensuring prison security and overseeing welfare for persons within their care in conjunction with medical staff. Students were impressed with professionalism of staff and the experience removed any preconceptions of daily life in prison for all persons. Students also reported how the experience removed any concerns they might have had previously regarding engaging with criminal justice institutions and professionals, and a few students reported that they were considering careers with the Prison Service. Significantly, the experience

removed any sense of intimidation in visiting with criminal justice institutions, and interacting with criminal justice professionals, and imbued students with confidence to engage in future experiential learning activities. Having observed student interactions with staff and prisoners during the visit, their affective and cognitive domains of learning and understanding were enhanced as indeed were their interpersonal skills. An illustration of this is the ingenuity of some prisoners in their abilities to make an assortment of weapons, and a device for tattooing (utilising an electric razor motor, USB wire connector, and diabetic hypodermic needle); whereas if this ingenuity were used for legitimate purposes offenders, such as learning a trade or pursuing educational opportunities, offenders would have real potential to be rehabilitated and reintegrated as law-abiding and productive members of society.

Field trips empower students to take ownership of their learning and understanding and facilitate learners to relate active learning with academic knowledge (theory), or indeed practical experience for part-time students working full-time as criminal justice professionals. The unique opportunity to bridge the pedagogical gap, make connections between criminal justice policies, theory, and practice was evidenced during the interactive field trip wherein students demonstrated various levels of ability to apply their knowledge. The contextualisation of academic knowledge (theory) in a real-world setting and the ability to think critically and creatively are examples of the multifarious benefits.

The success of field trips is largely dependent on planning for the experiential learning event well in advance, preparing students through enhancing their academic knowledge. Pre-field trip preparations to inform students on the sensitive nature of the prison environment with particular emphasis on security protocols, and what to observe during the visit, are key to enhancing the experiential learning activities for students. Utilising a diversity of guest speakers with expertise and relevant experience will greatly enhance student learning and engagement, contextualising real-world practicalities to enhance discussions in academic seminars through introducing new perspectives, and will inspire students prior to field trips.

The use of short-term field trips as experiential learning activities are well-established as a teaching method with outcomes that benefit learners and teachers alike. While the incorporation of field trips in the curriculum is conventional in cognate disciplines to law, and criminal justice programmes particularly in the United States (Kakar, 2025), there is a deficiency of empirical research in Ireland measuring the benefits and limitations for criminal justice students. This investigation has aimed to fill that pedagogical gap.

Conclusions

This investigation was conducted in the context of a postgraduate module on criminal justice and sentencing processes in an Irish university setting to evaluate the essence of short-term field trips as a pedagogical method. Thematic analysis of qualitative data revealed the essence of short-term field trips as experiential learning in the context of an operational prison for (postgraduate) criminal justice students. Student learning experiences showed transformations in cognitive and affective

learning on perceptions regarding criminal justice and sentencing policies with particular emphasis on punitiveness, functionality of prisons, daily lives and activities of prisoners, and prospects for rehabilitation.

The benefits of field trips in the context of criminal justice education facilitate students to make connections between academic (theoretical) knowledge and practicalities of the discipline in a real-world setting. This serves to remove discussions from the abstract in academic seminars and enables students to gain a deep understanding of the practicalities associated with the criminal justice and sentencing processes. These experiential (active learning) events play a significant role in the education of criminal justice students. Significantly, the field trip brought the criminal justice module alive and students were able to enhance their knowledge with a deep and flexible understanding of the discipline, demonstrating an ability to think critically and creatively. In essence, the field trip was a catalyst for learning and understanding, bringing everything together.

The result of this investigation supports existing literature on the essence of short-term field trips. Moreover, this investigation has revealed significant transformative learning and understanding for students with particular emphasis between the intersection of criminal justice and human rights in the context of an operational prison. While thematic analysis of experiential learning short-term field trip to an operation prison hold their own intrinsic interest for the purpose of this investigation in the context of an Irish tertiary institution setting, research findings might also inform teaching and learning strategies in a broader context.

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Teacher Shortages: What can be learnt from Countries without a Teacher Shortage?

By Ulrika Gidlund & Marcia Håkansson Lindqvist[±]*

The teacher shortage is a global challenge. However, some countries are less prone to teacher shortages. The aim of this study was to examine three countries with little or no teacher shortage to explore what these countries do to attract and retain educated teachers. The three countries selected for this case study were Finland (Europe), Singapore, and the Republic of Korea¹ (Southeast Asia). The data pertaining to these countries, as three specific case studies, come from policy documents, statistics, reports, and peer-reviewed articles. The themes in each case were thematically encoded and categorised by the described case context. The themes were identified deductively and strongly linked to the data. The results indicate that the teacher shortage and supply are related to teacher status and grounded in students' performance and results, teacher training/education, systems for incoming and graduated teacher students, and support during their first years in their profession. Teacher status is seen as a loop in which higher teacher status leads to a lower likelihood of a teacher shortage. The conclusion is that attracting and retaining teachers is a multifaceted and complex process that is the result of many interacting aspects in each specific country's context.

Keywords: Finland, multiple case study, Singapore, the Republic of Korea, teaching attractiveness.

Introduction

Teacher shortages appear to be a challenge worldwide. In a recent report, the United Nations Educational, Scientific and Cultural Organization (UNESCO) reported the need for some 44 million new teachers to reach the Agenda 2030 targets (UNESCO, 2025). According to the Organisation for Economic Co-operation and Development (OECD), some countries are more prone to shortages than others, especially in certain geographical areas, such as around sub-Saharan Africa; in specific subjects; and due to requirements for teachers to be of certain genders and ethnicities (OECD, 2023, 2025; UNESCO, 2025). However, some countries do not appear to be affected by teacher shortages. Of the 21 countries with available data, 18 reported facing teacher shortages at the start of the 2022/23 academic year, with only Greece, Korea, and Türkiye not reporting any shortages (OECD, 2024).

There is no universally consistent definition of a teacher shortage (Gorard et al. 2024), but the term implies an insufficient number of individuals recruited into

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¹In this article, Korea, South Korea, and the Republic of Korea will be used interchangeably based on the various terms our references use.

the profession. Eurydice (2021) revealed that 35 of the 43 education systems across Europe reported teacher shortages. Despite years of investment in recruiting and retaining teachers, the issue persists (McKinsley & Company, 2007). Teacher shortages can be general or specific to particular phases of education, subject areas, geographical locations (i.e., rural or high-risk areas), or types of school. Additionally, economic issues, such as salary, the prospect of bonuses, and understanding of the profession (e.g., required tasks, working conditions, student discipline) may be considered. What one individual or country perceives as a shortage of teachers may not be viewed as a shortage by others. In many developed countries, a teacher shortage is seen as a lack of qualified teachers to teach the subject that they are trained for. In some developing countries, the requirements to be a teacher are often less stringent. Unqualified or out-of-subject teachers might therefore be used without this being viewed as a sign of a teacher shortage (Gorard et al., 2024).

While many studies focus on teacher shortages in many contexts, the aim of this study is to examine countries with little or no teacher shortage. In contexts in which teacher shortages do not prevail, it is of interest to explore what these countries in their specific contexts do to attract and retain educated teachers, what specific aspects characterise these countries, and what can be learnt from them. The results of this study will therefore contribute to the broader literature on teacher shortages with its focal point on aspects that are important for attracting and retaining teachers.

This study begins with a presentation of research on teacher shortages worldwide and the how teacher shortage is defined and understood. Following this, the cases of Singapore, the Republic of Korea, and Finland are highlighted due to their lack of teacher shortage, according to McKinsley and Company's report (2007). Next, the findings are discussed from each case and emphasise the quality of teachers and teacher education in ensuring teaching profession as an attractive profession. Implications for practice and important issues for future research are then be presented.

Background

Countries where education is reported to be significantly affected by a teacher shortage have high student-teacher ratios (STRs) and larger class size. Conversely, countries with low STRs and smaller class sizes may not report major issues with teacher shortages. However, there are countries with large class sizes but low STRs. These countries generally do not report serious teacher shortages (OECD, 2019b). Teaching hours are higher in England than in many other OECD countries. This means that teachers in England can teach more classes, so classes can be smaller.

One concern about the shortage of teachers is the relatively low status of teachers as perceived by the public (OECD, 2019b; Thompson, 2021). In 2018, the Teaching and Learning International Survey (TALIS) survey (OECD, 2019b) showed that countries where teachers are less valued by society, policymakers, and the media report being significantly affected by a shortage of qualified teachers. Countries such as Singapore, China (Shanghai), Korea, and Finland, where teachers are more appreciated by the government and the public, generally do not report persistent teacher shortages. In Finland and Korea, teaching is apparently a

much-desired profession (OECD, 2023;2025). Besides status, pay, and workload, other aspects such as job satisfaction and working environment need to be considered in explaining the absence or presence of a teacher shortage (Gorard et al. 2024). The massive increase in spending on education reforms in almost every country in the world has barely decreased the teacher shortage (McKinsley & Company, 2007).

Due to the many aspects that can describe teacher shortages and how important they might be in themselves, this study has been limited to the examination of the relation between the status and the attractiveness of the teaching profession in the selected countries.

The teacher shortage is a complex issue with many facets. To outline the structure of this study, a conceptual framework is used to connect it to existing knowledge of the area. Predictors of teacher shortages from UNESCO's (2024) Report on Teachers include teachers' working conditions, training, and social status. The framework does not focus on aspects that are general or specific to certain areas of teacher shortages. According to Gorard et al. (2024), issues such as *phases of education, subject areas, geographical locations (rural or high-risk areas), or types of school* can also be of importance but are not in focus in the study. The distinction between *unqualified* and/or *out-of-subject teachers* is not distinguished as the requirements to be a teacher differ so much among countries.

Aim and Research Questions

The overall aim of this study was to investigate characteristics of countries without teacher shortages through the study of three specific country cases. The following research questions were posed: 1) *Which aspects characterise countries lacking teacher shortages?* and 2) *What can be learnt from countries without teacher shortages?*

Methodology

Multiple-Case Study

In this research, a multiple-case study (Stake, 2005; Yin, 2014) is used to achieve a deep understanding of differences in teacher shortage and teacher supply among countries. The major advantage of multiple-case studies lies in its cross-case analysis. A multiple-case study shifts the focus from understanding a single case to the differences and similarities among cases. With a multiple-case study, an in-depth analysis of several cases is conducted, starting with an investigation of individual cases. Later, these individual results are combined, and similarities and differences are studied (Stake, 2005; Yin, 2014).

Case Selection

Based on the literature, three countries with little or no teacher shortage were selected for this study. Using UNESCO's (2024) *Global Report on Teachers*, three countries were selected: Finland, Singapore, and Korea. These countries are

highlighted specifically regarding the lack of teacher shortage in McKinsley and Company's report (2007) and their high results in international measurements such as the Programme for International Student Assessment (PISA), Progress in International Reading Literacy Study (PIRLS), and Trends in International Mathematics and Science Study (TIMSS).

Materials and Methods

For this research, international and national policy documents and statistics have been studied in combination with international reports and studies on teacher shortage, supply, recruitment, working conditions, and status. Peer-reviewed articles were also selected by a broad search in Scopus and a manual search for other suitable and reliable articles examining relevant areas.

The search terms (with their tautological terms) used were "Teacher supply AND Finland"; "Teacher supply" AND "Singapore"; "Teacher supply AND South Korea"; "Teacher shortage AND Finland"; "Teacher shortage AND Singapore"; and "Teacher shortage AND South Korea". The SCOPUS search was limited to peer-reviewed academic articles in English during the period of 2000–2024, resulting in 19 articles identified. After a review, nine were excluded as being out of scope—for example, covering the wrong country or wrong topic. A total of 10 articles were considered relevant for the study. The articles identified are enclosed in Appendix 1.

Data Analysis

A thematic case analysis (Creswell, 2013) was conducted for each country. After several readings of policy documents and selected articles, statements were coded into categories to form descriptions and broad themes (Creswell, 2013). The initial codes were deductively chosen from OECD's (2011) report, *Teachers Matter: Attracting, Developing and Retaining Effective Teachers*, a list of general pointers to serve as the understanding and analysis of the teacher shortage: *Working conditions*; *Teacher training/education*, and *Teacher status*. These aspects therefore served as the deductive codes of the analysis of the results and are illustrated in Table 1.

Table 1. Framework based on Attractiveness of the Teacher Profession (OECD, 2011)

Framework layers	Issues relevant to attractiveness
Working Conditions	Salary STR/school size Educational support personnel Continuous professional development (CPD) Job satisfaction
Teacher training/education	Selection system Teacher education certificate
Teacher status	Students' learning, performance, and results Society and mass media

The themes identified across the cases were then determined inductively. In this study, the coding was conducted manually and individually. Firstly, an open reading of each document was conducted individually to gain an overall understanding of the contents in the articles. After that, the codes were identified, analysed, and labelled into the subthemes under which the results were organised. Following this, categories based on themes emerging during the coding process were compared and discussed collaboratively. Acknowledging that it may be difficult to isolate one code from another because they often tend to overlap, the codes have been presented and discussed separately.

To generate a comprehensive and accurate description of our cases, a mixed methodological approach was employed in line with Creswell (1999). Thus, the study contains both quantitative and qualitative data. The study combines literature, the themes that emerged, as well as descriptive statistics to illustrate the three cases chosen for study.

Results

In the next section, the findings from the three cases will be presented. First, the articles will be discussed. Thereafter, the three cases of Finland, Singapore, and the Republic of Korea will be analysed.

The Articles Identified

In total, 10 articles were identified as relevant for the study. The country, number of articles, and references are illustrated in Table 2.

Table 2. Articles identified per Country

Finland	3	Koskinen Sandberg, P. (2021); Nislin, M., & Pesonen, H. (2019); Rojonen, H., Fonsén, E., Ukkonen-Mikkola, T., & Ahtiainen, R. (2024).
Singapore	1	Yang, W., & Lim, S. (2023).
South Korea	5	Binnie, C. & Wedlock, J. (2022); Lee, J.-A., Kang, M.O., Park, B.J. (2019); Dos Santos, L.M. (2020).; Dos Santos, L.M. (2022). Santos, L.M.D. (2022).
Finland and South Korea	1	Kang, J., Kim, H., Lee, B., ... Viljaranta, J., & George, S. (2024).
Total	10	

Three articles were identified concerning the Finnish context. Rojonen et al. (2024) examined the organisational structure of an early childhood education centre and how it affects roles and responsibilities. They found that that centralisation and decentralisation are balanced, although there is a lack of clarity in roles and decision-making. A shortage of qualified teachers negatively impacts organisations. Focusing on salaries, Koskinen and Sandberg (2021) investigated the 2018 social movement in Finland calling for higher salaries that emerged in response to wage-suppression agreements among municipalities despite a teacher shortage. The case highlights how feminist activism and wage politics can successfully question and change institutionalised practices in feminised professions. Nilsin and Pesonen (2019) studied the relationships among self-perceived competence, sense of belonging, and well-being among preservice and in-service special education teachers. The data revealed high engagement and low-to-moderate burnout. The findings highlight the need for a deeper understanding of how teachers can better meet diverse needs, with practical implications for teacher education.

One article focused on the context of Singapore. Yang and Lim (2023) examined a non-profit childcare centre in Singapore that achieved an emerging quality certification despite limited resources and a teacher shortage. Amid ongoing early childcare and education policy reforms, the article explores how centre-based conditions affect teachers' distributed pedagogical leadership and community of practice development. Three key themes were identified: the impact of national workforce context, organisational culture and power dynamics, and the shaping of a shared pedagogical vision. The findings highlight the complexities of quality improvement in early childcare and education and emphasize the importance of understanding teachers' lived experiences during reform.

Five articles were found in the South Korean context. Binnie and Wedlock (2022) explored the self-directed professional development (PD) of native English-speaking teachers (NESTs) in South Korea and whether their actions align with their beliefs. Data from 56 questionnaires and 11 interviews showed that only 35 teachers had engaged in self-directed PD in the past year. Barriers included lack of ambition, perceived need, limited career prospects, and the impact of COVID-19; they concluded that most NESTs did not engage in sufficient PD to enhance student learning outcomes.

Dos Santos (2022) explored the motivations and career decisions of native English teachers who chose to work in South Korea during the COVID-19 pandemic despite quarantine requirements. This article identified three key motivations: unique life experiences, ease of employment, and interest in Korean culture. Findings offer insights for school leaders and policymakers to better support foreign teachers and address long-term teacher shortages, especially as pandemic-related restrictions ease.

Santos (2022) reported on why foreign-language university instructors chose to remain in South Korea for over 15 years at the same institution. Findings reveal that personal and financial considerations are key motivators for long-term career commitment. The article highlights the importance of supporting foreign teachers' PD and addresses broader issues of teacher shortage while emphasising East Asia's appeal as a destination for international career growth.

Dos Santos (2020) investigated why foreign language teachers in Korea often leave after their first year. Based on the Model of Retention, Turnover, and Attrition, negative experiences with school environments, including discrimination, poor management, and disrespect from parents and students, were key aspects. The findings highlight the need for educational and HR reforms to improve support and retention of foreign teachers in Korea's education system.

Lee et al. (2019) examined motivations of 903 preservice teachers based on demographics. Findings showed differences between secondary and elementary preservice teachers in qualification fit, desire to teach, and task return. Male teachers valued qualification fit and influencing others more than female teachers, whereas STEM majors valued these aspects more than non-STEM majors. This article suggests that to improve teacher recruitment in countries facing shortages, policymakers should focus on enhancing task returns and benefits for teachers based on these insights.

Finally, one of the studies identified was a comparative study between Finland and Korea. Kang et al. (2024) explored and compared the motivations and perceptions of science preservice teachers (PSTs) in Finland and Korea, focusing on gender and subject differences. The results show that Korean PSTs have lower confidence and satisfaction in their career choice than Finnish PSTs. The article highlights the importance of prior science content study and the need to monitor preservice teachers' motivations, especially among women and non-biology majors, to support teacher recruitment and retention.

The Three Cases: Finland, Singapore, and the Republic of Korea

Finland

Finland is a small country in the north of Europe with some 5.6 million inhabitants (density 18.4/km²) and an area of 338,145 km². The capital, Helsinki, contains 684,589 inhabitants, or about 12% of the total population. Finland is a parliamentary republic within the framework of a representative democracy. National spending on education compared to the total gross domestic product

(GDP) in 2021 was 6.5% (UNESCO, 2025). Most pre-tertiary education is arranged at the municipal level. Around 3% of students are enrolled in private schools (mostly specialist language and international schools). Formal education usually starts at the age of 7 and is compulsory between the ages of 7 and 18. Primary school generally takes six years and lower secondary school three years. The curriculum is set by the Ministry of Education and Culture and the Education Board. After lower secondary school, graduates may apply to trade schools or gymnasiums (upper secondary schools).

Finnish comprehensive school consists of nine years of basic education, divided into primary education (years 1–6) and lower secondary education (years 7–9). In primary schools, class teachers typically teach the same group of pupils for several years. Often, some teachers specialise in the early learning phase (years 1–2), and others focus on teaching the remaining four levels of primary education. Besides class teachers, primary schools usually employ a few teachers for language instruction. Lower secondary education follows the subject-teacher model, although each class of approximately 25–30 pupils is assigned a teacher who acts as their coordinator. Primary and lower secondary phases are technically part of a unified comprehensive school, although in most cases, primary and lower secondary schools operate in different buildings and have their own headteachers. Most municipalities have more primary schools, which are also located closer to most pupils' homes than the lower secondary schools (Malinen et al., 2012).

Teachers' Working Conditions

Finnish teachers' salaries are 85% or more of the salaries of similarly educated workers (OECD, 2018). In 2024, the starting salary for primary school teachers was just above the OECD average of \$42,176. For lower secondary school teachers, it was \$45,306, compared to the OECD average of \$43,484. The salary for primary school teachers with 15 years of experience was \$51,740, compared to the OECD average of \$56,753, and \$55,579 for lower secondary school teachers, compared to the OECD average of \$58,596 (Table 3). Compared to the OECD average, Finnish teachers have about the same starting salary but a lower salary after 15 years of teaching.

In Finland, there are 13 students per teacher in primary education and nine students per teacher in lower secondary, which is fewer than the OECD average (Table 4) (OECD, 2025; OECD, 2024). Finland primary and lower secondary schools average 19 students per class, compared to the OECD average of 21 and 23, respectively (Table 5) (OECD (2024; 2025).

Finland has an inclusive educational system for students with special educational needs (SENs). Support is provided in mainstream schools in separate groups or with special support in regular classrooms, but special schools are also available. These students require special needs teachers and assistants. Concerning social difficulties at school, local authorities employ school health care services, student welfare officers, and school psychologists. School secretaries deal with office duties relating to school operations, such as tasks related to pupil welfare services and staff administration. Staff who assist teachers and students include, for example, IT support specialists, librarians, and school attendants (Eurydice, 2025).

Finland has no specific legislation governing continuing teacher education and training. Teachers are obligated to participate in CPD training for one to five days a year, according to the relevant statutes and collective agreements. Teachers have the right to participate in this obligatory training with full salary benefits. On the other hand, employers have the right to assign all full-time teachers to training. Employers also decide which training programmes and forms of education can be accepted as CPD training, conforming to the collective agreement. The primary responsibility for CPD lies with education providers, and local authorities support it within their financial limits and with financial support from the state (Eurydice, 2025).

Teachers' job satisfaction is high in Finland. Teaching was the first-choice career for 59% of teachers, compared to 67% overall according to the OECD. At least 66% of teachers in Finland report joining the profession because of the opportunity to influence children's development or contribute to society as a major motivation. Ninety-seven percent of teachers in Finland agree that students and teachers usually get on well with each other in the classroom.

In Finland, only 14% of teachers report experiencing a lot of stress in their work, which is lower than the OECD (2025) average (18%). Ninety-two percent of Finnish teachers feel that the advantages of being a teacher clearly outweigh the disadvantages (OECD 2025; TALIS, 2018).

Teacher Training/Education

Finnish teacher education is based on a five-year (bachelor + master) degree programme. There are different teacher education programmes for primary-school class teachers and subject teachers, which reflect the structure of the Finnish school system (Malinen et al., 2012). Requirements are mostly master-degree level: Early Childhood Education and Care (ECEC) teachers require 180 European Credit Transfer and Accumulation System (ECTS) credits over three years, class teachers require 300 ECTS credits over five years, and subject teachers require 300 ECTS credits over five to six years. Less than 20% of those who applied were accepted into Finnish teacher education in 2022 for class teacher education and 10%–50% for subject teacher education (Finnish National Agency of Education, 2023). Finnish PSTs usually spend half a year or more in school for the practicum (Kang et.al. 2024).

Top-performing school systems globally recruit teacher students from the top third of the cohort; Finland recruits from the top 10%. Students are selected through two-phase entrance exams that emphasise, in addition to academic qualifications, the candidates' personal suitability and motivation for teacher's work (Malinen et al., 2012). The entrance exams include tests on literacy, vocabulary, numeracy, problem-solving, strong interpersonal and communication skills, willingness to learn, and motivation to teach (McKinsley & Company, 2007).

There is no probationary period for new teachers in Finland. Teachers who have completed a rigorous initial teacher education programme, which includes extensive practical teaching experience, are fully qualified to start teaching independently as soon as they obtain their certificate. They continue to receive support to learn the fundamentals of the profession during their first years (OECD,

2024). Graduates in Finland are eligible to apply for teaching positions in all Finnish schools upon successful completion of their master's degree. Nevertheless, it is quite challenging for fresh graduates to secure a permanent position immediately after graduation, especially in larger towns. Instead, graduates typically begin as substitute teachers or seek short-term teaching contracts for approximately one to three years after graduation (Kang et al., 2024).

Teacher Status

The results of international tests (PISA, PIRLS, TIMSS) show that Finnish students have good test scores compared to the OECD average, despite declining a little since 2015 (the OECD average has also declined) (see Table 6-10).

Finnish teachers feel highly valued in society; 58% of teachers believe that the teaching profession is valued by society, compared to 26% in OECD countries (OECD, 2025; TALIS, 2018). The percentage of Finnish teachers reporting that the teaching profession is valued has remained stable since 2013 (OECD, 2025).

Teacher Shortage?

For a long time, primary school teacher education has been one of the most popular study programmes in Finland, typically attracting applicants with excellent secondary school diplomas. Recent years have seen one admitted student per approximately 12 applicants for class teacher education programmes nationwide. The popularity of class teacher education is further illustrated by the large number of previously unsuccessful applicants who apply to these programmes year after year. Once students are admitted to class teacher education, they rarely drop out or transfer to other programmes. Another indication of class teacher students' commitment is their average graduation time of five years, which is shorter than in many other fields. It is also noteworthy that after graduation, teacher retention in the profession is high compared to many other Western countries. It is estimated that only 10%–15% of Finnish educators switch to other occupations during their entire career (Malinen et al., 2012).

Singapore

Singapore, in South-eastern Asia, has a total area of 735.6 km² and over 6 million inhabitants. Singapore's population has grown from 1.8 million in 1965 to 5.1 million in 2011, and about 80% live in the capital. The country has the third highest population density of any country (7,804/km²). Singapore is a parliamentary republic with a legal system based on common law. There has been political stability in Singapore since its independence in 1965 under the leadership of the People's Action Party (PAP), the main political party in Singapore.

The Singapore brand of education, particularly its policymaking, differs from those found in educational systems in other developed (especially multi-party) Western democracies. In such democracies, general elections often lead to changes of governing party, with attendant and concomitant changes of educational values

and ideology underpinning government policy. In contrast, educational policy in Singapore has been under the control of one political party (PAP) since 1965. Consequently, Singapore leadership and policymaking have become renowned for consistency and coherence (Tan & Dimmock, 2014). The percentage of national spending on education compared to the country's total GDP in 2022 was 2.2% (UNESCO, 2025).

Education is structured into three stages: primary, secondary, and pre-university education, with primary education being compulsory. Pupils start with six years of primary school, consisting of a four-year foundation course and a two-year orientation stage. After these six years, pupils take the Primary School Leaving Examination (PSLE), which determines their secondary school placement. Secondary school lasts between four and five years and is divided into Express, Normal (Academic), and Normal (Technical) streams based on the pupil's ability level. National examinations are standardised across all schools, with tests taken after each stage. Education at all levels is predominantly state-supported, and Singaporean schools are closely regulated by the Ministry of Education (MOE), traditionally known for its top-down, command-and-control centralised system. All educational institutions, both public and private, must be registered with the MOE. Mainstream schools in Singapore follow a national academic curriculum in which the MOE outlines the aims, goals, visions, and, most importantly, the learning outcomes (Lee & Ho, 2021).

Teachers' Working Conditions

Compared to most other TALIS countries, Singapore has a high proportion of teachers (72%) who are satisfied with their salary (OECD, 2025).

As of 2023, Singapore averaged a class size of 33.6 students in primary school and 32.6 students in secondary school (Table 5), which is much higher than the OECD average. The number of students per teacher was 15.2 in primary school and 12.6 in secondary school, which is a little higher than the OECD average (Table 4).

Singapore has systems of inclusive education and separate special education schools. Children with mild SENs are enrolled in mainstream schools as part of the Compulsory Education (CE) framework. As of December 2019, 80% of students with SENs were enrolled in mainstream schools (Lee & Ho, 2021). These students include those with learning difficulties such as dyslexia, attention deficit hyperactivity disorder (ADHD), autism, or physical and sensory impairments.

Affordable government-funded special education schools catering to pupils with moderate-to-severe SENs are top priorities, with extensive specialised support and training for life and work provided to students. To promote inclusivity among all pupils, various interactions are fostered between mainstream pupils and those with SENs. Out of 32,000 employed teachers and school managers, 2,200 (14%) are allied educators who provide instructional support (Lee & Ho, 2021).

Teachers in Singapore have many opportunities to continually develop their professional skills and knowledge both individually and collectively. The Academy of Singapore Teachers (AST), various academies, and language centres offer workshops conducted by master teachers or by teachers for their peers. In addition to workshops, which can be face-to-face, online, or blended, the AST supports schools

in establishing professional learning communities. Most schools allocate weekly scheduled time for staff to participate in professional learning teams, in which student learning and instructional matters are discussed. This aligns with a nationwide effort to enable Singaporeans to continue learning and upgrading their skills beyond formal education. International reviews of teacher quality and teaching in Singapore have understandably been very positive (e.g., McKinsey & Company, 2007).

Beyond preservice training, in-service teachers' PD is a priority in Singapore. Teachers are encouraged to pursue postgraduate studies and attend various workshops and seminars to deepen their expertise. The government provides funding for teachers to attend workshops and conferences as well as opportunities for collaborative learning through networks and communities of practice (Ngozi Elems-Ikwegbu, 2023).

One notable initiative in evaluating and enhancing teacher effectiveness is identifying teachers' strengths and areas for improvement to target PD opportunities. The effectiveness of Singapore's teachers is measured through various means, including student achievement scores, feedback from students and parents, and classroom observations. Teachers are expected to continually reflect on their practice and adjust based on feedback from their peers and supervisors. The government also conducts regular reviews of the education system to ensure it remains effective and relevant (Ngozi Elems-Ikwegbu, 2023).

Job satisfaction is high. Teaching was the first-choice career for 71% of teachers in Singapore compared to 67% in OECD countries participating in the TALIS. Ninety-five percent of teachers in Singapore claimed that they joined the profession based on the opportunity to influence children's development or contribute to society as a major motivation (OECD, 2025).

The relations between students and teachers in the classroom are positive overall; 98% of teachers in Singapore agree that students and teachers usually get on well with each other. Regarding principals, only 4% of them report regular acts of intimidation or bullying among students, which is much lower than the OECD average of 14% (OECD, 2025).

Teacher Training/Education

An education system is as good as its teachers, who are the ultimate implementers of any educational policy. In Singapore, quality is controlled by the MOE, mainly through its teacher recruitment and PD.

As one of the top-performing school systems in the world, Singapore recruits teacher trainees from the top third of each Primary One cohort. This means that teachers are graduates with good A level results or top-tier Polytechnic Diploma graduates. All applicants are interviewed by a panel of senior educationists, including senior principals.

Teachers in state-funded schools must hold a teaching qualification from the National Institute of Education (NIE). University graduates who decide to pursue teaching undergo 16 months of training at the NIE, which includes 14 weeks of field experience or teaching practicum. Upon passing, they are awarded a Postgraduate Diploma in Education (PGDE) to teach at primary, secondary, or junior college levels. These levels are predetermined by the MOE before the teacher enters the NIE; the MOE determines teacher recruitment in terms of numbers, levels, and subject

specialisations. Trainees are typically prepared for two teaching domains and undertake numerous courses in educational psychology, language skills, classroom management, the use of ICT in teaching, home-school relations, and more. The NIE works closely with the MOE to ensure that the training provided aligns with and supports major MOE policies (Lee & Ho, 2021).

NIE offers a Diploma in Education programme for primary school educators and a Bachelor of Arts/Science in Education for secondary school educators. Student teachers are required to undergo teaching practicums to apply the theoretical concepts they acquire in the classroom context (Ngozi Elems-Ikwegbu, 2023). Upon completion of training, beginning teachers continue to receive support for the first two years after graduation through the Beginning Teachers Learning Programme, led by the AST and various school-level structured mentoring programmes (Lee & Ho, 2021).

There is a strong culture of mentoring and coaching among teachers, with experienced teachers often taking on the role of mentors for new teachers (Ngozi Elems-Ikwegbu, 2023). Singapore is unique in that preservice teachers are considered employees of the MOE and therefore are salaried. Attending the NIE implies being hired as a teacher without the need to “search” for employment after graduation (Lee & Ho, 2021).

Teacher Status

Singaporean students have performed at or near the top of international achievement tests in mathematics and science (PISA and TIMSS) for many years, justifying the system’s rating as one of the best performing in the world (Table 6-9). Teacher professionalism in Singapore is strongly encouraged. Official recognition is also provided through award ceremonies for teachers (Lee & Ho, 2021).

In Singapore, 72% of teachers believe that their profession is valued in society, which is higher than the average across OECD countries and economies participating in the TALIS (26%). Between 2013 and 2018, the percentage of teachers in Singapore reporting that the teaching profession is valued in society also has increased by four percentage points (OECD, 2025).

Teacher Shortage and Teacher Supply

Teacher shortages and supply do not appear to be an issue at present (OECD, 2019b).

The Republic of Korea

Located in South-eastern Asia, Korea has more than 51 million inhabitants and a population density of 507/km². About 50% of its citizens live in the capital city, and the country’s total area is 100,363 km². The political system is a unitary presidential republic. National spending on education compared to the country’s total GDP in 2021 was 4.9% (UNESCO, 2025).

Regarding the school system, a centralised administration in Korea oversees the education process from kindergarten to the third and final year of high school. The formal education system in Korea consists of elementary (six years), secondary (three years of school and three years of high school), and higher education (four years).

Although only six years of elementary and three years of middle school are compulsory, 96% of Korean students graduate from high school (KEDI, 2023).

Teachers' Working Conditions

Teachers in Korea have a lower starting salary of \$36,639 compared to \$43,000, the OECD average, and a higher salary after 15 years of teaching at \$64,699 compared to the OECD average of \$43,000 (Table 3). Teachers in Korea receive a yearly salary, as opposed to similarly educated workers who are paid hourly. Korean class sizes have been shrinking since 2000 (Table 5). In 2000, the distribution of the total number of students was as follows: 35.8% of students attended elementary school, 38% middle school, and 42.7% high school. Three years later, in 2023, of the total number of students there were 20.7% in elementary school, 24.6% in middle school, and 22.9% in high school, which is higher than the OECD average.

The STR has also decreased (Table 4). In 2000, the STR was 28.7 in elementary school, 20.1 in middle school, and 19.9 in high school. In 2023, there were 13.3 in elementary school, 11.6 in middle school, and 9.8 in high school, which is about the same as the OECD average.

Korea has both an inclusive school system and special schools for students with SENs, all with special needs teachers. Since 2000, the number of both has increased. In 2023, there were 194 special schools with 11,038 teachers and 11,701 special education classes within general schools containing 56,380 students (KEDI, 2023).

There has been rapid growth in Korean teachers' CPD participation since 2000, and Korean teachers' CPD participation rate was higher (91.9%) than the average for OECD countries (88.5%). Korea also ranked second among 23 countries in the number of days (30) spent participating in CPD. These data reflect policymakers' increasing efforts to promote CPD and strengthen in-service teachers' professionalism in Korea (Lee et al. 2019). Thirteen percent of teachers in Korea report participating in collaborative professional learning at least once a month (OECD average: 21%), and 19% engage in team teaching with the same frequency (OECD average: 28%) (OECD, 2025).

Teaching was the first-choice career for 80% of teachers in Korea and for 67% in OECD countries and economies participating in the TALIS. In terms of why they joined the profession, at least 80% of teachers in Korea cite the opportunity to influence children's development or contribute to society as a major motivation (OECD, 2025).

Korean teachers claim that relations between students and teachers in the classroom are positive overall, with 94% of teachers in Korea agreeing that students and teachers usually get on well with each other. No principals (0%) report regular acts of intimidation or bullying among their students, which is lower than the OECD average of 14% (OECD, 2025).

Eighteen percent of Korean of teachers report experiencing stress in their work "a lot", which is the same as the OECD average (18%). However, the proportion of primary education teachers for whom having too much administrative work is a source of stress is especially low in Korea (42.4%) (OECD, 2025).

Teacher Training/Education

According to the MOE in Korea, there are 13 elementary teacher education programmes in the country, and the majority of these programmes are highly centralised by the national and municipal/provincial governments. Secondary education is not as centralised as elementary education. Teacher education programmes offer very similar four-year courses following nationally accredited curricular standards that prepare teacher candidates for licensure upon graduation. Upon admission to university, although many courses are offered as electives, students are encouraged to take courses with their cohort to build cooperative relationships. After two years of required general education classes, preservice teachers in elementary and secondary programmes take courses on content-specific and pedagogic knowledge during their junior and senior years. Students in public teacher education programmes are mostly traditional college students aged 19–24 and are ethnically extremely homogeneous (Lee et al., 2019). Korean preschool teacher students have only four weeks of school practicum during their four years of study. Furthermore, Korean teacher education requires a four-year bachelor's degree (Kang et al., 2024).

With one of the top-performing teacher recruitment systems in the world, Korea recruits the top 5% of each graduating cohort (McKinsey & Company, 2007). To teach in a public school, teacher candidates must take an exam proctored by the provincial/metropolitan Offices of Education. Under the leadership of the Korean Institute for Curriculum and Evaluation (KICE), the provincial/metropolitan Offices of Education organised a consortium to develop the first-round written exams that assess teacher candidates' general education and content/pedagogic knowledge. Each provincial/metropolitan Office of Education is responsible for the second round: in-depth individual interviews covering teaching aptitudes, lesson planning, teaching demonstration, and performance/lab as needed. The public school teacher exams are extremely competitive. Although both public and private schools in all states and metropolitan education offices use identical salary tables, public schools tend to offer better benefits and working conditions (Lee et al., 2019).

Teacher education graduates in Korea need to apply for the national teacher employment test if they want permanent teaching positions in the public school sector. Competition is very high in Korea, although it varies depending on the provincial area (Kang et al., 2024). Teachers are required to renew their teaching certificates every five to seven years to demonstrate that they are still meeting performance standards. In Korea, teacher students are guaranteed a teaching position in a school after completing their training (Lee et al., 2019).

Teacher Status

Korean students' scores on national tests such as the PISA and TIMSS are well above the OECD average. On TIMSS tests, students' scores have decreased somewhat for middle-class students since 2015 but are still higher than the OECD average, as illustrated in Table 6-10.

In Korea, 67% of teachers "agree" or "strongly agree" that their profession is valued in society. This is a higher level than the average across OECD countries (26%), and this level has remained stable since 2013 (OECD, 2025).

Teacher Shortages

Teacher shortages are not a concern in Korea. Although Korea shares an East Asian, Confucian, collectivist culture with China (Lin et al., 2012), Korean teachers possess unique socio-cultural and economic characteristics that attract highly qualified individuals to teacher education programmes and the teaching workforce (Lee et al., 2019). On the contrary, an oversupply of teacher candidates is a national issue, particularly for secondary teacher candidates graduating from as many as 333 secondary education programmes. Oversupply is also a concern for elementary teacher education programmes (Lee et al., 2019). However, there has been a gradual decline in the popularity of the teaching profession in Korea (Kang et al., 2024). In Korea, the teaching profession is highly competitive due to the Confucian emphasis that affords teachers' job security and respect (Lee et al., 2019).

Similarities and Differences Between Countries Related to Themes on Teacher Shortages and Supply

Working Conditions

Teachers' working conditions are claimed to be one predictor of teacher shortages. In this study, the focus has been on salary, class size, student-teacher ratio, and workload compared to OECD averages. A basic predictor is countries' spending on education. Note that statistics on national spending on education are expressed as a percentage of the GDP. These figures can be compared to other international figures: The worldwide percentage of education spending compared to GDP for 2022 was 3.8%. In 2021, OECD countries overall spent 5.0%; Greece spent 4.1%, the USA 5.4%, and Sweden 7.6% (UNESCO, 2025). Increasing expenditure per student typically correlates with improved outcomes up to a point, after which additional investment shows little impact on performance. For instance, Japanese 15-year-olds' mathematics scores are higher than those of their US peers, even though Japan spends about 30% less per student aged 6 to 15 than the USA (OECD, 2024).

Teachers' salaries are also claimed to predict teacher shortages. Increasing teachers' salaries or having a steeper ladder for salary increase in relation to years working in the profession is often an argument for decreasing teacher shortages. The salary for teachers in the countries studied, not including Singapore, are shown in relation to the OECD average in Table 3.

Table 3. Salary in USD per country and school level

Country		Primary	Lower secondary
Finland	Starting	\$42,176	\$45,306
	15 years	\$51,740	\$55,579
Korea	Starting	\$36,639	\$36,639
	15 years	\$64,699	\$64,699
OECD average	Starting	\$42,062	\$43,484
	15 years	\$56,753	\$58,596

Source: (OECD, 2024)

Table 3 illustrates that the salary in studied countries do not differ much from the OECD average.

Class sizes and STRs are much-discussed aspects of education and are among the determinants of demand for teachers, along with students' instruction time, teachers' working time, and the division of teachers' time between teaching and other duties. Together with teachers' salaries, class sizes and STRs also have a considerable impact on the level of expenditure on education through teacher salary costs (OECD, 2024), as illustrated in Table 4.

Table 4. Student per Teacher Ratio

Country	Primary	Lower secondary
Singapore	15.2	12.6
Finland	13	9
Korea	16	13
OECD average	14	13

Source: (MOE, 2023; OECD, 2024)

Regarding class size, Singapore's classes are larger than the OECD average, whereas Finland's is lower and Korea is in line with the OECD average. This is illustrated in Table 5.

Table 5. Class Size

Country	Primary	Lower secondary
Singapore	33.6	32.6
Finland	19	19
Korea	22	26
OECD average.	21	23

Source: (MOE, 2023; OECD, 2024)

In conclusion, smaller classes demand more teachers with lower salary, and larger classes may lead to fewer teachers with higher salary, with the same amount of national spending on education.

Singapore, China, and South Korea are able to maintain low STRs despite larger-than-average class sizes, probably because they teach fewer classes (fewer hours teaching). These countries also tend not to be affected significantly by a shortage of qualified teachers. All of this suggests that, in isolation, class sizes and STRs may not be good indicators of teacher shortage (Gorard et al., 2024).

According to this study, students with SENs are taught by special teachers, either in special schools or special classes within mainstream schools. This approach differs widely among countries worldwide but is established for the countries included in this study. These countries' schools also employ support personnel to help teachers with tasks concerning students and other school-related issues. CPD programmes are highly developed and steered by the MOE in the countries of this case study.

Teacher Training/Education and Screening

Top-performing school systems globally recruit teacher students from the top third of the cohort. Singapore (30%), Korea (5%), and Finland (10%) all recruit their teacher students from the higher third of the cohort. Based on these figures, only Singapore recruits from approx. the top third, whereas Korea and Finland select from much smaller groups. Low-performing school systems rarely attract ideal teachers (the lower third of the cohort). All of the countries studied screened prospective teacher students' characteristics before admitting them to teacher training. The selection system consists of written tests and interviews on literacy, vocabulary, numeracy, problem-solving, interpersonal and communication skills, willingness to learn, and motivation to teach. Further, they are given support during their first years in the profession, and processes are in place to remove low-performing teachers from the profession.

Student Performance and Results

A school system's ability to attract teachers may be linked to the status of the profession. Good student learning performance supports the general public's view that teachers contribute to society, which in turn leads to high status for the teaching profession. The tables below illustrate students' performance and results on various tests according to the latest measurements.

Table 6. PISA 2022 Results

	Singapore	Korea	Finland	Mean
Mathematics	575	527	484	472
Reading	543	515	490	476
Science	561	528	511	485

Table 7. PISA 2018 Results

	Singapore	Korea	Finland	Mean
Mathematics	569	526	507	489
Reading	549	514	520	487
Science	551	519	522	489

Table 8. PISA 2015 Results

	Singapore	Korea	Finland	Mean
Mathematics	564	524	511	490
Reading	535	517	526	493
Science	556	516	531	493

The following tables illustrate the TIMSS and PIRLS results (OECD 2023, 2019a, 2016).

Table 9. TIMSS Results

	Singapore	Korea	Finland
2023 year 4	615	594	529
2023 year 8	605	596	504
2019 year 4	625	600	532
2019 year 8	616	607	509
2015 year 4	618	608	535
2015 year 8	621	606	-

Source: TIMSS (2024, 2020, 2016)

Table 10. PIRLS Results

	Singapore	Korea	Finland
2021	587	-	549
2016	576	-	566
2011	567	-	568

Source: PIRLS (2023, 2017, 2012)

Students in Finland, Singapore, and Korea perform better than the world average on all international tests (PISA, TIMSS) which is also true for Singapore and Finland (PIRLS).

Discussion

The overall aim of this study was to investigate characteristics of countries with no teacher shortages through the study of three specific country cases to determine what characteristics prompt teacher shortages. The following research questions are posed: 1) *Which aspects characterise countries lacking teacher shortages?* and 2) *What can be learnt from countries without teacher shortages?*

The focus of this study was to investigate aspects related to teacher shortage in context which do not have teacher shortage. When investigating the number of articles, a few were identified for the three countries. This result appears to support the idea that these countries lack teacher shortages at present. Therefore, the identification of these countries as lacking teacher shortages is reflected in low number of identified articles.

According to this study, a country's investment in education does not appear to affect teacher supply. In this study there are differences between the three countries' spending on education. However, none of these countries appear to have teacher shortages at present. Therefore, it could be argued that larger investments in school systems would not solve teacher shortages. There are also differences in teacher salary, class size, and student-teacher ratio among the country cases themselves and the OECD average. Even though these aspects are mentioned in many references (OECD, 2011, 2024), they do not seem to be important for the countries examined in this study.

In this study, within the three country contexts, it appears that student performance influences teacher shortages and STRs (OECD, 2019b). Therefore, these aspect may be seen to be a similarity and of interest to take note of. This may be the result of student performance influencing teacher status and, in turn, attractiveness of the profession (Gorard et al., 2024; McKinsley, 2017).

Limiting or controlling the number of open places in teacher training is also important to the status of the profession. With no teacher shortage, the lower need for teachers leads to a more stringent selection processes, which leads to a more attractive and high-status profession. As noted in this study, the selection processes in all these countries appear to be conducted using several methods and considering various perspectives, which appears to affect teacher status (OECD, 2019b; OECD, 2023; 2025). The possibility to achieve and maintain more stringent selection processes, appears to be a similarity between these three country contexts, and could be said to be the result of a lack of teacher shortage. Countries with teacher shortages may not have the possibility to select teacher students under such stringent condition in order to fill study places hopefully teacher shortages.

Inevitably, in Finland, the Republic of Korea, and Singapore, higher status for the teaching profession leads to less likelihood of a teacher shortage (Gorard et al., 2024; McKinsley, 2017). Furthermore, there seems to be a link between a lack of teacher shortage and higher status for teachers and the teaching profession. However, it is also important to note the cultural and national differences in history, religion, philosophy, politics, and governance among these countries—for example, contextual differences between Confucian East Asia and Western democracies. These differences must be acknowledged, as well as the complexities involved in comparing these countries.

Finally, teacher training and education are important to the status of the teaching profession, as well as support for new teachers (Gorard et al. 2024; UNESCO, 2023). A low-status teacher education leads to teaching being a low-status profession, functioning as a negative spiral that is unlikely to alleviate teacher shortages, according to the intentions of policy (UNESCO 2024; OECD, 2109b). The overall conclusion is that attracting and retaining teachers is a multifaceted and complex process and is the result of many interacting aspects in each specific country context.

Conclusions and Future Research

In conclusion, this study of three countries has highlighted some important aspects that may be related to teacher shortages. However, as noted, recommendations are difficult to make because the specific needs and structural realities of country contexts and educational systems vary. The results of this study may help policymakers, politicians, and heads of educational institutions in various countries better understand the importance of the status of the teaching profession and its underlying causes, helping to deal with teacher shortages in their own education systems. For policy makers it is of importance to support and promote teacher students' opportunities and to attract students to the teacher profession. For politicians, support for teacher students and teacher will be necessary to retain and development opportunities in the teacher profession, through supporting teacher

status and work environment issues. Finally, educational institutions will need to continue to support teacher students during their studies as well as providing high quality professional development for teachers in service. Thus, it appears that a key issue is appointing qualified and competent teachers; no educational system is better than the quality of its teachers.

Future research will be necessary to follow the development of these three countries in relation to teacher education, attractiveness, and retention over time.

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Artificial Intelligence and Didactics: Insights for teaching Latin

By Rita Colace, Michele Domenico Todino[±] & Iolanda Zollo[•]*

The article examines the integration of artificial intelligence (AI) into the didactics of Latin, framing AI as a transformative epistemic mediator rather than a mere technological adjunct. In the evolving digital landscape, AI is reshaping educational processes by influencing how knowledge is accessed, structured, and interpreted. The study critically explores four key areas—adaptive learning, gamification, assisted translation, and digital resources—demonstrating how AI can enhance pedagogical personalization, engagement, and inclusive learning experiences. Special attention is given to the challenges posed by algorithmic opacity, teacher mediation, and the ethical tensions surrounding automation in educational settings. The Latin language, understood as a symbolic and logical construct, is presented as uniquely suited to benefit from AI-enhanced learning environments, which can support complex interpretive practices. When implemented within a coherent pedagogical framework, critically and ethically, AI has the potential to revitalize classical language teaching, enhance students' interpretive skills and metalinguistic skills, foster both critical literacy and meaningful interaction with classical texts. Ultimately, this contribution argues for a humanistic and ethically grounded approach on AI integration in education: Latin and AI together offer new avenues for promoting critical thinking and cultural awareness in education, reaffirming the relevance of classical studies in the digital age.

Keywords: Artificial Intelligence; Inclusion; Teacher Education; Latin Didactics; Inclusive Technologies.

Introduction

We live in an era where the digital environment is no longer merely an external dimension of reality but increasingly becomes an integral and structuring component, significantly impacting our personal, professional, and social lives. Consequently, the field of education and pedagogical research must engage with the resources that artificial intelligence (AI), which is no longer a secondary tool, is introducing into the realm of educational technologies (Luckin et al., 2016).

As education occurs within a constantly transforming cognitive space, where distinctions between natural and artificial, human and computational, become increasingly blurred, intelligent technologies are shaping the ways we learn, teach, access information, and construct knowledge (Williamson & Eynon, 2020). This process is neither uniform nor predetermined, but probabilistic and dynamic, open to multiple interpretations and trajectories.

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Rather than representing a radical and univocal change, AI is emerging as a potential epistemic mediator. If consciously embedded within an educational project, it can filter, structure, and reinterpret the relationship between subject and knowledge, opening new methodological and reflective perspectives. This involves rethinking the role of teaching and educational aims in a dialogical and flexible way. The integration of AI into schools, through both teachers' knowledge of these tools and students' guided, active use, represents a profound educational choice, one that encourages students to engage with a world increasingly mediated by technology, with intelligence, critical thinking, ethical awareness, and cultural depth (Pham & Sampson, 2022).

Given these premises, it is essential to more precisely articulate the relationship between AI and education, focusing on how AI interacts with didactics in general and with Latin teaching in particular. Artificial intelligence may represent an opportunity for methodological renewal that enhances the formative and inclusive value of Latin. If integrated into a pedagogical framework aimed at understanding and reflection, AI can serve as a catalyst for complex educational experiences. It can promote deeper analysis and create cognitively stimulating environments in which learner-text interaction, supported by human-machine collaboration via avatars and NPCs, fosters a new form of critical, dialogical learning, one that does not merely provide automatic answers, oversimplify texts or replace the teacher.

This paper seeks to understand how artificial intelligence can constructively engage with Latin pedagogy, enhancing its cultural, formative, and inclusive value while redefining how Latin can be learned, without simply adding technology to the subject.

By considering AI as an epistemic mediation tool that transforms learning conditions (Holmes et al., 2019), and by analyzing regulatory frameworks and national and international strategies that guide the use of AI in education (UNESCO, 2021; OECD, 2021), this study aims to explore the tools, methodologies, and digital resources currently available for Latin instruction. It will highlight both potentials and limitations, with a focus on the pedagogical, cultural, and epistemological implications of AI in the humanities (Miao et al., 2021).

Reflecting on the use of AI in Latin education invites a dialogue between tradition and innovation, between memory and future, encouraging educators to consider how such technologies can inspire new teaching practices. These practices must align with Latin's inherent complexity, and be part of a thoughtful pedagogical design that integrates existing methodologies and technologies to enrich the cultural dimension of Latin and the relationship between humanistic knowledge and new forms of intelligence.

Artificial Intelligence and Education

Within the theoretical and pedagogical framework in which artificial intelligence is situated, this section focuses on how AI intervenes in educational processes by transforming the very structure of the teaching relationship. It explores AI's contribution to the transformation of educational mediation and highlights the implications of its use in school settings.

Every educational act is a form of mediation, between knowledge and learner, content and context, intention and interpretation, where meaning is not transmitted but co-constructed. In this context, artificial intelligence introduces new possibilities, but also new responsibilities. It becomes a technology *of* education, not merely *in* education, because it reshapes the ways in which cognitive experiences take form. As Floridi (2023) notes, every digital artifact is an information and representation technology that filters, structures, and guides our relationship with knowledge.

AI actively participates in knowledge construction by selecting data, proposing patterns, suggesting connections, and introducing adaptive personalization models (Brusilovsky & Millán, 2007), as well as predictive models for assessment and environments capable of dynamically responding to students' behaviour. In these intelligent environments, learning becomes a dynamic system of adaptive interactions mediated by algorithms that continuously reshape experiences based on students' cognitive actions and strategies (Luckin et al., 2016).

However, it is essential that these systems operate based on transparent, interrogable, and negotiable algorithmic logics (Bender et al., 2021). A fundamental tension arises: while AI offers opportunities to personalize learning, adjust difficulty levels, and provide immediate and consistent feedback, it simultaneously renders the logic behind didactic mediation increasingly invisible and opaque. This is the issue of the so-called "algorithmic black box": who controls the cognitive infrastructure of learning? What criteria guide the interaction? Who determines what is "correct" or "incorrect" in an AI-generated exercise? (Williamson & Eynon, 2020; Binns, 2018).

In this context, the teacher becomes a conscious mediator between student, knowledge, and technology, safeguarding the purpose and intention behind didactic choices, something that AI, by its nature, cannot possess. Therefore, a new kind of critical professionalism is essential, one capable of interpreting and evaluating AI-generated outputs, integrating algorithmic contributions into pedagogical design, especially in the humanities. In these fields, the value of learning lies in semantic complexity, interpretive plurality, and reflective depth.

Thus, discussing artificial intelligence in education also means rethinking pedagogical paradigms, since AI redefines the very notions of knowledge and competence.

If embedded within a deliberate pedagogical vision, artificial intelligence can represent a valuable opportunity to rethink the foundations of contemporary education. It can help restore the teacher's central role as a critical intellectual, a mediator of meaning, and a designer of authentic learning experiences. Only within this framework can AI truly serve as a cultural tool, rather than being reduced to just another technological device for adaptive training. To achieve this, a deep epistemic and ethical awareness is necessary, one that can guide didactic choices and critically

manage mediation through human-machine interaction using avatars and NPCs (Coppola, 2024; Di Tore et al., 2022).

Artificial Intelligence and Education: Key International Frameworks

The integration of artificial intelligence in educational contexts today requires more than ever a careful and multi-level regulatory approach. Such regulation must balance innovation with responsibility and manage the systemic transformation affecting the very nature of learning, teaching, and assessment. In recent years, major international and European organizations have developed a range of guidelines, recommendations, and strategic documents aimed at guiding AI integration into society and educational systems based on shared ethical principles.

The European Union has taken a leading role in this process, which culminated in the enforcement of the *Artificial Intelligence Act (AI Act)* in August 2024. This is the world's first comprehensive legal framework dedicated to AI regulation. The act classifies AI systems based on risk levels, imposing stricter requirements on high-impact technologies, particularly those used in education, healthcare, employment, and security, thereby establishing a legal foundation for the safe and responsible use of AI within the EU. It seeks to protect fundamental rights while fostering innovation (European Commission, 2024).

Another structured initiative promoted by the European Commission is the policy document titled "*A European Approach to Artificial Intelligence*" (European Commission, 2021). This vision emphasizes reliability, transparency, safety, and respect for fundamental rights. The European model is built on the premise that AI must be "*trustworthy by design*", meaning it should incorporate democratic and social values at its core. The educational sector, given its high social impact, is identified as a priority area. Technologies used for learning must remain under human oversight, their operational logic must be inspectable, and their outcomes verifiable.

This approach aligns closely with *UNESCO's Recommendation on the Ethics of Artificial Intelligence* (2021), which asserts that every AI technology should aim to strengthen human rights, promote inclusion, guarantee equitable access to education, and preserve cultural diversity. The document also stresses the urgency of global AI governance in education, grounded in principles of non-discrimination, accountability, and algorithmic transparency.

Earlier, the OECD had also addressed AI's educational implications through its *Future of Education and Skills 2030* project. This initiative offers a framework focused on developing transversal, metacognitive, and social skills in response to the challenges of new digital environments. AI is viewed as a lever to reshape school curricula, guiding them toward lifelong learning, adaptability, and student empowerment, where learners are seen as active agents in their own educational journey (OECD, 2019).

These international perspectives have also found resonance at the national level. In Italy, policy documents such as the *Proposals for a National AI Strategy* (MIMIT, 2021) and the *Guidelines for AI in Public Administration* (ACN, 2022) emphasize the need to train school staff, build digital educational ecosystems, promote shared ethical

standards, and develop critical and interdisciplinary digital skills from the early stages of education. These documents also emphasize the importance of providing teachers with specific training programs so that they can become interpreters and mediators of intelligent technologies in the classroom.

Nonetheless, these frameworks are not without limitations. In many cases, the language adopted is deliberately general, avoiding the deeper pedagogical tensions introduced by AI, such as those between personalization and standardization, support and surveillance, or educational freedom and algorithmic optimization. In particular, key elements such as the epistemic value of error and ambiguity, which are essential to the learning process, are still largely overlooked.

The risk is that AI regulation in education may be reduced to a technical-legal issue, overlooking its cultural and pedagogical nature. Therefore, policies should not be viewed merely as administrative constraints, but rather as starting points for conscious educational design. Such design must integrate AI in ways that are consistent with a humanistic and critical vision of learning.

Artificial Intelligence and Latin Didactics

At present, no large-scale international project exists to assess the impact of artificial intelligence on schools, nor are there ministerial documents offering practical guidance for its application to specific subjects. It is therefore crucial to begin reflecting on these issues through a deeper understanding of AI tools and the training of students to use them actively and critically. Teachers also need specific training on such tools and should engage in large-scale action research in their classrooms to test possible uses and opportunities. Moreover, it is important to ask how humanistic knowledge can be reformulated within today's digital infosphere (Floridi, 2023), and to what extent AI can be useful for the teaching of Latin in a way that is sustainable and respectful of the dialogical nature of knowledge, its epistemological foundations, and the dignity of the student.

In order to explore the implications of artificial intelligence in Latin teaching (pedagogy) in an articulated way, it is useful to focus on a number of key directions: the use of adaptive learning systems, which open up possibilities for constructing personalized pathways that respond to learners' specific difficulties; the integration of gamification to strengthen motivation through playful and immersive environments; the reflective use of assisted translation to support linguistic and semantic analysis of texts without replacing the student's hermeneutic activity; and the adoption of specific digital tools that help reinforce reading and comprehension practices, fostering interdisciplinarity and inclusivity.

Adaptive Learning

Adaptive learning systems, based on predictive analysis and the modelling of learning behaviours, represent one of the most advanced forms of artificial intelligence in education. They work by identifying recurring patterns in student interaction with content and by proposing learning paths tailored to those configurations (Brusilovsky & Millán, 2007).

Such systems can reveal the mismatch between prescribed knowledge and actual internalization. Through continuous interaction, personalized feedback, and adaptive monitoring, intelligent systems can make this discrepancy visible far more precisely than traditional assessment. For example, an AI tutor might detect that a student, although correctly completing exercises on grammatical rules, consistently makes errors in open-ended contexts (the student may know that a final clause uses *ut* and the subjunctive but may fail to recognize that *ut hoc facerent* is an example). This gap between theoretical knowledge and genuine understanding thus becomes observable and subject to analysis.

In this sense, adaptivity identifies obstacles and suggests alternative paths. In Latin teaching, this allows for the design of exercises that do not assume linear learning progression but reflect the discontinuity of learning and the complexity of syntactic constructs.

Alatin is an example of such an intelligent system: a Latin course platform designed to support remediation and skill enhancement through personalized exercises delivered via tablet or smartphone, based on the most frequent errors and the learner's progress (<https://alatin.it>). The teacher, in turn, gains the opportunity to personalize instruction, respect individual learning paces, embrace diversity, and construct flexible, participatory learning paths (Sibilio & Aiello, 2015).

Based on the same principles, other platforms have been developed that rely on adaptivity and offer students exercises based on prior mistakes, providing immediate feedback. These platforms act as virtual tutors that guide learners in analyzing, understanding, and translating Latin texts. When students make mistakes, the multimedia assistant helps them move forward without interruption (<https://www.cloudschooling.it/cicero/demo/9845/>) (Balbo, 2021). Other platforms, such as Atticus (<https://sanoma.it/prodotti-digitali/atticus>), provide personalized learning by adapting to individual student needs through artificial intelligence, with the aim of progressively developing language skills using a cognitive approach to Latin.

Gamification and Motivation

Another area in which artificial intelligence has introduced an epistemic discontinuity is that of gamification. If play, in its archetypal form, represented for Plato a simulation of true learning, the current convergence of AI and gamification generates a new dimension of educational attention, in which playful interaction becomes a tool for cognitive immersion.

In Latin education, this translates into responsive and intelligent learning environments capable of recognizing mistakes, sterile repetition, and proposing new

challenges, lateral pathways, and alternative puzzles to solve. Gamification supported by AI thus restructures learning as an exploratory process.

Scientific studies have shown that a gamified approach to Latin learning results in higher levels of student engagement and satisfaction. Bibliometric analyses confirm that gamification is increasingly regarded as an effective strategy to enhance student motivation and classroom participation (Irwanto et al., 2023).

Gamification is becoming increasingly present in school settings, contexts traditionally not associated with play, because it has been shown that gaming increases student motivation and reframes error not as failure but as an opportunity to reflect on and analyze one's weaknesses in a given subject area. Through virtual reality, gamification can create immersive and interactive ancient environments that aim to reduce the sense of distance students often feel when studying cultures that thrived millennia ago. It can “transport” learners to ancient Rome, allowing them to hear spoken Latin and see the places and people of Roman civilization. Through this immersive approach, students can also explore contemporary issues, such as gender representation in antiquity, showing that not only the Latin language but also Roman culture can be experienced as a living subject (Torres & Pérez, 2022). Students can reflect on the concept of the Roman Republic and engage in interdisciplinary learning, thereby demonstrating the interconnectedness of knowledge domains and enhancing teaching quality and engagement of students.

The gamified lesson itself proves to be motivating because it includes clear communication and a formal reward system embedded in each session. Increased motivation helps students to be more productive and engaged, making it easier for them to meet lesson objectives. Based on the feedback received, students would like greater immersion in virtual learning environments, as they find it enjoyable to use Latin in the same way they play video games and to learn it during their leisure time (Beams & Crofton-Sleigh, 2024). This dynamic, in turn, enhances intrinsic motivation, an essential factor in student success.

Among the most widely used language learning apps that include Latin are *Duolingo*, available only in English-Latin version, and *Rosetta Stone*, which includes Latin only in its desktop version and requires at least a six-month subscription. Feedback on these apps is generally positive (noting feelings of progress and satisfaction, as well as in-app gamification features), but some limitations remain, for instance, the apps' difficulty in accurately recognizing pronunciation, which can lead to frustration and a sense of failure (Yuen & Schlote, 2024).

Regarding the future of AI in language learning and instruction, it is important to acknowledge both the numerous advantages it brings to educational apps and the challenges it presents. These include the need for continuous updates and improvements to AI algorithms and ethical considerations about potential bias in AI-based language assessments. Such biases must be identified and counteracted to ensure fairness and inclusivity in the design and implementation of AI systems. Emerging educational AI policies, such as UNESCO's guide for generative AI in education and research (Miao & Holmes, 2021), offer valuable insights for developing best practices for integrating AI into language learning.

Overall, teaching techniques based on play show strong results in terms of motivation. A range of transversal skills and playful dimensions are unconsciously activated by students, and the benefits of integrating AI functionalities into language learning applications, particularly in terms of motivation and learner assessment, appear to outweigh the risks.

Computer-assisted Translation

One of the main objectives in teaching Latin is to develop the ability to translate, a skill that is among the least automatic. Translation entails a hermeneutic act, contextual interpretation, and semantic work that goes far beyond simple word-for-word correspondence. It involves complex interpretive activity that promotes deep comprehension, taking into account the communicative intent, context, and logical structure of a passage.

Faced with this complexity, current machine translation technologies show clear limitations. While tools like *DeepL* or *Google Translate* can produce acceptable versions in modern languages, this is not the case with Latin. In fact, *DeepL* does not even include Latin among its supported languages.

A more promising approach lies in assisted translation, which does not aim to replace the student's interpretive actions, but rather to accompany it. Such tools offer suggestions, disambiguations, and alternative logical structures, fostering deeper reflection and stimulating doubt. The most well-known and widely used tool in this context is *ChatGPT*, a chatbot based on machine learning language models. Its online accessibility and ongoing development have contributed to its widespread use, although it now has competitors such as *Google Gemini*, *Microsoft Copilot*, and *Perplexity AI*.

When considering the use of *ChatGPT* in Latin instruction, the following activities are currently possible:

- text production
- basic text correction
- error detection and analysis
- imitation of literary styles ("writing in the style of...")
- textual analysis
- assignment development and execution
- introduction drafting
- translations
- information retrieval
- preparation of intermedial teaching materials
- simulation of oral examinations and questionnaires
- creation of summary tables

From various exercises submitted to the chatbot, it emerges that it is capable of accurately translating simple, artificial texts of a primarily grammatical nature, and it also offers acceptable lexical suggestions. Its performance is reliable at basic grammatical levels but still imperfect when it comes to more complex tasks. One must

also consider that the model's primary language is English, and although it handles Italian correctly, it is not always precise (Balbo, 2024).

Moreover, it is important to note that the chatbot does not generate knowledge capable of explaining or interpreting problems; it can only describe them in depth based on the databases it was trained on (Hayashi, 2023). This becomes evident when analyzing literary responses. When presented with a passage from a classical Latin author, the AI produces approximate answers, particularly in translation, summarization, and analysis of complex syntactic structures. Furthermore, whether in completing or solving exercises, it often fails to recognize all Latin verb voices or distinguish the different uses of the same prepositions such as *cum*.

Even when prompted correctly, ChatGPT cannot always respond adequately because the model operates using short-term memory mechanisms, such as Retrieval Augmented Generation (RAG), which allow it to temporarily retain information during a session in order to refine its replies. However, ChatGPT's capabilities remain tied to the data and algorithms it was originally trained on, and it lacks the capacity for dynamic, permanent learning based on user input (Balbo, 2024).

This highlights the static nature of its training and the ethical and legal constraints that currently prevent real-time adaptive learning, raising important questions about the balance between the adaptive capabilities of language models and regulatory limits, as well as the challenge of ensuring both innovation and privacy protection in the use of conversational AI.

Digital Tools

The recent advances in artificial intelligence applied to Latin teaching rely largely on the availability of open, annotated, and interoperable linguistic *corpora*, which serve as the raw material for automated processing.

In this area, resources such as the *Perseus Digital Library* (part of the *Alpheios Project*) (<https://www.perseus.tufts.edu/hopper/>; <https://alpheios.net>) or the *Digital Latin Library* (<https://digitallatin.org>) make it possible to achieve an enhanced understanding of classical texts. Unlike simple repositories like *The Latin Library* or *Classic Archive* (<https://www.thelatinlibrary.com>; <http://classics.mit.edu>), these platforms offer advanced semantic functionalities, such as automatic morphosyntactic analysis, logical structure visualization, and textual variant comparison. In this way, reading a Latin text becomes an experience characterized by interaction, exploration, and rich contextual information.

There are also digital platforms specifically dedicated to Latin, such as *Perseids (Arethusa)* (<https://www.perseids.org/perseids-platform/>; <https://www.perseids.org/tools/arethusa/app/#/>), which includes projects that graphically represent syntactic structures of Latin sentences, often drawn from classical literature, using tree diagrams and color coding to highlight syntactic dependencies. These visualizations engage spatial-visual learning channels, which can help students develop active competence and support learners with Specific Learning Disorders (SLD) (Rydberg-Cox, 2016).

Daniel Patterson, for instance, created the website/platform *Latinitium* (<https://latinitium.com>), which contains Latin-language videos with English subtitles on literary topics, presented by Patterson and his colleagues. It also includes multimedia

and self-learning resources such as a detective story written in classical Latin. Additionally, the *Legentibus* app, a free mobile tool for Latin learning, is centered around a library of classical and modern Latin texts that can be listened to and read. Exercises are integrated to help learners progress in their skills.

This approach combines Latin texts with synchronized audio and targeted comprehension tasks, promoting both textual understanding and learner motivation.

Ultimately, the proper use of new technologies in teaching Latin offers the clear advantage of reaching every student and making each learner an active protagonist in their own educational journey.

Conclusions

Every technology, as a product of design aimed at action, carries both a transformative potential and an epistemic responsibility. When applied to education, artificial intelligence (AI) emerges as a technology of mediation, capable of reorganizing both the forms of knowledge and its modes of transmission. However, no informational infrastructure is ever neutral, as it reshapes the very ontology of the subjects involved, generating new relationships and new dependencies (Floridi, 2014).

Applying AI to the teaching of Latin therefore entails a dual challenge: on the one hand, to harness its advantages in terms of access, personalization, and cognitive enhancement; on the other, to recognize its structural limitations, ethical tensions, and epistemic risks that come with delegating learning processes to machines.

One of the main benefits of AI in Latin instruction is its ability to make the classical language more accessible, particularly for students who struggle with traditional methods. Tools based on Natural Language Processing (NLP) and machine learning, such as lexical assistants or educational chatbots, function as cognitive prostheses (Clark & Chalmers, 1998), helping to decode morphology and understand complex constructions. Especially adaptive learning platforms, as described by Brusilovsky and Millán (2007), personalize the educational experience according to learners' cognitive needs. In parallel, AI can suggest alternative readings, highlight semantic ambiguities, or pose metalinguistic questions that encourage active and critical engagement from students (Holmes, Bialik & Fadel, 2019).

However, if learning is entirely guided by machines, the roles of both teacher and learner are altered, and knowledge risks being transformed from a dialogical process into an algorithmic product. There is a real danger that students may become passive consumers of knowledge, relying on decision-making systems they do not fully understand (Floridi, 2014). This leads to the issue of algorithmic opacity, as many AI tools make it difficult to trace the origin of the responses they generate, thus creating a crisis of trust: "If we cannot know where a translation suggestion comes from, how can we assess its reliability?"

The teacher risks becoming a mediator of a technology they do not control, effectively delegating the educational act to the machine. In such a scenario, education risks losing its ethical and relational dimension and being reduced to data management rather than a shared construction of meaning. This is why it is essential to train teachers in the understanding and conscious use of artificial intelligence.

Alongside epistemic challenges are the structural and cultural limitations of using AI in Latin education. Firstly, there is the issue of infrastructure: not all schools have the technological resources needed to implement advanced AI tools, and not all teachers possess the skills to use them effectively. The risk is that the digital divide may widen, excluding precisely those students who would benefit most from personalized and adaptive teaching. Secondly, there remains a lack of high-quality Latin linguistic corpora for training effective AI models.

Finally, it must be remembered that language, every phrase, syntactic construct, or semantic nuance, is a product of worldview and context. As advanced as it may be, AI can calculate but not comprehend and thus cannot replace the experiential depth of human understanding (Selwyn, 2019).

If artificial intelligence can now participate, alongside students and teachers, in the construction of meaning in education, then a new pedagogical vision is needed: an *informational humanism* that reaffirms the centrality of the human within increasingly complex, interconnected, and autonomous digital environments (Floridi, 2023).

The exploration of how AI can be integrated into Latin teaching suggests that, if well designed and contextually grounded, it can contribute to redefining teaching practices. In particular, it becomes clear that when critically integrated, AI can help renew didactic approaches, broaden access to texts, enhance motivation and critical thinking, and support the formative and inclusive value of Latin.

The introduction of AI into Latin pedagogy represents a complex educational challenge, one that involves the meaning of learning itself, the teacher's formative responsibility, and the student's individuality. From this perspective, AI can be understood as a technology of epistemic mediation, capable of redefining how knowledge is perceived, explored, and shared, thereby transforming the relationship between teacher, learner, and content, and reshaping the very conditions of educational experience.

The learning modes examined, adaptive learning, gamification, assisted translation and digital tools, have demonstrated how AI can enrich various dimensions of education: from the personalization of learning pathways to the reactivation of motivation, from the facilitation of linguistic analysis to the construction of interactive environments. Adaptive learning, by tailoring pathways to students' errors and needs, proves to be a valuable tool for respecting individual learning rhythms and trajectories. Gamification, supported by intelligent digital environments, revitalizes the playful dimension of classical knowledge and strengthens motivation through immersive and narrative learning. Computer-aided translation serves as a form of cognitive mediation that fosters questioning, linguistic reflection, and textual awareness. Lastly, digital tools, from annotated *corpora* to interactive platforms, enable new forms of access to and engagement with Latin texts, supporting both inclusion and learner autonomy. AI thus emerges as a cognitive environment within which Latin teaching can be reimaged, in a dynamic balance between methodological innovation and fidelity to the complexity of humanistic knowledge.

However, there are also ethical issues that accompany the introduction of AI into educational settings, such as algorithmic opacity, the outsourcing of cognitive processes, the risk of overdependence on tools, and unequal access to technologies.

In this context, the teacher plays a fundamental role in evaluating and managing intelligent systems in light of educational objectives, acting as an indispensable mediator between knowledge, technology, and learners. Latin can be understood as a symbolic and logical structure which, when supported by coherent digital environments, can be reactivated as a space for reflection, in-depth exploration, and interpretive practice, where artificial intelligence helps to make meaning more accessible, visible, and shareable.

Latin, as a language of the future (Gardini, 2018), and artificial intelligence, together, can help shape critically aware citizens. If educators and software developers collaborate and establish ethical guidelines and effective policies, the future of language learning, including Latin, enhanced by AI and new technologies, will continue to evolve and thrive.

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Fostering Students' Engagement and learning through Simplex Didactics Approach¹

By Naomi La Manna, Emanuela Zappalà[±] & Maurizio Sibilio[•]*

Several studies, both nationally and internationally, highlight how student engagement is a strong predictor of academic performance. In the literature, the term “engagement” is described as a multidimensional construct, comprising behavioral, emotional, and cognitive components, which together provide a holistic understanding of the school experience. Given the increasing complexity of educational contexts, this multidimensional nature underscores the need for teachers to adapt their practices to students' needs and cognitive styles, promoting active participation in the teaching-learning process. In this perspective, the approach of Simplex Didactic becomes particularly relevant. Grounded in a bio-educational vision, it offers an innovative approach to understand and guide the adaptation of complex systems - such as educational ones - to the principles of living systems. Recognized as an effective tool for promoting inclusion, Simplex Didactic may also serve as a valuable strategy to enhance student engagement. Based on these premises, the present study aims to validate the adapted Italian version of the Engagement Questionnaire (Abbasi et al., 2023) to assess engagement levels among future support learning teachers participating in a 30-hour training course on Simplex Didactic. The research is part of a broader investigation designed to explore whether the adoption of simple teaching practices fosters engagement, learning, and school inclusion.

Keywords: Engagement; Simplex Didactics; Teaching-Learning process; Inclusion

Introduction

In the broader discussion on inclusive education, student engagement embodies both educational equity and inclusivity, serving as a key factor in promoting academic achievement by fostering active participation, a sense of belonging, and equitable access to learning opportunities. According to Fredricks et al. (2004), Guthrie & Anderson (1999), and Wigfield et al. (2000), student engagement is characterized by active, affective and reflective involvement in the learning process. This multidimensional perspective (cognitive, behavioral, and emotional) has become a shared orientation in literature. Empirical evidence shows that inclusive pedagogies rooted in engagement theories may promote benefits, particularly for students with special educational needs or at risk of marginalization (Aiello, Pace, &

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²The article is the result of a collaboration between the authors. However, Naomi La Manna wrote paragraphs “2. Simplex didactics' theoretical framework”, “3. Engagement: theoretical framework”, “4. Methodology”, “6. Discussion”; Emanuela Zappalà wrote paragraph “1. Introduction” and “Conclusion”; Maurizio Sibilio is the Scientific Coordinator of the research.

Sibilio, 2023; Alnahdi, Poblete & Schwab, 2022; Di Gennaro et al., 2018; Joshi et al., 2022; Zollo et al., 2018). In this perspective, engagement is not merely an individual trait but a relational outcome, shaped by the interaction among teachers' pedagogical perspectives, their professional agency and their ability to critically reflect on their educational actions. Within this framework, teacher agency assumes a pivotal role to foster both the learning process and students' engagement, understood as the «capacity of teachers to act purposefully and constructively to direct their professional growth and contribute to the quality of education» (Priestley, Biesta & Robinson, 2015, p. 137). This agency encompasses professional judgment, reflection-in-action (Schön, 1983), and the willingness to adapt instructional strategies to meet diverse learning profiles (EADSNE, 2012; Di Gennaro et al., 2016; OECD, 2018).

Nevertheless, in the Italian context, validated tools to measure engagement are still lacking, especially in teacher education programs. This gap makes it difficult to systematically assess and promote engagement in inclusive classrooms. Addressing this limitation requires not only reliable instruments but also a clearer understanding of how inclusive learning environments actually work and how teachers should act to foster students' engagement and learning process.

Inclusive learning environments should be conceived as dynamic systems that evolve over time rather than as static contexts. Their key aim is to guarantee that all students, regardless of abilities, socioeconomic background or preferred learning styles, have equitable access to and may fully participate in meaningful and engaging educational experiences. From this perspective, the challenge for teachers is to develop adaptive strategies that move beyond linear and standardized models of instruction.

To navigate the complexity of classroom life, teachers require approaches that enable them to flexibly respond in real time. In this sense, Alain Berthoz's (2012) theoretical insights and their pedagogical elaboration (Sibilio, 2020, 2023) offer a useful conceptual framework. According to Berthoz, human cognition relies on adaptive strategies of simplification that allow individuals to efficiently address complex situations, without compromising responsiveness, intentionality, flexibility or emotional sensitivity (Berthoz, 2012). Its didactic transposition, known as Simplex Didactics, provides a foundation for rethinking the teaching-learning process as a complex, relational system where both teachers and students co-construct knowledge, identity and sense of belonging (Sibilio, 2012, 2015, 2020). At the heart of this approach lies the teacher's adaptive gaze that is, the ability to recognize and respond in real time to the variability of classroom life, while valuing students' diversity and potential (Aiello, Pace & Sibilio, 2023).

By promoting full participation, embracing diversity and fostering deep learning, Simplex Didactics offers a pedagogical framework based on principles of complexity management. It equips teachers with theoretical and practical tools to address today's educational challenges, moving away from one-size-fits-all teaching toward more personalized, differentiated and contextually responsive practices. Within this framework, teachers are encouraged to create learning environments that are simultaneously structured and flexible, where their agency emerges as a cornerstone of inclusive pedagogy.

Given that the development of professional agency and reflexivity is a major concern in teacher education, the applicability of Simplex Didactics is even more

apparent. Professional development depends on metacognitive awareness and the capacity to reflect on, in and about one's own actions (Schön, 1983). According to the theory of Simplicity, teacher candidates should learn how to use their innate adaptive abilities (such as pattern recognition, affective attunement, and strategic inhibition) pedagogically rather than being taught about them. Building on these theoretical premises, the present study focuses on a specific objective: validate the adapted Italian version of the Engagement Questionnaire (Abbasi et al., 2023) to assess engagement levels among future support learning teachers participating in a 30-hour training course on Simplex Didactic. Through the validation of this instrument, the study aims to provide quantitative data useful for promoting more personalized, differentiated and complexity-sensitive teaching practices, reinforcing the idea that engagement is a collective achievement rather than a mere individual attribute.

Simplex Didactics' Theoretical Framework

The increasing complexity of learning environments underscores the need to identify effective strategies to ensure that all students, regardless of their individual needs, feel involved, interested and actively engaged in the learning process, so they can maximize the benefit of the educational experience (Fredricks et al., 2004). Within this framework, the construct of engagement assumes particular importance. Defined as a multidimensional process encompassing behavioral, cognitive and emotional components (Fredricks, Blumenfeld & Paris, 2004), engagement is recognized as crucial for fostering meaningful and sustained participation in educational activities. High level of engagement is associated with improved academic performance, greater task persistence, and deeper intrinsic motivation.

On the other hand, there is an ongoing debate about the set of skills teachers should have to feel adequately equipped to act professionally and effectively in increasingly complex educational contexts (Aiello et al., 2023). In the field of national pedagogy, a noteworthy contribution comes from neurophysiology through Berthoz's Simplicity theory, which has increasingly gained attention. This theory offers a compelling vision of how complex systems, such as in the educational one, adapt harmoniously by activating a series of biological mechanisms that emerged over the course of evolution (Aiello et al., 2023). Rather than challenging or replacing existing pedagogical models, this theory provides a systemic and integrative perspective and may also represent a conceptual toolbox for teacher training that enables educators to operate within what Van Geert and Steenbeek (2014) describe as an epistemologically complex system such as education, managing to understand the system and achieve important things from their own perspective (Van Geert and Steenbeek, 2014).

The properties and principles of Simplicity provide an integrated operational and theoretical framework, useful for designing educational experiences that stimulate cognitive engagement (through the modular and comprehensible structuring of content), behavioral engagement (through flexible teaching strategies that respond to environmental stimuli), and emotional engagement (through the creation of a climate of reliability, cooperation, and positive anticipation). In his theory of Simplicity, Berthoz identifies a set of «biological devices, or processes [that] have appeared in

the course of evolution to enable animals and people to survive on our planet [by] processing complex situations very quickly, elegantly and efficiently, taking into account past experience and anticipating the future» (Berthoz 2012). The cognitive physiologist and neuroscientist identify a list of six properties or action patterns that constitute the tools for life and six principles or rules that define the framework of reality (Aiello et al., 2023). These are applied independently or in parallel to create different models of action and interaction to effectively solve complex problems. These cognitive processes work in cooperation with emotion that quickly attributes values to possible solutions based on the memory of past decisions or regret to anticipate the future. In line with complexity thinking, the principle of intersubjectivity is fundamental in his theory as it allows complex adaptive systems to understand and predict not only the consequences of their actions, but also the intentions of others (Berthoz, 2003, 2012).

Within this framework, logic is neither linear (that is, linking a problem to a single, fixed solution) nor reproductive, automatic, which would involve replicating solution technically modeled by others (Sibilio, 2023). Instead, the framework of Simplicity, invites us to reflect on the relational nature of meaning-making, highlighting how the process of understanding is inseparable from the process of explanation, especially when we seek to determine the personal or contextual significance of something.

Focusing on the teaching-learning process, Sibilio (2014) argues that this theory may guide teachers to deal with the complexity of inclusive educational contexts. In his works, Sibilio (2012, 2015, 2017) provides an analogy between the above characteristics of Complex Adaptive Systems and the teaching-learning process, stating that the latter is a dynamic system that constantly interacts with many other elements that are part of a larger system. Such interactions are highly characterized by non-linear behaviors that require constant reorganization that in turn lead to emergent structures that are highly unpredictable (Aiello et al., 2023). Consequently, by tracing the simplex properties and principles within this process, it is hypothesized that if teachers gain awareness of these innate laws and tools that regulate behavior within complex adaptive systems, they will be able to deal with emerging complexity more effectively (Aiello, Sharma, and Sibilio 2016; Sibilio 2015).

Teachers need to develop explicit awareness of these laws and tools, as their use often becomes automatic in complex classroom scenarios. Close to reflexive or learned behaviors (such as breathing, walking, or driving) these practices may operate unconsciously, shaping classroom interactions without deliberate reflection (Aiello et al., 2023). It is scientifically proven that improving, changing or eliminating some of these tendencies may improve our well-being. Focusing on breathing, for example, may reduce tiredness and anxiety (Burtch et al., 2017). Focusing attention on posture can help relieve back pain (Qaseem et al., 2017), while focusing more on driving improves performance and in turn limits road accidents (Allahyari et al., 2008). Supporting this view is the importance given to reflective practice before, during and in action as a core competence and fundamental practice in all professions for transformative action (Schön, 1983), without exception for teachers (EADSNE2012; Shulman2004).

Berthoz's theory has been applied to date in several research fields as a guide to understanding how complex systems organize themselves to thrive in harmony with their environment. Its principles and properties, simplifying themselves complex,

provide a feasible approach to address complexity rather than denying it. This theory may be considered a suitable theory to guide research and practice in different educational systems since it is based on premises that are neither context-specific nor tied to the culture of the time (Berthoz, 2012; Sibilio, 2014; Aiello et al., 2021). Further research is needed to be able to validate its potential to improve teaching action to enable the teacher to act in an engaging and inclusive way.

Engagement: A Multidimensional Construct

Studies in the literature show that the term engagement should be understood as a multidimensional construct, consisting of intrinsically related and interdependent components (Hookham & Nesbitt, 2019; Fredricks et al., 2004). In line with Fredricks et al. (2004), it is framed as a meta-construct within which behavioral, emotional, and cognitive vectors interact (Guthrie & Anderson, 1999; Wigfield & Guthrie, 2000). When considered synergistically, these vectors allow for a holistic and comprehensive description of the school experience (Trowler, 2010). The integration of the paradigm of Simplicity (Berthoz, 2012) provides an effective interpretive framework to understand how engagement emerges from the dynamic interaction of multiple action patterns that educational actors adopt to manage the complexity of the learning context. This paradigm highlights how the behavioral dimension of engagement manifests through flexible and adaptive modules, enabling students to modulate their conduct in relation to environmental stimuli and feedback. In the literature, the behavioral dimension is articulated into three main areas: positive conduct, referring to compliance with rules and the absence of deviant behaviors (Finn, 1993; Finn, Pannozzo & Voelkl, 1995); commitment to instructional activities, including persistence, attention, concentration, and active participation (Birch & Ladd, 1997; Skinner & Belmont, 1993); and participation in school and administrative activities (Finn, 1993; Finn et al., 1995). Interpreted through the lens of Simplicity, these aspects appear as modular and interconnected elements of a complex system that regulates student behavior in a dynamic and context-sensitive way.

The emotional component of engagement concerns students' affective reactions during the school experience, such as interest, happiness, boredom, sadness, and anxiety (Connell & Wellborn, 1991; Skinner & Belmont, 1993). Simplicity emphasizes the role of reciprocal regulation of emotions within the learning system, considering the emergence of affective states as the result of interactions among individuals, environment, and teaching strategies. This perspective makes it possible to move beyond the dichotomy between situational and personal interests, highlighting the importance of co-constructing a sense of belonging and motivation within the educational system (Fredricks et al., 2004). The cognitive dimension focuses on psychological investment in learning, including flexibility in problem-solving, a preference for challenging tasks, and the adoption of self-regulation strategies (Connell & Wellborn, 1991; Corno et al., 1983). From a Simplicity perspective, these cognitive processes are interpreted as dynamic and adaptive patterns that enable students to self-organize and respond flexibly to the complexity of the learning environment, supporting the transfer and generalization of competences. In this scenario, the Simplicity

paradigm may take on a fundamental role as an operational tool for teachers, offering a model that facilitates the dynamic and modular management of educational complexity. Through principles such as modularity, adaptability, and co-regulation, teachers can use Simplicity to foster higher levels of engagement, flexibly calibrating teaching strategies to the needs of students in inclusive and complex contexts (Fredricks et al., 2004).

Increasing Student Engagement through Simplex Didactics

Engagement is a complex and multidimensional concept, and its definition is essential for the development of an appropriate methodological and interpretative framework. From the review of the reference literature, it emerges that the "engagement" should be understood as a multidimensional construct, which includes in its nature various intrinsically correlated components. For this reason, in agreement with Fredricks and colleagues (2004), it is believed that it should be thought of as a "meta-construct" within which behavioral, emotional and cognitive vectors move (Guthrie & Anderson, 1999; Wigfield, & Guthrie, 2000) which, if considered in a synergic way, have the peculiarity of being able to describe the school experience in a holistic and comprehensive way (Trowler, 2010).

The behavioral vector of the construct is commonly considered in three different ways depending on the reference studies: the first associates behavioral engagement with positive conduct carried out by the student in the classroom and more generally within the school environment; the indicators considered concern the ability to follow the main rules of behavior and the consequent absence of incorrect behavior (Finn, 1993; Finn et al., 1995; Finn, & Rock, 1997); the second group of indicators refers to the commitment that the student exerts in carrying out schoolwork (involvement in learning and academic tasks) and includes effort, persistence, concentration, attention and the set of those behaviors that recall the active conduct carried out during a lesson, such as asking questions or contributing to the discussion in class (Birch & Ladd, 1997; Finn et al., 1995; Skinner, & Belmont, 1993); The third group of studies talks about participation in school-related activities, considering the activities related to school management or administration (Finn, 1993; Finn et al., 1995).

The emotional component refers to the set of actual reactions that the student experiences when he or she is at school or in class and includes constructs such as interest, happiness, boredom, sadness and anxiety (Connell & Wellborn, 1991; Skinner & Belmont, 1993). Even within this component, precise distinctions must be made: while some research analyses emotional engagement by focusing on the emotional reactions that students experience towards school and their teachers (Lee & Smith, 1995; Stipek, 2002), others conceptualize it with the sense of belonging, defined as feeling important for the school in which one is enrolled (Finn, 1989; Voelkl, 1997); a second body of research focuses on feelings of appreciation towards school, teachers and activities, contrasting them with perceptions of boredom or disinterest (Epstein & McPartland, 1976; Yamamoto et al., 1969); finally, a further widely investigated dimension, which is usually

associated with emotional disengagement, is anxiety. It is considered as an emotional response to any present or future situation perceived as a direct threat to self-esteem. The main limit of this wide heterogeneity of the emotional dimension of the construct emerges from the comparison between the reference literature on Engagement and that which instead speaks of motivation. According to the National Research Council (2003) the terms *engagement* and *motivation* are often considered synonymous. Research on motivation typically differentiates between situational interests, which relates to specific characteristics of the activity, and personal interests, which refers to a student's deliberate choice to engage in an activity. In contrast, studies on engagement tends not to make this distinction. This represents a key limitation of the emotional dimension of engagement, as it is often difficult to determine the exact source emotional reaction being analyzed. For instance, it may be unclear whether a student's engagement stems from the teaching content itself, the influence of peers or effectiveness of teachers' instructional strategies (Fredricks et al., 2004).

Finally, when examining the cognitive component of the engagement construct, it becomes evident that a significant body of research focuses on the psychological investment that the student uses in the learning processes; for example, it can manifest itself in the desire to go beyond the teacher's requests or in preferring challenging situations. Connell & Wellborn (1991) conceptualize cognitive engagement by including in the macro construct of "psychological investment" flexibility in problem solving, the preference for demanding and challenging tasks and positive coping styles. Overall, literature identifies two main perspectives in defining the cognitive dimension of engagement. The first emphasizes students' psychological investment during the learning processes, whereas the second emphasizes the connection of cognitive engagement with the use of learning strategies. Clearly, neither perspective alone can be exhaustive and, as the reference literature underlines As Fredricks et al. (2004) suggest, it is essential to consider both dimensions in an integrated and holistic manner.

Therefore, the present study is grounded in a well-established theoretical framework that defines engagement as a three-dimensional construct, encompassing behavioral, emotional, and cognitive components. In line with this perspective, it is hypothesized that the principles and properties inherent to the Simplicity paradigm may synergistically act upon these dimensions, promoting both a qualitative and quantitative increase in students' engagement levels within educational contexts.

Building on the literature discussed thus far, this study proposes that the properties and principles of Simplicity could serve as a valuable pedagogical toolbox for teachers aiming to make their instructional practices more inclusive and engaging. In particular, the integration of Berthoz's six properties and six principles with the dimensions of engagement may enhance teaching effectiveness and promote deeper, more meaningful learning. The following hypotheses outline how these elements may interact with the various components of engagement:

<i>Simplex Didactics' properties and principles</i>	<i>Possible adoption to foster several components of engagement</i>
<i>Specialization and modularity</i>	May foster the cognitive dimension of engagement, as they would allow students to process and understand tasks in a more accessible and comprehensible way. This would also make the cognitive process clearer and more structured, stimulating students' interest and helping them stay focused.
<i>Rapidity</i>	May play a key role for managing the behavioral dimension of engagement, keeping students actively involved in the learning process without losing rhythm or motivation.
<i>Reliability</i>	Could enhance the emotional dimension of engagement, as students would feel secure, knowing that their needs are being recognized and met.
<i>Flexibility and the ability to adapt to changes</i>	Flexibility and adaptability in choosing the most appropriate teaching strategy based on stimuli from the environment, may be essential in maintaining high engagement while supporting students' emotions.
<i>Memory</i>	Could help regulate the cognitive dimension of engagement by anticipating students' needs, allowing for a more targeted and effective response.
<i>Generalization</i>	Could support both the behavioral and cognitive dimensions of engagement, as transferring acquired skills and knowledge to different contexts stimulates meaningful learning.
<i>Inhibition and the principle of rejection</i>	May help to avoid routine and stimulate the cognitive and emotional dimensions of engagement, promoting the introduction of new ideas, methods, and tools that engage students more deeply.
<i>Specialization and Selection</i>	Could support emotional, cognitive, and even behavioral engagement, as they would carefully select stimuli and information most suited to students' interests.
<i>Cooperation and Redundancy</i>	could be strengthened through the creation of a cooperative environment that encourages students' participation and emotional engagement.
<i>Probabilistic anticipation</i>	By allowing forward-thinking based on past experiences and contextual data, may sustain cognitive and behavioral engagement, helping students remain oriented and focused on future learning goals.
<i>Deviation</i>	It involves the creative adaptation of the teaching path according to the diverse needs of students, and for this reason, it may support emotional, cognitive, and behavioral engagement.
<i>Sense</i>	Based on the creation of significant goals, which can help strengthen all three dimensions of engagement (behavioral, emotional, and cognitive), leading students to feel motivated and involved in authentic and meaningful learning

Methodology

Objective

The main objective of this study is the adaptation and validation of the Italian version of the Engagement Questionnaire (Abbasi et al., 2024) on a sample of future support learning teachers. This step is crucial to provide a reliable and culturally appropriate tool for measuring engagement in inclusive educational contexts. The validation is part of a broader research agenda that will subsequently investigate the potential of the Simplicity paradigm as a theoretical and operational framework capable of enhancing student engagement levels.

Procedure and Participants

The study involved prospective Learning Support Teachers (LSTs) enrolled in a Specialization Course in Special Education designed to prepare educators to work with students with disabilities at the upper secondary school level. The course was conducted at the University of Salerno, and a total of 733 trainees voluntarily participated in the study by completing the questionnaire in its entirety. The participants, aged between 25 and 61 years, represent an adult learner population engaged in professional teacher training. Among the respondents, 86% reported previous experience as support teachers, whereas only 27.5% indicated prior experience as curricular (subject-specific) teachers.

The questionnaire was administered at both the beginning and the end of a course titled “Special education: cooperative and metacognitive approach”. The course consists of 30 hours of classes, including 15 hours of theoretical content focused on the inclusive potential of cooperative and metacognitive strategies. The remaining 15 hours were dedicated to the metacognitive approach of Simplex didactics, combining theoretical instruction with practical exercises. These sessions emphasized the application of simplex principles and properties in special education, general education, and subject-specific teaching.

Tool

Based on a comprehensive review of both international and national literature (La Manna et al., 2024; Abbasi et al., 2024), the Engagement Questionnaire (Abbasi et al., 2024) was selected, as it represents the most recent and multifactorial instrument aligned with the theoretical framework on engagement utilized in the present study. The authors (Abbasi et al., 2024) employed a rigorous, stepwise methodological approach to develop the questionnaire aimed at assessing student engagement in online English language classes. This process commenced with a thorough literature review addressing perceptual, methodological, and systemic variables (Abbasi et al., 2024). To operationalize the engagement indicators and generate questionnaire items, multiple existing engagement scales were examined, with particular attention to the three-

dimensional model of engagement. Some items were newly constructed, while others were adapted by the researchers to better fit the online learning context.

Abbasi et al. (2024) reported that the questionnaire was easy to administer and collect, demonstrating good adaptability and usability. To assess its reliability and construct validity, Cronbach's alpha and exploratory factor analysis were conducted using SPSS. The final version of the Engagement Questionnaire includes 54 items on a 5-point Likert scale, divided into three sections: behavioral engagement (15 items), emotional engagement (16 items), and cognitive engagement (17 items). In the present study, the questionnaire was initially translated from English into Italian, followed by a detailed item-by-item review and adaptation to ensure suitability for face-to-face classroom settings, aligned with the training course "Special Education: Metacognitive and Cognitive Approach" (Table 2). The questionnaire was then programmed on the Google Forms platform, through which a QR code and link were generated and distributed, enabling participants to access and complete the survey. Responses were recorded using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Data Analysis

A descriptive analysis (Table.1) was initially conducted, showing the mean and standard deviation for each item. There were no missing responses, and all 733 participants answered every item.

An internal consistency assessment was then performed for each factor using Cronbach's alpha, calculated through the Jamovie application. Preliminary analysis revealed a good reliability level of 0.875 (Table.2; Table.3). However, some items (C50, C46, C38, B25, B26, A9, A6, A7) reduced internal consistency, as they were negatively worded statements. Therefore, we applied reverse coding to these items.

We then recalculated Cronbach's alpha, obtaining an excellent reliability value of 0.918 (Table.4; Table.5), confirming that the items consistently measure the same construct and that the questionnaire is highly stable. The reversed items did not reduce reliability, indicating that they were properly formulated and well-integrated. The scale can be effectively used to measure the construct of interest, as it does not present reliability issues. No significant modifications to the questionnaire structure are needed.

Finally, we calculated the reliability for each dimension of the questionnaire: Cronbach's Alpha for the behavioral dimension is 0.805, with a mean of 4.13 and a standard deviation of 0.385; for the emotional dimension, Cronbach's alpha is 0.763, with a mean of 3.94 and a standard deviation of 0.763; for the cognitive dimension, reliability is 0.850, with a mean of 4.05 and a standard deviation of 0.373.

Table 1. Descriptive

	N	Missing	Mean	Median	SD	Minimum	Maximum
A1	733	0	4.85	5	0.391	1	5
A2	733	0	4.63	5	0.562	1	5
A3	733	0	3.70	4	0.937	1	5
A4	733	0	4.29	4	0.740	1	5
A5	733	0	3.76	4	0.835	1	5
A6REV	733	0	3.65	4	0.995	1	5
A7REV	733	0	4.05	4	0.870	1	5
A8	733	0	4.20	4	0.689	1	5
A9REV	733	0	3.93	4	1.148	1	5
A10	733	0	4.35	4	0.599	2	5
A11	733	0	3.98	4	0.846	1	5
A12	733	0	4.51	5	0.656	1	5
A13	733	0	4.47	5	0.590	1	5
A14	733	0	4.29	4	0.715	1	5
A15	733	0	3.66	4	0.884	1	5
A16	733	0	4.17	4	0.726	2	5
A17	733	0	3.67	4	0.773	1	5
B18	733	0	4.69	5	0.482	3	5
B19	733	0	3.72	4	0.880	1	5
B20	733	0	3.50	4	1.103	1	5
B21	733	0	4.55	5	0.600	1	5
B22	733	0	4.14	4	0.876	1	5
B23	733	0	3.39	3	0.861	1	5
B24	733	0	4.33	4	0.639	1	5
B25REV	733	0	4.36	5	0.940	1	5
B26REV	733	0	4.25	4	0.863	1	5
B27	733	0	3.81	4	0.974	1	5
B28	733	0	3.86	4	0.703	2	5
B29	733	0	4.24	4	0.669	2	5
B30	733	0	3.70	4	0.807	1	5
B31	733	0	4.35	4	0.670	1	5
B32	733	0	3.99	4	0.749	1	5
B33	733	0	3.00	3	0.904	1	5
B34	733	0	3.04	3	0.961	1	5
C35	733	0	3.68	4	0.802	1	5
C36	733	0	4.19	4	0.622	2	5
C37	733	0	4.17	4	0.685	1	5
C38REV	733	0	3.78	4	0.948	1	5
C39	733	0	3.84	4	0.712	1	5
C40	733	0	4.18	4	0.668	1	5
C41	733	0	4.31	4	0.628	2	5
C42	733	0	4.21	4	0.623	1	5
C43	733	0	4.40	4	0.607	1	5
C44	733	0	4.14	4	0.509	3	5
C45	733	0	3.95	4	0.711	1	5
C46REV	733	0	4.07	4	0.919	1	5
C47	733	0	3.20	3	0.859	1	5
C48	733	0	3.50	4	0.894	1	5
C49	733	0	3.93	4	0.755	1	5
C50REV	733	0	4.29	4	0.900	1	5
C51	733	0	4.04	4	0.747	1	5
C52	733	0	4.25	4	0.618	2	5
C53	733	0	4.29	4	0.600	1	5
C54	733	0	4.67	5	0.575	1	5

Table 2. Scale Reliability Statistics

scale	Media	SD	α di Cronbach
	3.73	0.280	0.875
Note. Items 'C50', 'C46', 'C38', 'B25', 'B26', 'A9', 'A6', and 'A7' are negatively correlated with the total scale and should probably be reverse-coded.			
Item Reliability Statistics	If the item is discarded		
	α di Cronbach		
A1			0.874
A2			0.873
A3			0.871
A4			0.871
A5			0.869
A8			0.871
A10			0.871
A11			0.871
A12			0.872
A13			0.872
A14			0.872
A15			0.871
A16			0.869
A17			0.870
B18			0.873
B19			0.871
B20			0.872
B21			0.871
B22			0.872
B23			0.871
B24			0.870
B27			0.874
B28			0.872
B29			0.870
B30			0.873
B31			0.872
B32			0.872
B33			0.872
B34			0.870
C35			0.870
C36			0.870
C37			0.870
C39			0.871
C40			0.871
C41			0.871
C42			0.870
C43			0.871
C44			0.871
C45			0.870
C47			0.870
C48			0.874
C49			0.872
C51			0.871
C52			0.871
C53			0.871
C54			0.872
C50			0.879
C46			0.879
C38			0.879
B25			0.878
B26			0.878
A9			0.879
A6			0.881
A7			0.880

Table 3. Scale Reliability Statistics

	Media	SD	α di Cronbach
scale	4.04	0.335	0.918
item reliability statistics			
	If the item is discarded		
	α di Cronbach		
A1			0.917
A2			0.916
A3			0.917
A4			0.916
A5			0.915
A6REV			0.916
A7REV			0.916
A8			0.914
A9REV			0.920
A10			0.915
A11			0.916
A12			0.916
A13			0.916
A14			0.916
A15			0.917
A16			0.915
A17			0.916
B18			0.916
B19			0.916
B20			0.918
B21			0.915
B22			0.917
B23			0.917
B24			0.915
B25REV			0.917
B26REV			0.917
B27			0.917
B28			0.916
B29			0.914
B30			0.917
B31			0.916
B32			0.916
B33			0.919
B34			0.916
C35			0.915
C36			0.915
C37			0.915
C38REV			0.917
C39			0.916
C40			0.916
C41			0.916
C42			0.915
C43			0.915
C44			0.916
C45			0.916
C46REV			0.916
C47			0.916
C48			0.917

C49	0.916
C50REV	0.917
C51	0.916
C52	0.915
C53	0.915
C54	0.916

Table 4. Behavioral Dimension: Scale Reliability Statistics

	Media	SD	α di Cronbach
scale	4.13	0.385	0.805

Table 5. Emotional dimension: Scale Reliability Statistics

	Media	SD	α di Cronbach
scale	3.94	0.374	0.763

Table 6. Cognitive Dimension: Scale Reliability Statistics

	Media	SD	α di Cronbach
scale	4.05	0.373	0.850

Discussion

The results emerging from the quantitative analysis of the *Engagement Questionnaire* (Abbasi et al., 2024), adapted to the Italian context and administered to a sample of 733 prospective special education teachers, suggest good internal validity and excellent overall reliability of the instrument, with a Cronbach's alpha value of 0.918 after reverse coding of negatively worded items. This finding confirms that the questionnaire is capable of consistently measuring the multidimensional construct of engagement, articulated across the three dimensions—behavioral, emotional, and cognitive—as proposed by international literature (Fredricks et al., 2004; Hookham & Nesbitt, 2019). The reliability value for the behavioral dimension ($\alpha = 0.805$) and that for the cognitive dimension ($\alpha = 0.850$) indicate excellent internal consistency, while the emotional dimension, although showing a slightly lower value ($\alpha = 0.763$), still falls within acceptable parameters, considering the subjective and fluctuating nature of emotions within the educational process. These results highlight that the three dimensions were consistently interpreted by the participants and are well-suited for investigation in educational contexts aimed at fostering reflective and inclusive professional development. Moreover, the high mean scores recorded across all dimensions ($M_{\text{behavioral}} = 4.13$; $M_{\text{emotional}} = 3.94$; $M_{\text{cognitive}} = 4.05$) suggest a positive perception of one's own engagement in the training process, particularly in relation to the applied phase of *Simplex didactics*. This finding supports the initial hypothesis that a training approach based on *Simplex didactics* (Berthoz, 2012; Sibilio, 2020) may serve as a valid tool for promoting student engagement and, by extension, fostering more inclusive educational environments. The presence of a high level of

engagement among participants, even in the initial phase of the course, may reflect intrinsic motivation and professional interest in innovative teaching methodologies. However, it is worth considering that the formative effect resulting from the introduction of *Simplex didactics* may have contributed to strengthening this engagement through the activation of reflective and adaptive strategies. From this perspective, the internalization of the principles and properties of *Simplex didactics* appears to enhance the ability of future teachers to address the complexity of the school context in a flexible, dynamic, and responsive manner, in line with a genuinely inclusive pedagogy (EADSNE, 2012; Aiello et al., 2021). This study successfully validated the Italian adaptation of the *Engagement Questionnaire* proposed by Abbasi et al. (2024), confirming its effectiveness in detecting the engagement of future special education teachers participating in a training pathway grounded in *Simplex didactics*. The collected data suggest that this pedagogical approach may act as a significant mediator in enhancing engagement, outlining a favorable framework for the systemic adoption of *Simplex didactics* in both initial and ongoing teacher education. The findings lay the groundwork for further longitudinal studies aimed at exploring the effectiveness of *Simplex didactics* in everyday teaching practices and in fostering inclusive and participatory environments where every student can feel like an integral part of the learning process. In this regard, future research is encouraged to explore not only the relationship between engagement and this pedagogical approach, but also the impact of these variables on the actual improvement of educational outcomes for students, especially those with special educational needs or at risk of exclusion. In conclusion, *Simplex didactics*, understood as a training paradigm based on adaptive simplification and the dynamic integration of knowledge, emerges as a promising pedagogical tool capable of enhancing both teacher and student engagement, thereby substantially contributing to the realization of a fair, inclusive, and actively participatory school environment for all stakeholders.

Conclusion and future directions

Future research should employ a longitudinal design to examine how support teachers operationalize, modify, and sustain Simplex Didactics concepts in actual classroom settings, building on the positive outcomes of the engagement measures during training. Higher trainee involvement suggests that the training program was effective in the short term, but it has not yet been experimentally demonstrated that it will have a lasting impact on inclusive pedagogical practice. Reflective practice, which Schön (1983) emphasizes as the characteristic that sets competent practitioners apart in complex contexts, is intrinsically linked to the development of such sustained professional competence. This perspective is reinforced by Sibilio's Simplex Didactics (2012, 2020, 2023), which characterizes teaching and learning as dynamic, nonlinear, and intersubjective processes. Berthoz's (2012) neurocognitive theory of Simplexity serves as the foundation for Simplex Didactics, which gives teachers cognitive and emotional skills, including inhibition of habitual reactions, probabilistic anticipation, modularity, and flexible adaptation, that support real-time decision-making and effective management of classroom complexity.

In the field of inclusive education, where educational measures must be continuously modified to meet the evolving needs of diverse student groups, this approach holds great promise. Simplex Didactics encourages a professional "adaptive gaze" (Sibilio, 2020) as an alternative to prescribing static procedures. This enables teachers to recognize and address new patterns in the behaviors, needs, and potentials of their students. This perspective is in line with broader trends in educational research that advocate for redefining inclusion as a structural commitment to pedagogical flexibility, reciprocal engagement, and cognitive equity rather than as a set of add-on solutions for particular groups (EADSNE, 2012; OECD, 2018). Crucially, this is connected to the growing recognition of teacher agency as a fundamental component of inclusive education. Priestley, Biesta, and Robinson (2015) state that the ability to make morally sound, well-informed, and adaptable decisions in a socio-professional setting is a component of teacher agency. By establishing agency in relational, embodied practices as well as metacognitive awareness, Simplex Didactics adds to this framework. According to Aiello, Pace, and Sibilio (2023), it encourages a teaching identity that actively works to change the classroom into a participatory, meaning-driven, and inclusive setting in addition to being sensitive to diversity.

Therefore, future longitudinal studies should investigate how support teachers who have received training in Simplex Didactics incorporate its tenets into their regular teaching methods and whether doing so results in quantifiable gains in student inclusion and engagement, especially for students with disabilities or those who are at risk of marginalization. Such studies would contribute to the creation of flexible, equity-focused pedagogies in ever-more complex educational environments and offer solid evidence in favor of the institutionalization of Simplex Didactics within teacher education programs.

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Appendix 1. Engagement Questionnaire (Abbasi et al., 2024)

1- I treat my classmates and teachers with respect either in Skyroom or in the WhatsApp group
2- I comply with the rules in the class by doing all my homework and being punctual
3- I work with great effort to answer the teacher's questions by typing in the chatbox or by clicking the Raising Hand icon
4- When I encounter a hard homework exercise, I continue working on it till I think I've answered it
5- I participate actively in activities such as presenting a lecture and participating in class discussions by asking the teacher to turn on my microphone
6- When I'm in class, my mind wanders
7- I discover that when the teacher is teaching, I think of other things and don't really listen to what is being said
8- When I am in class, I listen carefully
9- I turned in a homework assignment late or not at all
10- I never use my mother tongue in class; I keep speaking English
11- When I do not understand something in class, I request the teacher to clarify it
12 I fully charge my telephone, laptop, and internet to not disconnect during the class to lose the materials
13 When I do a task in class, I try to relate the task to prior knowledge
14 I tutored or taught the class materials to other students in the WhatsApp group after the class
15 When I participate in class discussions or present a lecture, I pause frequently to remember a word, or I laugh
16 I fully attend the class by affirming the teacher by typing "yes" or "that's right" in the chatbox
17 I speak fluently in class
18- I enjoy learning new things in online classes
19 The online class is one of my favorite places to be
20 When I run out of the internet or lose the connection, I worry a lot about it
21- I enjoy learning new things in class
22- When I have a project to do, I worry a lot about it not being disconnected
23- My teacher praises me most of the time when I work hard
24-I am interested in the work, discussions, and exercises in my class
25- When I'm not interested in the class, I excuse myself for a camera or microphone
26- When the teacher wants to teach new things, I complain by typing "no, please"
27- I feel relaxed doing exercises or during a discussion
28- I believe I can do it well during answering the exercise
29- I am all ears when my teacher teaches a new thing
30- My classmates always affirm my correct answers by typing "yes" or "very good"
31- Students in my class are there for me when I need them
32- I believe in myself when I want to present a lecture
33- When I present a lecture, I need my teacher's affirmation by saying "that's right" or nodding her head while her camera is on
34-I Volunteer to present in the class by clicking on the Raising Hand icon
35- Because I work hard, I succeed in class
36- I check my class- work to ensure that I have done it correctly
37- When I study for an exam, I attempt to combine the information from the book and the class

38- Finding the main ideas of a text is difficult for me
39- When my classmates do an exercise or present a lecture, I try to justify their answers or lecture
40- When I study or learn new things, I attempt to put the ideas in my own words
41- I make my own examples to understand the important concepts I learn from the class
42- When I study for a test, I repeat the important points several times
43- When I am studying a topic, I try to connect everything properly
44- When I am studying my coursebook, I try to outline its chapters to learn better
45- I try to give directions to my classmates when they do not know how to do the task
46- When lessons are difficult, I either stop studying or study only the easy parts
47- I work on practice exercises and answer the end-of-chapter questions even when I don't have to
48- Even when lessons are uninteresting, I continue studying till I finish
49- I try to use dictionaries or reference books in doing tasks and exercises
50- I prevent exchanging ideas with my peers or teachers during a discussion
51- I attempt to think carefully about topics and find what I'm expected to learn from them, instead of studying topics by just reading them over
52- When I am studying course materials, I try to join different pieces of information together in innovative ways
53- When I finish working on an exercise, I check my answer to see if it is reasonable
54- English class is important for achieving my future goals

Appendix 2. Adapted items of the Engagement Questionnaire

1- I treat my classmates and the teacher with respect
2- I abide by the classroom rules by doing all my homework and being on time
3- I work hard to answer the teacher's questions
4- When I encounter a hard assignment, I continue to work on it until I think I have answered it
5- I actively participate in activities during class
6- When I am in class, my mind wanders
7- I find that when the teacher is teaching, I think about other things and not really listen to what is being said
8- When I am in class, I listen attentively
9- I have turned in a homework assignment late or not done it at all
10- I use knowledge learned outside of class
11- When I do not understand something in class, I ask the teacher to clarify it
12- I take care of my notes and materials related to the class
13- When I do a homework assignment in class, I try to connect the assignment to prior knowledge
14- I use knowledge learned, teaching them to my students
15- When I participate in class I talk or laugh with other classmates
16- I participate actively by interacting with the teacher
17- I feel I have mastered the topics
18- I like learning new things
19- I feel like I belong in my class

20- When I am distracted from class, I get worried or annoyed
21- I am interested in simple topics
22- When I do group work, I get annoyed if I am distracted
23- My teacher gives me adequate reinforcement when I try hard
24- I am interested in simple exercises
25- I am not interested in the topics covered in class
26- I often complain about new topics
27- I feel relaxed during group work
28- I believe I can do the assigned exercises well
29- I am all ears when my teacher teaches something new
30- My classmates correct me when I make mistakes
31- My classmates give me support
32- I believe in myself when doing exercises
33- I always seek the teacher's approval when completing the assignment
34- I volunteer to raise doubts or questions
35- I succeed in exercises because I work hard
36- I always check my work in class to make sure it is done well
37- When I study, I integrate information from other sources
38- It is difficult for me to identify the main concepts of the topics explained
39- During a class project, I try to give explanations to my classmates about the topic learned
40- When I study a topic, I try to explain it in my own words
41- I use examples to better understand the topics
42- I repeat the important points of the topics explained
43- When I study, I try to make sure that the information I have is correct
44- I try to identify from the beginning which topics of the course are to be studied
45- I try to give directions to my classmates on how to do the assignment
46- When the topic is difficult, I stop studying or I only learn the easier things
47- I practice the topics learned even when it is not required
48- I continue studying even when the topics do not interest me
49- To do the exercises assigned I refer a lot to notes
50- I avoid exchanging ideas with my peers or teachers during a discussion
51- I try to carefully process new topics, rather than simply reading them.
52- When studying the course materials, I try to make new connections with another knowledge already possessed
53- When I finish an exercise, I check whether my answer is reasonable
54- The course is important to improve my teaching practice

Application of Combined Constructivist Strategies in Physics Teaching

*By Mihail Calalb**

Identifying the most effective teaching strategies for physics instruction is a persistent challenge for both researchers and schoolteachers. Studies indicate that the answer lies in Research-Based Instructional Strategies. A significant contribution in this area has been made by the theory of Visible Teaching and Learning, which measures the effects of over 250 factors influencing students' academic success. By knowing the possible impact of specific teaching strategies, educators can design instructional approaches with predictable outcomes. The research was conducted during the 2023-2024 academic year in two public schools in Moldova, involving 305 students across grades 6, 8, and 10. This study aimed to measure the effect of concurrently applying elements from multiple constructivist teaching strategies in physics lessons, including the Flipped Classroom, Early Physics Approach, 5E Model, and Peer Instruction with Conceptual Questions, on students' academic success and science competence in physics. At its core, the study was based on the 5E model, reinforced with pre-class tasks for students and the use of conceptual questions during the lesson. Science competence of students was structured into five components: understanding definitions, knowledge of measurement units, correct application of formulas, problem-solving skills, and the use of scientific language. The progression of these components was subsequently measured. The study also tracked the individual academic trajectories of both high-performing and low-performing students to assess their progress in physics. The study revealed that the combined application of these constructivist strategies can double students' ability to solve problem situations and triple the correct use of scientific language. In contrast, knowledge of measurement units (~80%) and the correct application of formulas (in the range of approx. 25% – 33%) remained relatively unchanged. The insignificant progress in the correct application of formulas is explained by the small number of problems analysed on a topic, the lack of individual tasks, and the need for more explicit scaffolding and individual feedback. Additionally, the study revealed that laboratory work marks are strong predictors of overall academic success, with the correlation between laboratory work and final evaluation being 60% in 6th grade, 70% in 8th grade, and 50% in 10th grade. Additionally, the research shows that in middle school, the increase in scores for high achievers is greater than that of low achievers – three times higher in 6th grade. In high school, the increase in scores for high achievers is twice as large as that of low achievers. Both groups, high and low achievers, improve their scores after the application of the Integrated Constructivist Model. Subsequent research would explore the synergistic effect of this, and other, combinations of constructivist teaching strategies on students' academic success, scientific competence components, and conceptual understanding.

Keywords: Integrated constructivist model, didactic synergy, science competence, academic success, physics teaching.

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Introduction

Traditional expository teaching methods limit student success and interest in physics, especially when it is perceived as a difficult subject (Bologna et al., 2024; Guisasola, 2019; Zhou, 2004). Interactive strategies based on active knowledge construction stimulate curiosity and active participation, thus improving students' attitudes toward science.

Teaching strategies are a factor that influences intrinsic motivation. Certain teaching approaches focused on facilitation and communication can have positive effects on intrinsic motivation components (Bomia et al., 1997; Hansson et al., 2023; Hattie, 2009). At the same time, relatively rigid learning environments do not favor the application of motivational strategies, such as fostering group cohesion among students or strengthening the teacher-student relationship (Guilloteaux & Dömyei, 2008; McNeil, 2018). When designing an instructional approach aimed at fostering motivation, we can rely on five principles proposed by Linnenbrink-Garcia et al. (2016):

1. Competence is fostered by well-designed instruction, cognitively challenging tasks, and ongoing mutual feedback.
2. Student autonomy is encouraged by providing opportunities for decision-making and careful guidance.
3. Physics identity and active student engagement are promoted through personalized, relevant, and interesting tasks.
4. Emphasizing learning and understanding rather than performance and competition.
5. Supporting group cohesion by fostering feelings of belonging and relationships between students and teachers.

These principles emphasize the importance of instructional design that nurtures both cognitive and emotional aspects of learning, ultimately fostering a deeper and more sustained commitment to physics. Moreover, research indicates that effective teacher practices aimed at enhancing student motivation are largely consistent with these theoretical principles, suggesting that school practice generally adheres to Research-Based Instructional Strategies (RBIS) (Radil et al., 2023; Schell & Butler, 2018).

Physics is a discipline based on fundamental concepts, and rote learning of formulas and definitions without deep understanding leads to difficulties in applying knowledge to new situations. Identifying effective teaching strategies contributes to developing critical thinking and solid conceptual comprehension.

A constructivist teaching strategy cannot be built within the paradigm of traditional, lecture-based instruction that relies on memorization. Simply providing students with definitions of concepts does not help them integrate new information into their knowledge and value system (Brafman, 2003; Freeman et al., 2014). For example, mere note-taking of the teacher's statements is less effective for retention compared to developing cue signals or concept maps (Iofciu et al., 2011; Pals et al., 2017). Establishing connections between abstract concepts and concrete situations through recurrent priming appears to be a solution for improving conceptual understanding (Johnstone, 2000).

Strategies such as the open inquiry learning model positively affect conceptual understanding and attitudes (Arra, 2021). The Flipped Classroom method significantly enhances (effect size of 0.953) comprehension of basic scientific concepts (Ugwuanyi, 2022), while the Peer Instruction method yields various positive learning outcomes, such as deeper conceptual understanding, improved problem-solving skills, and increased student engagement (Crouch et al., 2007; Schell & Butler, 2018). Multiple studies have shown that the constructivist 5E model improves science learning outcomes for students of different ages, with an effect size of 0.82 when implemented instead of traditional instruction methods, such as direct instruction, lectures, or traditional lab work (Polanin, 2024).

At the same time, research indicates that misconceptions persist among school students, university students, and even teachers, regardless of whether instruction follows traditional or constructivist approaches. This suggests that the key factor in addressing misconceptions is not merely the teaching strategy itself but the explicit effort to correct prior misunderstandings rather than simply striving for higher grades (Müge & Hacıoğlu, 2022).

Following this idea, effective physics instruction must incorporate core principles that enhance conceptual understanding and engagement. According to Bonacci (2020), six essential requirements for teaching physics can guide the design of instructional strategies:

1. Appealing epistemological richness
2. Interdisciplinary study
3. Curiosity about basic notions
4. Compact formulation of fundamental ideas
5. Unifying logic of explanations
6. Captivating narration

Physics is not just about accumulating information; it is a discipline that develops essential competencies such as problem-solving, logical reasoning, and the use of scientific language. In physics lessons, the focus is not merely on transmitting information but on acquiring knowledge structured on two levels:

- Factual knowledge – understanding facts and their physical meaning.
- Procedural knowledge – applying and integrating knowledge.

The term “acquisition” itself points to the cognitive effort students must make as a prerequisite for effective learning (Calalb, 2023). This effort is shaped by individual starting points, as research shows that while the assimilation mechanisms of high-achieving and lower-achieving students are fundamentally the same, differences arise from their prior knowledge and initial level of understanding at which learning begins (Binder et al., 2019).

Prior knowledge forms the basis of strategies such as retrieval practice, which positively influences problem-solving skills (Gjerde et al., 2022). Teaching strategies influence problem-solving, but equally important is how the problem is presented by the teacher—whether verbally, pictorially, or graphically (De Cock, 2012). This

highlights the importance of training students to analyse problem situations using multiple approaches. Effective teaching strategies should support the development of these competencies, preparing students for complex academic and professional contexts.

Physics laboratory activities, when designed based on constructivist principles and focusing on competence development rather than mere content retention, enhance students' critical thinking skills (Walsh et al., 2022). Physics lessons are particularly suitable for fostering critical thinking, as scientific reasoning, which is continuously exercised in physics classrooms and laboratories, is symbiotically linked to critical thinking (García-Carmona, 2023).

In a heterogeneous classroom, some students progress quickly while others struggle. Well-chosen teaching strategies enable personalized learning, providing support for struggling students and appropriate challenges for advanced students, thereby reducing educational inequalities.

Developing teaching methods that consider students' initial knowledge levels and incorporate active learning strategies helps bridge performance gaps and ensures progress for all students (Salehi et al., 2019). Research indicates that the effect size of instructional strategy clusters on physics achievement is approximately 0.73 (Sezgin Selçuk, 2010). Teaching strategies based on research, combined with PhET simulations, significantly improve students' conceptual understanding and help them overcome alternative conceptions (Quezada-Espinoza et al., 2015).

The SCALE-UP model, as an RBIS one, emphasizes active learning and student engagement, aligning instructional approaches with student needs (Scanlon et al., 2019). The effectiveness of RBIS lesson sequences is determined by three key factors: cognitive scaffolding, feedback-based methodology, and the presence of student-led inquiry or IBSE (Inquiry-Based Science Education) in the classroom (Guisasola, 2019).

RBIS strategies have been rigorously tested in various educational contexts, demonstrating their impact on student learning (Hattie, 2009). This reduces uncertainty and increases the likelihood of positive outcomes when using teaching methods focused on active student learning and experimental validation (Freeman et al., 2014).

Instructional strategies scientifically validated enhance students' conceptual understanding and their attitude toward science while allowing teachers to design lessons with more predictable outcomes, avoiding inefficient methods based solely on intuition or personal experience (Neri et al., 2011).

Research in Physics Education Research (PER) and Science Education examines teaching strategies across different levels, from primary school — where foundational understanding of natural phenomena and exploratory learning are emphasized (Makarskaite-Petkeviciene, 2023) — to high school, where the core concept in physics lesson design becomes Visible Teaching and Learning, increasing student achievement through constructivist strategies (Tong et al., 2023).

RBIS frameworks highlight four categories of variables that influence physics learning: prior domain-specific knowledge, auxiliary prior knowledge, past academic achievements or skills, and metacognition and motivation (Delahay et al., 2023). However, further quantification and operationalization of RBIS and constructivist frameworks are needed to facilitate their classroom implementation (Radicuks et al., 2025).

Thus, identifying the most effective strategies for teaching physics is crucial for enhancing student engagement and conceptual understanding. Approaches such as Flipped Classroom, Peer Instruction, IBSE, and Early Physics Approach offer significant potential for improving learning outcomes. The following section will explore the theoretical foundations that support the integration of these constructivist strategies into a unified pedagogical approach, emphasizing their synergistic effect in physics education.

Theoretical Framework

The methodologies in PER are “delightfully unsettled” and, in the pursuit of improving physics teaching and understanding, integrate pedagogy, cognitive sciences, and educational theories (Hammer, 2023; Docktor, 2024). Since critical thinking and creativity are key vehicles for achieving conceptual understanding in physics learning, teaching methods should adapt to foster these two components of constructivist learning. In order to effectively stimulate critical thinking and creativity, teaching strategies are expected to align with constructivist principles. This requires adopting innovative instructional approaches that encourage student engagement and ownership of their learning process (Calalb & Zelenschi, 2023; Rutto et al., 2023). Moreover, any constructivist teaching strategy in physics will emphasize the development of student motivation and engagement (Linnenbrink-Garcia et al., 2016; Radil et al., 2023), as motivation and engagement lead to greater involvement, promote self-directed learning, and ultimately enhance academic performance (Kazakova et al., 2022).

From the broad spectrum of RBSE constructivist strategies, we will briefly describe those that formed the foundation of our experiment. First, we consider the Flipped Classroom concept, introduced by J. Wesley Baker and further developed in the early 2000s by Bergmann & Sams (2012), who recorded their chemistry lessons for students to watch at home. In physics lessons, the Flipped Classroom is widely applied within the Peer Instruction method developed by E. Mazur (Crouch et al., 2007), where students read the lesson material in advance and respond to a set of control questions. This approach supports the inclusion of students who struggle to concentrate during class, thus addressing individual differences (Eroğlu & Yüksel, 2020). Moreover, the Flipped Classroom does not fundamentally alter the traditional 5E instructional model; instead, it facilitates the implementation of the first two phases, Engagement and Explanation, and shifts the teacher’s role toward facilitating peer discussions. As a result, the Flipped Classroom increases classroom interactions, thereby enhancing feedback, making both teaching and learning more visible (Calalb & Zelenschi, 2024).

Secondly, we applied elements of Peer Instruction, which is an inherently constructivist strategy, as it actively engages students in the learning process through conceptual questions that require reasoning rather than mere memorization. Discussions among peers, as they analyse possible answers to these conceptual questions, facilitate conceptual understanding by helping students abandon their prior misconceptions (Miller et al., 2015), thereby resolving cognitive conflicts. The

teacher, acting as a guide and facilitator, directs students' learning towards dialogue and collaboration. At the same time, Peer Instruction is also an RBIS method, as it is grounded in research on the difficulties students face in constructing conceptual understanding. Its effectiveness has been demonstrated by experimental studies showing significant improvements in conceptual comprehension (Stoen et al., 2020) and academic achievement, with an effect size of 0.92 (Hattie, 2009), more than twice that of traditional or lecture-based teaching, which has an effect size of 0.40. Additionally, frequent formative assessment through conceptual questions ensures immediate feedback, aligning Peer Instruction with the principles of Visible Teaching and Learning.

Thirdly, the design of our pedagogical approach was based on the 5E model (Bybee et al., 2006), an active and constructivist learning method. In each of its five stages (Engagement, Exploration, Explanation, Elaboration, and Evaluation), students are encouraged to actively engage in the learning process, construct understanding through hands-on experiences, and apply concepts in new contexts (Polanin et al., 2024). In the Engagement stage, students are stimulated to connect prior knowledge with new concepts, while in Exploration, they investigate through experiments and practical activities, incorporating elements from Inquiry-Based Science Education. The Explanation stage focuses on clarifying and consolidating knowledge through discussions and reflections guided by the teacher. Furthermore, the 5E model ensures that feedback is continuous, immediate, and reciprocal throughout the lesson (Calalb, 2021). Thus, the 5E model fosters an iterative and interactive learning process that ultimately shapes students' attitudes and their physics identity. It is important to emphasize that the 5E model aligns with the RBIS, as it is supported by research showing significant improvements in students' scientific understanding and academic performance. For example, the effect size for academic success is 1.132, for retention 1.417, and for attitude 0.552 (Anil & Batdi, 2015).

The transition from traditional teaching to constructivist learning is further supported by the Early Physics Approach (Bologna et al., 2024), which addresses both teachers' understanding of students' learning difficulties, aligning with the principles of Visible Teaching and Learning, and the revision of Pedagogical Content Knowledge to better integrate mathematical reasoning into physics instruction. This integration is crucial, as mathematical reasoning enables students to grasp the physical meaning of learned concepts (Uhden et al., 2011). By strengthening algebraic thinking skills, Early Physics Approach facilitates the comprehension of physics concepts, allowing students to build flexible and well-conceptualized cognitive representations. Moreover, EPA fosters the development of an active scientific language in both physics and mathematics (Bologna et al., 2023), a particularly valuable aspect in an era of declining overall scientific literacy.

As seen, EPA is rooted in constructivist principles, as it combines multiple representations with scientific discourse, enabling students to articulate their reasoning scientifically and develop a critical understanding of newly acquired concepts. At the same time, since the theoretical foundation of the Early Physics Approach is based on educational frameworks such as ISLE (Investigative Science Learning Environment) (Etkina et al., 2021) and incorporates innovative methodologies and experimental tests validated by previous studies in Physics Education Research, it can be confidently

classified as part of the RBSE (Research-Based Science Education) spectrum. EPA is particularly applicable in secondary education, especially in early middle school years, when students first encounter physics and require support in transitioning from fundamental mathematical concepts to physical principles.

The Concept of Didactic Synergy

The integration of elements from multiple teaching strategies within a single lesson to enhance learning efficiency has been explored in various studies within Physics Education Research (PER). For instance, in 1997 Eric Mazur demonstrated that combining Peer Instruction with the Flipped Classroom significantly improves students' conceptual understanding (Mazur, 1997; Crouch et al., 2007). Similarly, in 1998, Richard Hake showed that using Just-in-Time Teaching (JiTT) alongside ConcepTests leads to greater conceptual understanding compared to traditional teaching methods, with later research reporting a normalized learning gain of $g = 0.56$ (Hake, 1998).

More recently, Eugenia Etkina et al. (2021), building on the principles of Inquiry-Based Science Education (IBSE), developed the Investigative Science Learning Environment (ISLE) – an approach that fosters both critical thinking and student autonomy, with an effect size of 1.06 on students' attitudes toward physics (Brookes et al., 2020).

Thus, based on these examples, we can talk about the concept of Didactic Synergy when elements from different teaching strategies are used within the same lesson. For instance, in a student research-based learning project, we use Project-Based Learning, Problem-Based Learning, Inquiry-Based Science Education, Conceptual Questions, the 5E model, etc. The first step in applying Didactic Synergy is the sequential design of the lesson or teaching unit, where we can opt for a cyclical structure – an IBSE project, or a recurrent linear structure such as Reflective Practice. The following steps involve selecting strategies for a particular lesson sequence that align with the didactic goals and cognitive objectives of the lesson. Thus, Didactic Synergy is a holistic approach based on the teachers' PCK, their ability to use multiple teaching strategies, and it stems from the need to constantly motivate students and diversify activities in the learning process. It is worth noting that, according to Dewey, changing the type of activity stimulates a more efficient mental process. Therefore, through Didactic Synergy, active, dynamic, and interactive learning is achieved. Moreover, according to Vygotsky, to fully leverage the students' potential, i.e., to bring them into the zone of proximal development, challenges and experiences are necessary to expand their thinking and stimulate their interest in knowledge (Vygotsky, 1978). According to Piaget, this shift in the range of activities contributes to students' assimilation of new knowledge and the adjustment of previous ones (Piaget, 1977). Thus, the variety of teaching strategies applied within the same lesson facilitates cognitive development through a set of different activities based on interaction.

According to these considerations, we can assert that for Didactic Synergy to generate a cumulative effect that surpasses the effect size of its most effective individual component, it is advisable to adhere to the following three principles:

- a) at least one of the employed teaching methods should foster cognitive activation;
- b) one method should involve metacognitive inquiry;
- c) one method should ensure the visibility of teaching and learning, meaning it should be feedback-based.

To exemplify how these principles translate into practice, Table 1 presents several instructional methods structured accordingly and categorized into teaching and learning methods. It can be observed that the most effective methods for activating cognition or cognitive effort of students are those classified as learning methods, where the teacher coordinates and guides students. In other words, while learner independence is valuable, it has its limits. High-quality learning, where students make meaningful progress in their knowledge, is impossible without teacher guidance. At the same time, the most effective metacognition-based methods are the learning ones and, according to Visible Learning (Hattie, 2009), have the highest effect sizes. However, methods such as Scaffolding or Summarization highlight the essential role of the teacher in directing students toward conceptual understanding. As expected, feedback-based methods cannot be strictly divided into learning or teaching methods, as genuine feedback is inherently mutual — the student and teacher engage equally in the process — in full alignment with the principles of Visible Teaching and Learning.

Table 1. Didactic Methods clustered by Cognitive Activation, Metacognition, and Feedback

Type of method	Learning method & effect size, ES		Teaching method, ES	
Cognitive Activation	Reciprocal teaching	0.75	Cognitive task analysis	1.29
	Rehearsal and memorization	0.74	Jigsaw method	1.20
	Deep motivation and approach	0.69	Strategy to integrate with prior knowledge	0.93
	Field independence	0.68	Scaffolding	0.82
Metacognitive Inquiry	Self-report grades	1.44	Summarization	0.79
	Piagetian programs	1.28	Planning and prediction	0.76
	Help seeking	0.72	Evaluation and reflection	0.75
	Self-verbalization and self-questioning	0.55	Elaboration and organization	0.75
Feedback-based	Teacher estimates of achievement			1.29
	Response to intervention			1.29
	Transfer strategies			0.86
	Classroom discussion			0.82

In line with the concept of Didactic Synergy stated above, a single lesson can integrate essential elements from at least five methods: two for cognitive activation (one focused on learning, the other on teaching), two for metacognitive inquiry, and at least one feedback-based method. Thus, as an example, we can select the following:

For cognitive activation: as a teaching method, Cognitive Task Analysis (ES = 1.29), where the teacher helps students break down complex tasks to facilitate deeper

learning; as a learning method, Reciprocal Teaching ($ES = 0.75$), which promotes active thinking through structured discussions among students.

For metacognitive inquiry: as a teaching method, Summarization ($ES = 0.79$), which supports students in identifying key ideas and organizing their knowledge; as a learning method, Piagetian Programs ($ES = 1.28$), which foster cognitive development through activities tailored to students' developmental stages.

For feedback: Classroom Discussion ($ES = 0.82$), which encourages bidirectional feedback and concept clarification through direct interaction.

Thus, by systematically selecting and applying such teaching methods, since it is crucial for students to fully master all the details and nuances of these methods to avoid wasting valuable lesson time, we can significantly enhance their academic success. The cumulative effect size remains to be demonstrated, but it is expected to exceed the highest ES of the individual components applied.

Research Objectives

The overall aim of this research was to assess how a combination of constructivist teaching strategies (Flipped Classroom, Early Physics Approach, 5E Model, Peer Instruction with Conceptual Questions) can be effectively implemented in physics lessons and to evaluate its impact on students' academic success and on scientific competence, which in this study is structured into five key components: understanding of definitions, knowledge of measurement units, correct application of formulas, problem-solving skills, and the use of scientific language. Additionally, we have examined how different student groups (high-performers and low-achievers) respond to this instructional approach.

Research Questions

RQ1: How does the integration of constructivist teaching strategies in physics influence the academic success of students at different school levels?

RQ2: What is the impact of the method on the components of students' scientific competence?

Research Hypotheses

H1: The combined application of constructivist teaching strategies (Flipped Classroom, Early Physics Approach, 5E Model, Peer Instruction with Conceptual Questions) enhances the academic success of students and the components of their scientific competence in physics.

H2: As a result of the combined application of constructivist teaching strategies, the improvement in academic success will be greater for high-performing students than for low-performing students.

Methodology

The experiment took place throughout the entire 2023-2024 academic year and was conducted in two public schools in the Republic of Moldova: “Mihai Eminescu” Theoretical High School in Ungheni and “Hyperion” Theoretical High School in Durlăști. A total of 305 students from the 6th, 8th, and 10th grades participated. Apart from laboratory work and end-of-chapter evaluations, all lessons were conducted according to the Integrated Constructivist Model (ICM), presented in Table 2. ICM is based on the 5E model and implemented as follows: a) Flipped Classroom – where students independently familiarize themselves with the upcoming lesson topic at home by watching a 10–18-minute video on the *educatieonline.md* platform developed by Education Directorate of Chișinău (2021); b) Peer Instruction, involving 2-3 Conceptual Questions during the lesson; c) Early Physics Approach, emphasizing the understanding and scientific explanation of phenomena. We mention that group work of 4-5 students (Explore phase) and guided discussions are present in every lesson phase. Thus, the structure of the lesson is similar to that presented by M. Planinic et al. (2024), which contained the same distinctive elements of a constructivist lesson: guided discussions, interactive demonstrations, group work, and conceptual questions. In the final phase of the lesson, students complete an exit ticket with a question that summarizes what they have learned and stimulates metacognition. For example: “Today I understood that Ohm’s Law helps us to...” or “A new thing I learned today is...” For the conceptual questions and exit ticket, anonymous digital assessment was used with the Turning Point clicker system.

Table 2. Integrated Constructivist Model for a Physics Lesson

Phase	Action
0	Flipped Classroom
1. Engage (7 min.)	Demonstration Conceptual question 1
2. Explore (8 min)	Early Physics Approach Demonstration Guided discussions and conclusions
3. Explain (15 min.) Peer Instruction	Explanation Conceptual question 2 Virtual experiment and conclusions
4. Elaboration (10 min)	Graph and table drawing of measurement data. Discussions and conclusions
5. Evaluation (5 min)	Exit ticket

Research Design

The study analyses the impact of applying the Integrated Constructivist Model on the academic success and scientific competence components of students. The experiment was conducted at three school levels: lower secondary – 6th grade (121 students), upper secondary – 8th grade (127 students), and high school – 10th grade (57 students). The main objective was to compare students’ performance before and after

applying the method, using quantitative indicators. The research is designed with a pre-test and post-test.

The analysed variables are the following:

1. Academic success (pre-test and post-test), noted as Evaluation Pre-test and Evaluation Post-test.
2. Marks from laboratory work (pre-test and post-test), noted as Lab Pre-test and Lab Post-test.
3. Evolution of scientific competence, analysed through five components:
 - Knowledge of definitions (pre-test and post-test), noted as Def Pre-test and Def Post-test.
 - Knowledge of measurement units (pre-test and post-test), noted as UM Pre-test and UM Post-test.
 - Proficiency in using learned formula for solving simple problems (pre-test and post-test), noted as Formula Pre-test and Formula Post-test.
 - Ability to solve problem situations (pre-test and post-test), noted as PS Pre-test and PS Post-test.
 - Capability to use fluently scientific language (pre-test and post-test), noted as SL Pre-test and SL Post-test.

For the description of academic success, marks from 1 to 10 from the final assessments of each chapter were used. Within each chapter, students perform at least one laboratory work, for which they are marked on a scale from 1 to 10. The five components of scientific knowledge were extracted from the analysis of specific assessment items in the final evaluations and were scored with 0 and 1.

Participants

In this pedagogical study, the participants were:

- lower secondary level (6th grade), 57 boys and 64 girls, aged 11–12 years
- upper secondary level (8th grade), 58 boys and 69 girls, aged 13–14 years
- high school level (10th grade), 23 boys and 34 girls, aged 15–16 years

All students came from a similar urban environment and shared a comparable socio-economic background, ensuring consistency in external factors that might influence academic performance.

Data Collection and Analysis

In Table 3, the results from the evaluations and laboratory work at the beginning and end of the experiment are shown. For the evaluations, we observe an increase of about 10%, while for the laboratory work, the increase is about 17%. The figures for standard deviation indicate that as a result of the intervention, there is greater variability in both the control and laboratory work results. The skewness values close

to zero suggest a symmetric distribution of the marks. The Shapiro-Wilk values close to 1 indicate a normal distribution of the data. The Lab Pre-test and Lab Post-test have p-values which indicate that the data in these categories deviates slightly from normality but is still within an acceptable range for most analyses. Thus, the progress index shows a moderate effect of the ICM on the academic success of 6th-grade students (0.572) and a strong impact on performance in laboratory work (0.887).

Table 3. Descriptive Statistics of Marks from Final Evaluations and Laboratory Work in 6th Grade

	Evaluation Pre-test	Evaluation Post-test	Lab Pre-test	Lab Post-test
Valid	121	121	121	121
Mean	6.458	7.092	6.126	7.183
Std. Deviation	1.108	1.227	1.191	1.295
Skewness	-0.122	-0.134	0.143	-0.107
Shapiro-Wilk	0.985	0.984	0.978	0.977
P-value	0.217	0.152	0.049	0.033
Progress Index	0.572		0.887	

In Table 4, the 8th-grade evaluation results show an 8.3% mean increase, while laboratory work marks improved by over 15.7%. Standard deviations indicate a slight rise in variability in post-tests. Skewness values remain close to zero, suggesting symmetric distributions. The Shapiro-Wilk test results confirm near-normal data distribution, with minor deviations that remain acceptable for analysis. Thus, the progress index shows a moderate effect of ICM on the academic success of 8th-grade students (0.611) and a strong impact on performance in laboratory work (0.921).

Table 4. Descriptive Statistics of Marks from Final Evaluations and Laboratory Work in 8th Grade

	Evaluation Pre-test	Evaluation Post-test	Lab Pre-test	Lab Post-test
Valid	127	127	127	127
Mean	7.157	7.751	6.872	7.949
Std. Deviation	0.972	1.203	1.169	1.243
Skewness	0.005	-0.144	-0.027	-0.325
Shapiro-Wilk	0.989	0.979	0.981	0.970
P-value	0.416	0.050	0.071	0.006
Progress Index	0.611		0.921	

In Table 5, the 10th-grade results show an 8.9% increase in marks for final evaluations and a 14.1% rise in marks for laboratory works. Standard deviations indicate a slight rise in variability. Skewness values suggest higher-end scores, especially in laboratory tasks. The Shapiro-Wilk test confirms near-normal distribution, except for the Lab Pre-test, which deviates due to the small sample size and a higher number of students with high scores. Thus, the progress index shows a moderate effect of ICM on the academic success of 10th-grade students (0.563) and a strong impact on performance in laboratory work (0.816).

Table 5. Descriptive Statistics of Marks from Final Evaluations and Laboratory Work in 10th Grade

	Evaluation Pre-test	Evaluation Post-test	Lab Pre-test	Lab Post-test
Valid	57	57	57	57
Mean	7.156	7.795	7.619	8.695
Std. Deviation	1.134	1.293	1.318	1.481
Skewness	0.134	0.203	0.900	0.816
Shapiro-Wilk	0.963	0.961	0.914	0.947
P-value	0.075	0.061	< .001	0.015
Progress Index	0.563		0.816	

Table 6 presents the correlation between the marks obtained in laboratory work and those from final evaluations for the 6th, 8th, and 10th grades, using two regression models:

- M_0 – the baseline model, corresponding to the null hypothesis, which assumes there is no relationship between laboratory marks and final evaluations.
- M_1 – the improved model, corresponding to the alternative hypothesis, which includes laboratory marks as a predictor for final evaluation marks.

It was found that the relationship between the marks for laboratory and those for final evaluations is significant in all grades, but stronger in the 8th grade ($R = 0.882$) and weaker in the 10th grade ($R = 0.720$). The 8th grade has the best prediction (Adjusted $R^2 = 0.775$, RMSE = 0.570), suggesting that laboratory marks are a better predictor for final evaluations at this age. In the 10th grade, the correlation is weaker, indicating that additional factors may influence the final evaluation marks (e.g., the difficulty of the subject).

Table 6. Correlation between Marks for Laboratory Works and Final Evaluations

Grade	Model	R	R ²	Adjusted R ²	RMSE
6 th	M_0	0.000	0.000	0.000	1.227
	M_1	0.778	0.605	0.602	0.774
8 th	M_0	0.000	0.000	0.000	1.203
	M_1	0.882	0.777	0.775	0.570
10 th	M_0	0.000	0.000	0.000	1.293
	M_1	0.720	0.519	0.510	0.905

In Table 7, the descriptive statistics for the final evaluation scores are presented for high achievers (H), i.e., those students who completed the academic year with scores above 9; medium achievers (M), who finished with scores between 7 and 8; and low achievers (L), whose scores were below 7. It is important to note that students who started the year with scores below 9 but ended with scores above 9 have been included in the category of high achievers, and similarly for the other groups.

In the 6th grade, the academic performance of high achievers increased by 13.2%, or 1.111 points, for medium achievers by 10.1%, or 0.697 points, and for low

achievers by 8.1%, or 0.35 points. Thus, the increase in scores for high achievers in the 6th grade is three times greater than the increase for low achievers.

In the 8th grade, academic performance for high achievers increased by 9.8%, or 0.839 points, for medium achievers by 10.4%, or 0.749 points, and for low achievers by 0.8%.

In the 10th grade, academic performance for high achievers increased by 9.9%, or 0.882 points, for medium achievers by 8.5%, or 0.615 points, and for low achievers by 6.9%, or 0.4 points. Therefore, the increase in scores for high achievers in the 10th grade is double that of low achievers.

Table 7. Descriptive Statistics for High (H), Medium (M) and Low (L) achievers in 6th, 8th and 10th Grades

Grade		High		Medium		Low	
		Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
6 th	Valid	9	9	68	68	44	44
	Median	8.300	9.500	6.800	7.400	5.600	5.950
	Mean	8.400	9.511	6.874	7.571	5.418	5.857
8 th	Valid	23	23	72	72	32	32
	Median	8.500	9.300	7.050	7.800	6.100	6.150
	Mean	8.591	9.430	7.175	7.924	6.088	6.156
10 th	Valid	11	11	32	32	14	14
	Median	8.800	9.900	7.200	7.750	5.750	6.300
	Mean	8.900	9.782	7.194	7.809	5.800	6.200

The overall picture of the ICM impact on academic success and laboratory work performance across all participating classes is presented in Table 8. The results include *t-values*, degrees of freedom (*df*), significance levels (*p*), and Cohen's *d* effect sizes with their standard errors (*SE Cd*). The *t*-test results indicate statistically significant improvements ($p < .001$) in both final evaluations and laboratory work for all grades. The Cohen's *d* values reveal strong to very strong effects, particularly for laboratory performance, where effect sizes range from 2.554 (10th grade) to 4.758 (8th grade), suggesting a profound impact. In comparison, the effect sizes for final evaluations, though still substantial (between 1.198 and 1.677), are also high, consistently lower than those for laboratory work. The standard error (SE) of Cohen's *d* remains low across all measures, reinforcing the reliability of the effect size estimates. Overall, these results suggest that the intervention had a markedly greater impact on laboratory performance than on final evaluations, with the strongest effects observed in the 8th grade.

Table 8. The Effect of ICM on Student Performance in Final Evaluations and Laboratory Work in the 6th, 8th and 10th Grades

Grade	Measure 1	Measure 2	t	df	p-value	Cohen's d	SE Cd
6 th	Evaluation Pre	Evaluation Post	13.179	120	< .001	1.198	0.053
	Lab Pre	Lab-post	48.043	120	< .001	4.368	0.052
8 th	Evaluation Pre	Evaluation Post	18.897	126	< .001	1.677	0.034
	Lab Pre	Lab-post	53.617	126	< .001	4.758	0.055
10 th	Evaluation Pre	Evaluation Post	11.446	56	< .001	1.516	0.063
	Lab Pre	Lab-post	19.286	56	< .001	2.554	0.076

The effect of ICM on academic success in the 6th, 8th, and 10th grades is illustrated in Figure 1 and on laboratory works results in Figure 2.

Figure 1. The Effect of ICM on Student's Academic Success

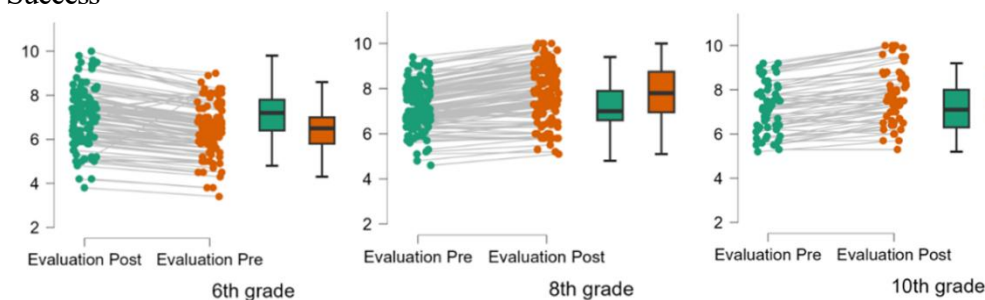
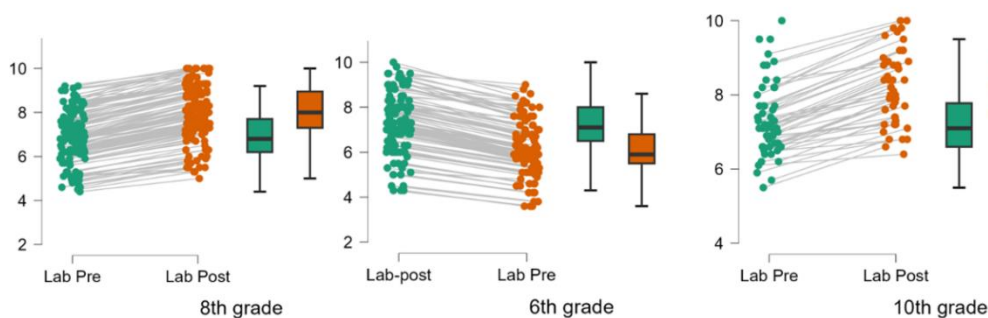


Figure 2. The Effect of ICM on Marks for Laboratory Works



Let us now analyse the results regarding the description of the mix of constructivist strategies on the components of scientific competence: DEF (knowledge of definitions), UM (knowledge of units of measurement), FORM (knowledge and application of formulas in problem-solving), PS (ability to solve a problem or translate a problem situation into the terms of a typical physics problem), SL (scientific language or the appropriate and coherent use of learned terms). Each of these five components was measured at the beginning (pre-test) and at the end of the intervention (post-test). For this purpose, students' responses to each item from all evaluations during the academic year were analysed. Each test included items that highlighted each of the five components of scientific competence, scored as 0 – the

student does not possess the respective competence – and 1 – the student possesses the respective competence. Thus, Table 9 presents the descriptive statistics for the components of scientific competence in 6th, 8th and 10th grades.

Table 9. Descriptive Statistics for the Components of Scientific Competence

	6 th Grade			8 th Grade			10 th Grade		
	Valid	Mean	StD	Valid	Mean	StD	Valid	Mean	StD
DEF Pre	121	0.298	0.459	127	0.323	0.469	57	0.316	0.469
DEF Post	121	0.380	0.487	127	0.425	0.496	57	0.421	0.498
UM Pre	121	0.810	0.394	127	0.780	0.416	57	0.632	0.487
UM Post	121	0.851	0.357	127	0.866	0.342	57	0.807	0.398
FORM Pre	121	0.231	0.423	127	0.244	0.431	57	0.333	0.476
FORM Post	121	0.256	0.438	127	0.339	0.475	57	0.456	0.503
PS Pre	121	0.215	0.412	127	0.189	0.393	57	0.246	0.434
PS Post	121	0.248	0.434	127	0.386	0.489	57	0.456	0.503
SL Pre	121	0.107	0.311	127	0.228	0.421	57	0.298	0.462
SL Post	121	0.347	0.478	127	0.677	0.469	57	0.632	0.487

In order to quickly interpret these data, we will calculate the growth rate for each component of scientific competence in each grade. For this purpose, we will use the formula $Growth\ Rate = (PostTest - PreTest) / PostTest$. The results for the Growth Rate are presented in Table 10.

Table 10. Growth Rate for the Components of Scientific Competence

Component	Growth Rate, 6 th Grade	Growth Rate, 8 th Grade	Growth Rate, 10 th Grade
DEF	27.51%	31.63%	33.33%
UM	5.06%	11.03%	27.71%
FORM	10.83%	38.11%	36.90%
PS	15.35%	104.74%	85.37%
SL	224.30%	196.49%	112.08%

Table 11 presents the statistical analysis of the effect of ICM on the components of scientific competence in 6th, 8th, and 10th grades. Large t values across all components confirm that ICM had a positive effect on students' scientific competence in all grades (6th, 8th, and 10th). The magnitude of the t values (from 2.274 to 10.129) correlates with the strength of the improvement, with higher t values indicating greater improvements. For example, the use of scientific language in the 8th and 10th grades or the ability to solve problem situations in the 8th grade showed greater improvements. In general, the t values in Table 10 highlight that ICM had a significant and positive impact on the development of scientific competence, with varying degrees of effectiveness across different components and grades.

The p -values indicate that most results are highly significant ($p < 0.001$), confirming the positive impact of ICM on scientific competence. However, the weakest effects were observed in the 6th grade, specifically in knowledge and the ability to apply simple formulas ($p = 0.083$) and in solving problem situations ($p = 0.045$).

The results for the effect size or Cohen's *d* indicate small effects of ICM on knowledge of definitions (DEF) across all grades, and knowledge of measurement units (UM), knowledge and ability to apply simple formulas (FORM), and solving problem situations (PS) in the 6th grade. It is important to note that the relatively small effects for definitions and measurement units are likely due to the fact that students already had a high level of knowledge in these areas before the intervention, leaving limited room for significant improvement. For this reason, ICM shows a moderate effect on UM and DEF in the 8th and 10th grades. Additionally, problem-solving skills (PS) and formulas (FORM) showed moderate improvement, indicating that elder students benefitted more from ICM in structuring and applying knowledge. The most significant improvement was observed in scientific language (SL) in the 8th grade, suggesting that ICM greatly enhanced students' ability to express and articulate scientific concepts.

The values for the Standard Error of Cohen's *d* (SE Cd) help to assess the precision of the effect sizes. Smaller SE Cd values (e.g., for DEF and UM in 6th grade) indicate that Cohen's *d* is more precise, suggesting that the positive effects of ICM are reliable in these components. Larger SE Cd values (e.g., for SL in 10th grade) suggest that while the effect of ICM is significant, the effect size estimate is less precise, potentially due to more variability in the data for these components. Overall, the impact of ICM on scientific competence is clear and significant across most components and grade levels.

Table 11. The Effect of ICM on the Components of Scientific Competence

Component	Grade	t	df	p-value	Cohen's d	SE Cd
DEF	6 th	3.288	120	0.001	0.299	0.054
	8 th	3.791	126	<.001	0.336	0.057
	10 th	2.567	56	0.013	0.340	0.087
UM	6 th	2.274	120	0.025	0.207	0.048
	8 th	3.457	126	<.001	0.307	0.066
	10 th	3.452	56	<.001	0.457	0.118
FORM	6 th	1.747	120	0.083	0.159	0.033
	8 th	3.626	126	<.001	0.322	0.058
	10 th	2.800	56	0.007	0.371	0.092
PS	6 th	2.025	120	0.045	0.184	0.039
	8 th	5.557	126	<.001	0.493	0.083
	10 th	3.864	56	<.001	0.512	0.122
SL	6 th	6.150	120	<.001	0.559	0.100
	8 th	10.129	126	<.001	0.899	0.117
	10 th	5.292	56	<.001	0.701	0.148

Let's now analyse how each of the five components (FORM, PS, SL, DEF, UM) fits within the common construct of scientific competence, referred to as Factor 1 in Table 12. Factor loadings indicate how strongly each component is associated with Factor 1, which represents the overall construct of scientific competence, while uniqueness reflects the proportion of variance in each component that is not explained by that factor.

Across all grades, the FORMULA component (knowledge of formulas and the ability to apply them to simple problems) and PS (the ability to solve problem situations or translate a verbally stated real-life problem into a typical one) show high and very high loadings, suggesting that they contribute significantly to the underlying construct. In addition, the DEFINITION component (knowledge of definitions of recently studied scientific quantities) and SL (the proper and coherent use of scientific terms) exhibit mostly moderate loadings, indicating that these components also contribute meaningfully to the common construct. The low uniqueness values of these four components suggest that they are well explained by the construct of scientific competence. In contrast, UM (knowledge of measurement units) exhibits lower loadings and higher uniqueness, especially in the 6th and 8th grades, indicating that this component is less integrated into the overall construct of scientific competence.

Table 12. Factor loadings for the Components of Scientific Competence

	6 th Grade		8 th Grade		10 th Grade	
	Loading Factor 1	Uniqueness	Loading Factor 1	Uniqueness	Loading Factor 1	Uniqueness
Formula	0.927	0.140	0.879	0.227	0.945	0.107
PS	0.907	0.178	0.945	0.107	0.835	0.302
SL	0.808	0.347	0.644	0.586	0.791	0.375
Definition	0.762	0.420	0.929	0.136	0.810	0.344
UM		0.896	0.415	0.828	0.546	0.702

In order to better understand the relationship between the components of scientific competence, let's examine the rotated and unrotated solutions presented in the Table 13. These solutions provide a deeper insight into how the five components (FORM, PS, SL, DEF, UM) load onto the common construct of scientific competence and help us assess the strength and clarity of their relationships within the overall factor structure.

Thus, the high Eigenvalues (3.304 – 3.487) indicate that the main factor (scientific competence) captures information from approximately three components out of the five analyzed. These would be: FORMULA, PS, SL, and to some extent, DEFINITION. Additionally, the slight increase in the Eigenvalue from the 6th grade to the 10th grade shows that the structure of scientific competence in students is established early on and does not undergo essential changes but rather refines over time without being restructured.

The Sum of Squared Loadings remains almost constant (~3) and the same across both unrotated and rotated solutions. This means that the scientific competence factor explains approximately the same proportion of variance in the data across all grades.

The values of the Proportion of Variance and the Cumulative Proportion of Variance remain the same for both Rotated and Unrotated Solutions, ranging from 0.604 in the 6th grade to 0.634 in the 10th grade. This indicates that approximately 60% of scientific competence is explained by these components. This confirms that three of the five components fit into the general construct of scientific competence.

Table 13. The Characteristics of the Scientific Competence Factor for rotated and unrotated Solutions

Grades	Solution	Eigenvalue	Sum Sq. Loadings	Proportion var.	Cumulative
6 th	Unrotated	3.304	3.019	0.604	0.604
	Rotated		3.019	0.604	0.604
8 th	Unrotated	3.383	3.117	0.623	0.623
	Rotated		3.117	0.623	0.623
10 th	Unrotated	3.487	3.170	0.634	0.634
	Rotated		3.170	0.634	0.634

Results and Discussion

Regarding the answer to RQ1: “How does the integration of constructivist teaching strategies in physics influences the academic success of students at different school levels?”, the research findings allow us to state the following:

At the lower secondary level, specifically in 6th grade, when students encounter physics for the first time in school, the implementation of the ICM model throughout the academic year led to the following outcomes:

- Students’ marks on summative assessments at the end of the year increased by approximately 10% compared to the beginning of the year (see Table 3), with a moderate Progress Index (PI = 0.572).
- Final laboratory work marks improved by about 17% from the start of the year (see Table 3), with a strong Progress Index (PI = 0.887).
- The correlation between laboratory results and summative assessments is approximately 60% (see Table 6), meaning that a 0.6 increase in the assessment grade corresponds to a 1.0 increase in the laboratory grade. This further confirms the influence of “doing” on “learning” and highlights the necessity of a constructivist approach to achieve higher learning outcomes.

At the upper secondary level, specifically in 8th grade, the following results were obtained:

- The marks on summative assessments increased by approximately 8.3% (see Table 4), with an average score of 7.75 and a moderate Progress Index (PI = 0.611). The relatively small percentage increase in marks is due to the saturation effect: before the intervention, the students had already answered these items correctly at a rate of 80%. The impact of the ICM model on academic performance is also clearly visible in the analysis of skewness values. At the pre-test, skewness was nearly zero (0.005), indicating a symmetric distribution of student marks, while at the post-test, it became slightly negative (-0.144), meaning that a higher number of students obtained high grades, with fewer students receiving low grades (see Table 4).

- Laboratory work marks increased by 15.7%, with an average of 7.95 and a strong Progress Index (PI) = 0.921 (see Table 4). The effect of the ICM model is also evident in this case: at the pre-test, skewness was slightly negative (-0.027), and after the intervention, it became more pronounced (-0.325), indicating an increase in the proportion of students with high grades.
- The correlation between laboratory and assessment results is higher than in 6th grade, reaching 77.5% (see Table 6). In other words, an increase of one unit in the laboratory average should lead to an increase of approximately 0.77 in the assessment average.

At the high school level, specifically in 10th grade, the following results were obtained:

- Assessment scores increased by 8.9%, with an average of approximately 7.80 (see Table 5). The Progress Index in this case is moderate, PI = 0.563.
- Laboratory scores increased by 14.1%, with an average of approximately 8.70, showing a strong PI = 0.816. The high and positive skewness values in 10th grade indicate that most students have high scores, with only a few students scoring lower.
- The correlation between laboratory work and assessments reached approximately 51%.

Additionally, it is interesting to examine the impact of the ICM model on academic performance among high, medium, and low achievers. At all levels, the average scores increased as follows:

- In 6th grade: high achievers' scores increased by 1.111 units, medium achievers by 0.697 units, and low achievers by 0.35 units.
- In 8th grade: high achievers' scores increased by 0.839 units, medium achievers by 0.749 units, while the increase for low achievers was insignificant.
- In 10th grade: high achievers' scores increased by 0.882 units, medium achievers by 0.615 units, and low achievers by 0.4 points.

Thus, the increase in scores for high achievers is greater than for low achievers — three times higher in 6th grade and twice in 10th grade.

Overall, the effect size of the ICM model (Cohen's *d*) on academic performance ranges from 1.198 to 1.516, indicating a strong effect, while for laboratory work, it ranges from 4.368 to 2.554, corresponding to a very strong effect (see Table 8). This larger effect size in laboratory work compared to assessments was expected since ICM is primarily a constructivist method. To achieve a similar increase in assessments, it would be necessary to enhance the use of teaching strategies related to metacognition and feedback.

Regarding the answer to RQ2, "What is the impact of the method on the components of students' scientific competence?" we can state that the effect of ICM on the scientific components of students in different grades was as follows:

- For 6th-grade students, the highest growth rate was observed in the use of scientific language (SL), with an increase of approximately 224%, followed by the memorization of definitions (DEF) at around 27%.
- For 8th-grade students, the highest growth rate was also in SL—about 196%—and in solving real-life problem situations (PS), with an increase of approximately 105%.
- For 10th-grade students, a similar trend was observed: SL increased by 112%, while PS grew by 85% (see Table 10).

Thus, the results for the effect size, or Cohen's *d* (see Table 11), indicate the highest effect size for SL, ranging from 0.559 to 0.899 across different grades, suggesting that ICM significantly enhanced students' ability to express and articulate scientific concepts. Next, PS and the ability to apply formulas in simple problems (FORM) show effect sizes ranging from 0.184 to 0.512. In third place, FORM ranges from 0.159 to 0.371, corresponding to a moderate improvement. The smallest effect size of ICM is observed for knowledge of definitions (DEF), ranging from 0.299 to 0.340, and knowledge of measurement units (UM), ranging from 0.207 to 0.457. This can be explained by the saturation effect, as students had already answered these test items at approximately 80% accuracy in the pre-test.

We have to mention that factor analysis indicates that the scientific competence is formed by approximately three components out of the five analysed: FORMULA, PS, SL, and to some extent, DEFINITION. Thus, about 60% of scientific competence is determined by these three-four components. Also, we established that the structure of scientific competence in students is established early on and does not undergo essential changes but rather refines over time without being restructured.

Conclusions

This study was based on the idea of applying RBIS when designing a teaching approach or strategy. Additionally, it was founded on the premise that overlapping elements of constructivist teaching strategies with a confirmed effect size adds value. In other words, we can refer to the Concept of Didactic Synergy, where the effect size of the mix of teaching strategies is greater than the highest effect of its individual components.

Based on these considerations, the Integrated Constructivist Model (ICM) was developed, incorporating elements from the 5E Model, Flipped Classroom, Peer Instruction with Conceptual Questions, and the Early Physics Approach. Thus, both research hypotheses were confirmed.

The effect size values obtained for assessments indicate a moderate to strong effect of ICM (1.198; 1.677) and a strong to very strong effect on laboratory work results (2.554; 4.758).

Additionally, the analysis of scientific competence components revealed significant progress in the use of scientific language (SL) and problem-solving ability (PS). These competencies showed favourable effect sizes, with values reaching 0.899 for SL and 0.512 for PS, highlighting that ICM enhanced not only the learning of

theoretical information but also students' ability to express themselves coherently in scientific terms.

Furthermore, after one year of ICM implementation, the success rate of high achievers increased significantly more than that of low achievers – three times in the 6th grade and twice in the 10th grade.

Therefore, the systematic integration of these constructivist strategies into daily teaching is recommended to maximize students' academic outcomes.

In conclusion, the results of this study provide empirical grounding for several key theoretical contributions in the field of educational research. They confirm Hattie's (2009) synthesis on visible learning by demonstrating that when evidence-based strategies are combined, their cumulative impact on achievement surpasses that of isolated interventions. At the same time, they extend Zhou's (2004) perspective on interactive and student-centered teaching by showing that inquiry, peer dialogue, and formative feedback can be structurally integrated within a single coherent model. Furthermore, they reinforce Bonacci's (2020) insights regarding the role of conceptual engagement and reflective thinking in science education, as ICM operationalizes these principles in real classroom settings. Taken together, these correspondences indicate that the Integrated Constructivist Model does not merely replicate the assumptions of prior research, but contributes to their synthesis through an empirically validated constructivist framework tailored for physics teaching.

Despite these findings, the statistical analyses conducted in this study are inherently static and descriptive, reflecting correlations within a specific educational context rather than dynamic causal relationships. The data capture a cross-sectional perspective of students' progress within one academic year, which limits the generalization of results beyond the observed cohorts. Moreover, factors such as individual cognitive profiles, teacher mediation, and contextual variability were not dynamically modelled. Future research should therefore apply longitudinal or experimental designs to explore the evolving interactions among constructivist strategies over time and to validate the causal pathways suggested by the present results.

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Exploring Pronunciation Teaching: A Case Study of Practices and Perceptions in an English Classroom

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Despite its direct impact on intelligibility and fluency, pronunciation frequently receives minimal attention in English language classrooms. This study explores the current state of pronunciation teaching in a selected English bilingual class at a Slovak high school. It specifically investigates how a confident English language teacher handles pronunciation instruction regarding its extent, content, integration, models, materials, and techniques. Additionally, it examines the attitudes, perceptions, motivations, and reflections of both the participating teacher and students. A qualitative case study approach integrated data from three research methods: observations, a teacher interview, and a focus group interview. These data were triangulated to achieve in-depth understanding of the situation. While findings from a small-scale case study are not generalisable, they can offer valuable insights in similar contexts in English language pronunciation instruction. While the teacher confidently incorporated pronunciation, their approach had significant weaknesses: largely intuitive, unsystematic, and decontextualized tasks. This repetitive practice reduced effectiveness and lacked productive engagement. Both teacher and learners did not critically reflect on these shortcomings, highlighting a crucial need to raise awareness and address L1 interference. The findings suggest that a more focused methodological teacher training can substantially improve pronunciation instruction in similar contexts.

Keywords: English Language Teaching, Pronunciation Teaching, Bilingual Education, Teacher Perceptions

Introduction

Pronunciation is an important component of language learning, directly influencing learners' intelligibility and fluency in communication. Despite this importance, current research consistently indicates that pronunciation teaching often receives no or only limited attention in English language classrooms (Scrivener, 2011; Murcia, Brinton & Goodwin, 2010), whether resulting from prioritising other language aspects in the restricted classroom time, the teachers' view of pronunciation practice as unnecessary, or their uncertainty of how to integrate pronunciation in language lessons effectively (Griffiths, 2011; Gilbert, 2008; Datko, 2013; Harmer, 2007). This attitude, however, has a large impact on learners' ability to communicate effectively: considering that the differences in sound inventories and prosody between various languages can be rather broad, the acquisition of accurate and intelligible pronunciation of a foreign language can be a challenging

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task. Therefore, a systematic approach to pronunciation practice and proper guidance from teachers is needed in this process. Recognising the above-stated gap in this area, this study aims to explore the state of pronunciation teaching in a selected English bilingual class at a Slovak high school, including its extent, content, integration, models, materials and techniques. Simultaneously, its goal is to understand the attitudes, perceptions, motivations and reflections of the selected teacher and learners on the examined pronunciation instruction. By employing a qualitative case study design with triangulated methods — observations, a teacher interview, and a focus group interview, it provides a more complex view of the reality and challenges of pronunciation instruction in the described context. The findings contribute to ongoing discussions on effective pronunciation teaching, drawing pedagogical recommendations based on the identified weaknesses that can support the development of more effective and engaging pronunciation instruction.

Literature Review

Pronunciation Teaching: Shifting from Native-like Accents to Intelligibility

Over the past 70 years, English has evolved from being a foreign language to becoming a global language, playing a significant role in nearly every country worldwide. Today, English primarily facilitates communication between individuals with different mother tongues rather than serving as a medium between native speakers (Crystal, 2003).

This unique position and function of English have also influenced the perception of pronunciation teaching goals. In the context of English as an international language, the importance of native accents in cross-cultural communication has diminished significantly, as noted by Brown (2001). The rapid global spread of English has led to a shift in the objectives of pronunciation teaching, moving away from achieving native-like accents and toward ensuring intelligibility. This approach aims to help learners surpass the "threshold level" at which their pronunciation no longer hinders effective communication (Celce-Murcia et al., 1996).

Moreover, achieving a native-like accent is an unrealistic goal for most adult learners. Research suggests that only a small number of exceptionally talented and highly motivated individuals can attain such proficiency (Celce-Murcia et al., 1996). In today's multilingual and multicultural world, accents are widely accepted, further emphasizing that "native-speakerism" is both an unrealistic and irrelevant objective.

It is important to highlight that "if intelligibility is the goal, then it suggests that some pronunciation features are more important than others" (Harmer, 2007, p. 249). Research conducted by Jennifer Jenkins (2001) identifies specific pronunciation features essential for intelligibility in interlanguage communication between non-native speakers, a concept known as the "Lingua Franca Core." For example, features such as vowel length, aspiration after fortis plosives, and nuclear stress are critical for ensuring intelligibility. In contrast, other features, such as assimilations or intonation, carry less importance and may require less instructional focus compared to the core features.

Teaching English Pronunciation in the Slovak Context

In the context of English language education in Slovakia, pronunciation teaching should focus on areas impacted by language interference, which often leads to negative transfer. By addressing these specific challenges, teachers can help learners improve their pronunciation and enhance overall communication effectiveness. This section outlines key problem areas and provides guidance for teaching pronunciation in upper secondary education, supported by relevant research and sources.

Acquiring a second language requires learners to master the sounds of the target language, which may be new, similar, or identical to their native phonemes. English and Slovak have similar numbers of phonemes (44 and 42, respectively), but significant differences in articulation quality often lead to substitutions that reduce comprehensibility (Vančová, 2016). According to Roach (2009), articulation differences are a decisive factor in language interference, causing Slovak learners to replace English phonemes with the closest Slovak equivalents.

Additionally, Slovak learners face challenges with English's less predictable relationship between spelling and pronunciation. For instance, the English phoneme /k/ has multiple representations ("ck" in *duck*, "k" in *kitchen*, and "c" in *cat*), while the grapheme "a" can correspond to nine distinct phonemes (/æ/ in *cat*, /eɪ/ in *cake*, /ə/ in *sofa*, /ɑ:/ in *father*, /e/ in *any*, /ɔ:/ in *water*, /ɒ/ in *swap*, /ɪ/ in *village*, silent letter in *marriage*). This unpredictability of spelling and pronunciation can cause confusion, particularly at the beginning of language learning.

Pedagogical recommendations emphasize raising awareness of these differences and practising problematic sounds. Based on research (Vančová, 2016; Metruk, 2019), priority should be given to:

- *Schwa vowel (/ə/)*: often substituted with full vowels resembling written letters.
- *e-sounds (/e/, /æ/, /ə/, /ɜ:/, /eə/)*: frequently replaced by Slovak vowels /e/, /e:/, or /er/.
- *Vowel length*: misinterpreted before fortis and lenis consonants, as Slovak vowel length is unaffected by neighbouring consonants.
- *Dentals (/ð/, /θ/)*: substituted with Slovak /t/, /d/, /f/, /s/, or /z/.
- *Aspirated plosives (/p/, /t/, /k/)*: produced with excessive or insufficient aspiration.
- *Non-rhotic "r" (/r/)*: Realized as an alveolar tap, resembling Slovak "r".
- *-ng cluster (/ŋ/)*: Often pronounced as /ng/ instead of /ŋ/.
- *Sound distinctions (/w/ vs. /v/, /n/ vs. /ŋ/)*: frequently confused, affecting meaning.

Suprasegmentals, including stress, rhythm, and intonation, are vital for effective communication, as they provide meaning and emotional nuance to speech (Derwing & Munro, 2009). Mistakes in suprasegmentals are often more disruptive than errors in segmental features (Bázlik & Miškovičová, 2012). Key challenges

for Slovak learners include (Sabol & Zimmerman, 1994; Král', 2009; Mistřík et al., 1993; Sičáková, 2002):

- *Stress placement*: Slovak's fixed first-syllable stress contrasts with English's variable stress patterns, leading to errors in syllable quantity and vowel pronunciation.
- *Stress-timed rhythm*: Slovak learners often fail to differentiate sufficiently between stressed and unstressed syllables, resulting in monotonous delivery that disrupts English rhythm.
- *Fluency*: Slovak's rhythmic pattern, characterized by clearly separated words, conflicts with English's connected speech.
- *Assimilation patterns*: Slovak learners tend to transfer Slovak assimilation rules to English, such as incorrectly devoicing final consonants and altering grammatical endings.
- *Distinctive intonation*: Slovak learners struggle with English's broader pitch range and melodic transitions, often resulting in flat, monotonous intonation.

Teaching suprasegmentals should focus on raising awareness of stress patterns, improving rhythm through stress-timed practice, and addressing intonation to enhance learners' naturalness and communicative clarity in English.

Effective pronunciation teaching in the Slovak context requires targeted instruction addressing both segmental and suprasegmental challenges. By prioritizing features that impact intelligibility, such as schwa vowels, stress placement, and connected speech, teachers can help learners achieve clearer, more effective communication. Incorporating these insights into practice will ensure better alignment with the communicative demands of English in real-world contexts.

Recommended Pronunciation teaching Materials

When selecting materials for language teaching, teachers must consider factors such as learners' age, proficiency level, background knowledge, and comprehensibility of the materials (Reid, 2014). Pronunciation teaching typically uses two types of materials: authentic and adapted.

Authentic materials are texts or recordings created for native speakers rather than language learners (Harmer, 2007). These offer several advantages, including:

- exposing learners to natural language;
- making interactions meaningful and realistic;
- providing cultural context;
- suitability for various proficiency levels;
- offering engaging, up-to-date content.

Despite challenges like complex language or preparation demands, authentic materials are valuable for pronunciation teaching. Examples include songs (useful for stress, intonation, and connected speech), podcasts, TV shows, radio programs, public speeches, and real-life conversations (Holden & Nobre, 2019).

Adapted materials are resources modified to meet learners' specific needs by simplifying language, adding support, or adjusting content. They are convenient, “ready-made,” and versatile for any age or proficiency level. However, they can lack authenticity and meaningful language. Effective adapted materials for pronunciation teaching include handouts targeting specific features, explanatory videos, dictation texts, pronunciation apps, interactive quizzes, and coursebook recordings.

Key Pronunciation teaching Techniques

When teaching pronunciation, the choice of technique is crucial as it significantly impacts learners' acquisition of the target's language pronunciation. A well-chosen technique can enhance learning by ensuring clear mediation, increasing student motivation, and creating a supportive environment that fosters accurate pronunciation and confidence (Brown, 2001). According to Celce-Murcia et al. (1996), there are two primary approaches to pronunciation teaching: the intuitive-imitative approach, which relies on learners imitating sounds and rhythms from models, and the analytic-linguistic approach, which uses tools like the phonetic alphabet and contrastive information to explicitly inform learners. These approaches complement each other, with the analytic-linguistic approach providing additional resources to enhance pronunciation skills. Pronunciation teaching can also be approached from either a top-down or bottom-up perspective. The top-down approach emphasizes larger language units like suprasegmentals, while the bottom-up approach focuses on smaller segments like individual sounds (AMEP, 2002). There is now a shift toward a balanced approach that integrates both levels, emphasizing pronunciation in the context of regular language lessons.

Below are common pronunciation teaching techniques (Celce-Murcia et al., 1996; Alhassan, 2023; Reid, 2016; AMEP, 2002; Brewster et al., 1992; Mardiani & Hanifah, 2023) that can be used in English lessons, along with comments on their benefits, disadvantages, and suitability for our target age and proficiency group (16 years old learners, B2 level):

- *Listening and Repeating*: this traditional method involves learners imitating a model provided by the teacher. It is simple to use and can be integrated at any point in the lesson, even without specialized materials. Adding audio or video resources enhances engagement and provides diverse models. This technique is suitable for learners of all age groups.
- *Drilling*: drilling provides valuable practice, particularly for new language learners, but it can be repetitive and disengaging for older students. To maintain engagement, drills should incorporate both segmental and suprasegmental features and be varied, including repetition drills, minimal pair drills, substitution drills, transformation drills, chain drills, tongue twisters, and chants.
- *Ear Training*: focused on improving the ability to perceive sounds, ear training helps learners recognize and produce accurate pronunciation. Though better suited for younger learners, it remains valuable for all age groups.

Aspects of connected speech (assimilation, elision, weak forms) are suitable for more advanced students.

- *Tongue Twisters*: are fun and effective for teaching challenging sounds and prosodic features, beneficial for both younger and older learners.
- *Songs and Rhymes*: Their rhythmic nature helps learners with pronunciation, rhythm, and intonation. While ideal for younger learners, older students may enjoy these activities if presented in a non-embarrassing way.
- *Drama*: dramatizing helps learners with both segmental and suprasegmental aspects, especially with rhythm and intonation. It is suitable for all age groups.
- *Reading Aloud/Recitation*: this technique allows teachers to identify pronunciation errors promptly. It is effective for older learners with strong reading skills and can target specific pronunciation features.
- *Recordings*: Recording allows learners to self-assess their pronunciation, making it particularly useful for more advanced learners. Feedback from teachers or peers further enhances the learning process.
- *Visual Aids*: Tools like sound-colour charts and phonemic symbols help learners understand how sounds are produced, especially beneficial for advanced learners.
- *Use of technology*: can be a useful tool for learning pronunciation. Many applications and websites are available for listening, repeating, recording pronunciation, and even correcting mistakes.
- *Explicit Learning*: provides learners with theoretical knowledge of sound production and suprasegmentals enhances their ability to understand and apply pronunciation rules, particularly useful for advanced learners.
- *Phonics*: Primarily used with younger learners, phonics helps establish the connection between sounds and letters, aiding reading skills and pronunciation.
- *Phonetic Training*: This technique teaches learners the articulatory process and phonetic symbols, offering deep insight into pronunciation. It is especially helpful for adult learners who struggle with hearing or imitating sounds.

Combining these techniques with contextually integrated activities helps ensure effective and engaging pronunciation instruction for learners of varying age groups and proficiency levels and overall language competence.

Phonological Competence in teaching English as a Foreign Language

Teaching a foreign language is a complex task, encompassing a wide range of competences, each contributing to building overall language proficiency. According to the Common European Framework of Reference for Languages (CEFR, 2020), phonological competence is one of the linguistic competences, alongside grammatical, lexical, and orthographic competences. Linguistic competence, in turn, is one of the three communicative language competences, alongside sociolinguistic and pragmatic competences.

Our research examines the state of pronunciation teaching in English language lessons at the upper secondary level, specifically within a five-year bilingual program at a high school. According to the national curriculum, the *Maturita* exam (equivalent to

the A-level) is expected to be at the C1 level (NIVAM, 2015). However, the observed students were at the B2 level (second year), so our study focuses on the theory of phonological competence as defined for B2 learners.

The CEFR (2020) describes the overall phonological control of B2 students as being generally accurate in using appropriate intonation, correctly placing stress, and articulating individual sounds clearly. While their accents are often influenced by other languages, this typically has little to no effect on intelligibility. Specifically, in terms of sound articulation, B2 learners can produce most target language sounds clearly during extended speech, remaining intelligible despite occasional systematic mispronunciations. Regarding prosodic features, they can employ stress, intonation, and rhythm effectively to convey their intended message, although some influence from other languages may persist.

Despite their relatively high level of English pronunciation, certain issues remain, particularly in the problematic areas identified for Slovak learners. Addressing these issues can further enhance their phonological competence and overall communicative ability.

Methods

A Statement of the Problem and Research Questions

Research frequently reports that pronunciation teaching is often neglected or delivered in a disorganised manner lacking a clear focus on addressing problematic features (Scrivener, 2011; Gilbert, 2008; Murcia, Brinton & Goodwin, 2010; Vančová, 2020; Reid & Debnarova, 2023). This research study selects a teacher who regularly includes pronunciation instruction and is confident in their pronunciation teaching to qualitatively investigate how pronunciation is taught in their lesson.

Research Aim

The aim of this research is to explore the state of pronunciation teaching in a selected English bilingual class. Specifically, the study seeks to examine how pronunciation teaching is perceived and implemented by an experienced and confident English language teacher, the content they prioritize, and the teaching techniques and materials they employ during their pronunciation teaching.

Research Questions

1. How is English pronunciation instruction in a selected English bilingual programme class?
2. How does the chosen English language teacher perceive and integrate pronunciation teaching into their English language lessons?
3. How do students in an English bilingual programme perceive pronunciation learning during their English language lessons?

Instruments and Procedure

A case study was chosen for this research, as the focus is on understanding how pronunciation teaching is perceived and practised in English language lessons. Case studies provide an in-depth examination of real people in real situations, enabling readers to gain a clearer and deeper understanding of the issues being investigated.

To ensure a comprehensive understanding of the case, multiple research methods were employed. These methods collected data from real-life contexts and generated detailed, descriptive reports. Triangulation was used to compare data from different sources to confirm or challenge the findings (Robson, 2011). The outcomes of case studies can contribute to individual development, provide valuable feedback, support evaluations, and inform educational policymakers. However, researchers must acknowledge the limitations of case studies, including the lack of generalizability, and challenges in making comparisons due to selective, personal, and potentially subjective data.

This case study served as an umbrella framework, combining data from several research methods: observation, an individual interview, and a focus group interview (Cohen, Manion, Morrison, 2007, Flick 2010).

Semi-structured observation sheet was developed, with categories and codes derived from the collected data. These included the contents, materials, and teaching techniques used for pronunciation instruction, as well as how pronunciation was integrated into observed English language lessons. Observations were conducted over two months in a high school offering an English bilingual programme in Slovakia.

Semi-structured interview was conducted with the observed English language teacher to explore their perception and integration of pronunciation teaching. The interview examined their attitudes towards the importance of pronunciation instruction, the content she focused on, the materials and teaching techniques she used, and the pronunciation model she employed. It also included their self-reflection on their pronunciation and methodological preparedness.

Focus group was conducted with 16 observed students (aged 16, in their second year of study) after the observations were completed. Focus groups are particularly valuable in qualitative research, as they foster dynamic discussions, allowing participants to complement one another's points, resulting in more diverse responses and a more complete and reliable account of the examined reality (Cohen, Manion, Morrison, 2007). The focus group aimed to gather authentic insights into the presence and extent of pronunciation teaching, the content covered, the materials and models used, and the teaching techniques applied during their English language lessons (not only the observed ones).

All collected data were analysed using descriptive narrative methods and coding. All collected data were coded independently by two researchers to enhance the validity of findings. To strengthen both reliability and validity, triangulation was employed by cross-referencing data obtained through different research methods (Cohen, Manion, Morrison, 2007; Flick 2010).

Participants and Ethics

Purposive sampling was employed in this case study. As it was mentioned earlier, pronunciation instruction tends to be overlooked or approached inconsistently. For this reason, we selected a teacher who is aware of this issue and confident in their pronunciation teaching. The chosen teacher has more than 17 years of teaching experience at the selected school. The rationale for selecting an experienced and confident teacher was to qualitatively explore how she teaches pronunciation, including their focus on segmental and suprasegmental aspects, the teaching techniques and materials she uses, and how she integrates pronunciation instruction into their lessons. The observed teacher was informed about the focus of our research, though only in relation to the broader topic of pronunciation teaching. The class of 16 students in their second year of a bilingual program at a high school (B2 level) was selected by the observed teacher and participated in a focus group interview.

The observed teacher participated voluntarily in the research and provided written informed consent. The school principal also signed the informed consent form, confirming their understanding of the research purpose and procedures. Students and their legal guardians were fully informed about the aims and process of the research and provided written consent prior to participation. They were clearly briefed on their roles in the observations and interviews, and were assured of complete anonymity and confidentiality. The collected data were handled in a way that ensured no public identification of the school or participants. All research procedures complied with the ethical standards of the researchers' university and adhered to the principles outlined in the Declarations of Helsinki.

Results

The following section provides the analysis of the observed lessons taught by the teacher, followed by the analysis of data gathered from an individual interview with their and from the focus-group interview with the learners of the observed group. For better orientation in the data, the categories and corresponding codes are presented in tables after being summarised and analysed in text.

Observation Analysis

Pronunciation teaching was present in all observed lessons, though its scope and depth varied considerably. The instruction focused predominantly on segmental features, such as vocabulary with unique and unpredictable pronunciation (e.g., city names like *Gloucester*, *Leister*), irregular verb forms (e.g. *read* in present vs. past simple), homonyms (e.g. *Wait a minute!* Vs. *They found minute particles of dust in the air*), and words with silent letters (e.g. *I wrapped the wreath in the wrong paper*). These features were typically highlighted in order to draw learners' attention to irregularities in English orthography – phonology correspondence. However, the

treatment of suprasegmental aspects was noticeably minimal, restricted to occasional references to lexical stress related to affixation and word class. This imbalance between segmental and suprasegmental instruction reflects a missed pedagogical opportunity. While segmental features are fundamental, suprasegmental features, such as rhythm, weak and strong forms, and sentence stress, play an equally crucial role in developing learners' intelligibility and communicative competence. At the proficiency level of the observed learners, systematic practice of both levels of pronunciation would have been appropriate and beneficial, yet suprasegmentals received only marginal attention.

While the focus on unpredictable pronunciation of phonemes was generally appropriate, instruction tended to be superficial and decontextualized. Features were presented in isolation rather than as part of meaningful communicative practice. For instance, vocabulary items were often chosen randomly, selected primarily to exemplify phonological irregularities rather than to support communicative goals. Dictation activities illustrating silent letters or drills on irregular verb forms, while useful for raising awareness, remained disconnected from authentic usage and therefore limited in their pedagogical impact. Learners became aware of irregularities but were rarely provided with opportunities to internalize or practice these features in speech, dialogues, or interaction activities. As a result, the potential of pronunciation instruction to contribute to long term improvement in fluency and intelligibility was only partially realized.

The teacher relied heavily on adapted materials, most notably handouts designed to target specific pronunciation aspects (e.g. word stress marking or transcription decoding). The lack of thematic coherence and meaningful communicative context in these materials significantly reduced their relevance and applicability beyond the classroom exercises themselves. Bilingual/translation dictionaries (both online and printed), considered semi-authentic materials, also played an important role, particularly in supporting learner autonomy. However, reliance on bilingual dictionaries limited learners' exposure to authentic pronunciation models. The use of monolingual dictionaries would be more advisable, as they typically provide pronunciation in both British and American English, along with accurate phonemic transcriptions and audio recordings. These tools enabled learners to analyse pronunciation features, decode transcriptions, identify stress patterns, and verify pronunciation. Despite their clear value in raising awareness, the use of dictionaries primarily facilitated surface-level engagement with pronunciation rather than encouraging active and confident use of pronunciation in spoken communication. Consequently, the materials and classroom activities observed tended to develop receptive phonological skills, at the expense of communicative pronunciation competence.

The teaching techniques employed were strongly influenced by the nature of the materials, focusing on phonetic training and explicit learning. These techniques included transcription and its decoding (e.g. matching transcribed words with their spelling representations using a dictionary) and sometimes ear training (e.g. dictation of sentences with silent letters). Lessons often concluded with plenary discussions, where the teacher corrected errors, guided students in repeating the correct pronunciations, and provided brief explanation. However, these explanations were often limited to pointing out rules rather than analysing them in detail. This approach

prioritized written language and abstract sound representations, fostering orthographic awareness rather than true phonological development. For instance, the dictation of silent letters focused more on the relationship between phonemes and graphemes than on their production in speech. While valuable for building foundational phonological competence, this repetitive and unilateral approach had significant limitations. It prioritized skills with limited real-life applicability (e.g. transcription) and offered few opportunities for learners to actively use targeted features in spoken contexts. This was further reinforced by the frequent individual task format, which limited interactive practice.

Most observed activities appeared disconnected from preceding or subsequent tasks, suggesting that pronunciation was targeted specifically due to the researchers' presence in the classroom. The decontextualised materials and narrowly focused content made it challenging for the teacher to seamlessly integrate pronunciation tasks into the lesson flow. Consequently, opportunities for practical application of targeted features over time were limited. In some cases, the degree of integration was unclear due the significant portion of the lesson devoted to pronunciation. However, one successful example involved integrating the unpredictable pronunciation of irregular past forms into a lesson on narrative tenses (past simple, past continuous, past perfect. and past perfect continuous).

Table 1. Data gathered by Lesson Observations of the Teacher

Lesson observations		
	Categories	Codes
1	The contents of pronunciation teaching	Segmentals – vocabulary with unpredictable pronunciation, silent letters, past forms of irregular verbs, homonyms Suprasegmentals – lexical stress
2	The materials used for pronunciation teaching	Adapted - handouts Semi-authentic – translation dictionary
3	The techniques used for pronunciation teaching	Phonetic training – transcription, matching spelling and transcription Explicit learning – marking lexical stress Ear training – dictation Listening and repeating
4	The integration of the tasks	Not integrated, inconsistently integrated

Teacher Interview Analysis

The interview with the observed teacher provided valuable insights and enhanced understanding of the observational data, particularly regarding their approach to pronunciation teaching, choice of content, materials and techniques, as well as their self-reflection and attitudes toward this aspect of language instruction. The teacher stated that pronunciation practice is a regular part of their English language lessons, with an intensive focus during the first year of the bilingual program. In this initial period, an entire month is dedicated to pronunciation

instruction, during which students are introduced to the International Phonetic Alphabet (IPA), taught transcription skills, and guided in using dictionaries to access phonetic information. Beyond the first grade, the frequency of pronunciation teaching depends on the group's specific needs. For learners with strong pronunciation skills, the teacher addresses pronunciation less frequently, focusing primarily on areas requiring correction.

Regarding content, the teacher prioritizes error correction of challenging and unpredictable words (segmentals) and word stress, while also addressing suprasegmental features such as weak forms and linking, particularly when these are incorporated in the coursebook. To mediate this content, she claims to employ a mix of adapted and authentic materials. In addition to handouts targeting specific pronunciation features, which she has collected over the years, she regularly uses podcasts and videos to provide real-world input. Dictionaries play a central role in their instruction, serving as a key tool for helping learners independently access phonetic information. The teacher emphasized that the ultimate goal of their pronunciation teaching is to enable students to use dictionaries effectively, supporting their ability to improve pronunciation independently outside the classroom. While using dictionaries for autonomous learning is a good approach, bilingual/translation dictionaries are not always reliable for phonemic transcription. Therefore, monolingual dictionaries would be a better choice.

In terms of techniques, the teacher primarily relies on transcription as a form of phonetic training, complemented by explicit instruction targeting specific pronunciation features. She incorporates ear training activities, such as using podcasts and videos, to raise learners' awareness of pronunciation patterns. While she focuses on British English (Received Pronunciation) and American English (General American) as neutral models for production, she advises learners to remain consistent in their chosen pronunciation model. She also includes recordings of various accents like Scottish or Australian English when these are part of the coursebook, particularly for receptive tasks. However, she expressed the belief that exposure to other variants is unnecessary for the learners unless they plan to visit specific English-speaking regions where such accents are prevalent.

Reflecting on their approach to pronunciation teaching, the teacher described herself as confident and well-prepared, both linguistically and methodologically. She attributed their expertise to years of practical experience, during which she developed an understanding of learners' needs, rather than to university education or any other formal training. Although she considers their current approach effective, she acknowledged that further improvements could be made depending on teaching priorities. Overall, she affirmed that pronunciation teaching is a crucial aspect of language learning and should be included regularly in English language lessons.

Table 2. Data gathered by Individual Interview with the Observed Teacher

Individual interview with the observed teacher		
	Question categories	Codes
1	The extent of pronunciation teaching	Addressed regularly The extent depends on the needs More intensively in the first grade
2	The content of pronunciation teaching	Segmentals – difficult words, mispronounced words Suprasegmentals – lexical stress, aspects of connected speech
3	The materials used for pronunciation teaching	Adapted – handouts, coursebook Semi-authentic – translation dictionary Authentic materials – videos, podcasts
4	The techniques used for pronunciation teaching	Phonetic training – transcription Ear training Explicit learning
5	The pronunciation models	British English American English Other variants receptively, peripherally
6	The reflection on personal teaching pronunciation competences	Feels methodologically well-prepared Feels linguistically well-prepared Considers their pronunciation teaching sufficient
7	The attitude towards pronunciation teaching	Pronunciation should be taught regularly

Focus Group Interview Analysis

The learners confirmed that pronunciation instruction in English lessons is most intensively addressed in the first grade, with an introduction to transcription and dictionary use. Beyond this stage, pronunciation teaching occurs only occasionally, focusing on new or challenging words and correcting errors as needed. According to the focus group, materials used include handouts targeting specific pronunciation features, listening exercises from coursebooks, and, less frequently, podcasts or videos. These tasks are typically completed individually, such as by looking up explicit information about particular pronunciation patterns. Learners noted that the teacher frequently employs phonetic training, explicit learning, and ear training techniques.

The learners also described the usual procedure for pronunciation instruction, which involves the teacher writing a new or difficult word on the board, providing its transcription, and occasionally adding related explicit learning tasks. British and American English are emphasized as pronunciation models, with limited attention to other varieties. While most of the learners expressed little need to address other varieties of English, some expressed that exposure to these could enhance receptive skills, indicating interest in a broader understanding of English variants.

Reflecting on their experience with pronunciation instruction, learners generally did not see the need for activities focused solely on improving pronunciation, as they felt their current level of exposure was sufficient for developing strong

pronunciation skills. However, they valued the teacher's guidance in identifying and addressing problematic areas, which they considered helpful, albeit repetitive and monotonous.

Table 3. Data gathered by Focus Group Interview with the observed Group of Learners

Focus group interview with the observed group of learners		
	Question categories	Codes
1	The extent of pronunciation teaching	Addressed occasionally The extent depends on the needs More intensively in the first grade
2	The content of pronunciation teaching	Segmentals – difficult words, mispronounced words
3	The materials used for pronunciation teaching	Adapted – handouts, coursebook Semi-authentic – translation dictionary Authentic – videos, podcasts
4	The techniques used for pronunciation teaching	Phonetic training – transcription Explicit learning Ear training
5	The pronunciation models	British English American English Other variants receptively, peripherally
6	The attitudes towards pronunciation teaching	Pronunciation is taught sufficiently Pronunciation does not need to be taught

Discussion and Triangulation

This section provides a comprehensive understanding of the teacher's approach to pronunciation teaching by comparing data from lesson observations, an interview with the teacher, and a focus group interview with their students. It evaluates the strengths and limitations of the observed practices while addressing the research questions of this study.

Research question 1: *“How is English pronunciation taught in a selected English bilingual programme class?”*

The data consistently show that pronunciation teaching is present in the teacher's lessons, although its extent remains unclear. While the teacher claimed it is addressed regularly, students reported it occurs only occasionally. Both agreed that the first grade of the bilingual program receives the most intensive focus, beyond this stage, pronunciation teaching becomes sporadic and is tailored to learners' immediate needs. While this approach addresses specific challenges, it lacks the consistency necessary for systematic skill development across grade levels.

Regarding content, all data sources confirm the teacher's focus on segmental features, particularly error correction and challenging vocabulary. Suprasegmental aspects receive minimal attention, with lexical stress observed and connected speech mentioned by the teacher. Students noted a focus exclusively on segmental

elements related to unique or unpredictable vocabulary. However, as observed, this focus is largely restricted to relationship between spelling and pronunciation. Implemented primarily through transcription and written tasks, the teaching leans more toward orthographic awareness than communicative pronunciation skills, lacking emphasis on spoken output. By neglecting to integrate target features into meaningful contexts, the teacher misses opportunities to enhance learners' fluency and naturalness in speech. Additionally, it is important to note that neither segmental nor suprasegmental aspects arising from Slovak interference in the English were addressed, leaving a critical area of pronunciation teaching unaddressed.

The materials and techniques used for pronunciation teaching also showed significant limitations, particularly due to their decontextualized and repetitive nature. As confirmed by all three data sources, the materials—predominantly adapted handouts and bilingual/translation dictionaries—are heavily focused on phonetic training and explicit learning. While these materials help raise learners' awareness of targeted pronunciation features, their effectiveness is diminished by the lack of meaningful context for applying the learned content. We believe that the teacher's reliance on such decontextualized materials limits their ability to effectively integrate pronunciation tasks into the lesson flow. The observed pronunciation tasks often appeared disconnected or isolated from the broader objectives of the lesson, further reducing opportunities for practical application of the targeted features. Thus, although the materials' content was relevant, their lack of integration prevented sufficient elaboration. Although the teacher reported using authentic materials, such as videos and podcasts, which was confirmed in the focus group interview, these did not appear in the observed lessons. This suggests that their implementation might be limited and not specifically focused on pronunciation practice.

Similarly, the techniques employed, as confirmed by observations and both interviews, primarily include phonetic training, explicit learning, less frequently ear training, and listening and repeating. These techniques are heavily focused on representation of sounds and written language (e.g. practising transcription skills and using dictionaries) at the expense of active spoken production. Limited opportunities for actual pronunciation practice emerged in the observed lessons. Even when such opportunities arise (e.g. listening and repeating or plenary discussions of correct answers), they were isolated, repetitive, and lacked integration into meaningful contexts, which reduced their real-world communicative value. These techniques mainly develop receptive skills and raise their awareness of the pronunciation features but do not provide sufficient interactive practice for acquiring these skills.

As reported and criticized by the focus group, the repetitive nature of the techniques and procedures made the approach monotonous, predictable, and unilateral. Combined with the abstract nature of the tasks and the lack of engaging elements, this approach is unsustainable in the long term, even for the most motivated learners.

In discussing the pronunciation model used in the classroom, both the teacher and learners acknowledged a consistent focus on British English and American English, with limited attention to other varieties of English, primarily for receptive purposes when included in coursebook recordings. However, the teacher and some learners felt that exposure to other English accents was unnecessary, but some

focus group members expressed an interest in gaining a general understanding of various accents. While choosing neutral models like British Received Pronunciation and General American is reasonable for productive tasks, the view that exposure to various English accents is unnecessary is misguided. In today's globalized world, learners are likely to encounter various accents even without traveling to regions where specific varieties are spoken. Therefore, it is essential for learners to develop an awareness of global English variations (Crystal, 2009; Holden & Nobre, 2019) to effectively adapt and comprehend English in diverse linguistic contexts.

Research question 2: *"How does the chosen English language teacher perceive and integrate pronunciation teaching into their English language lessons?"*

Research question 3: *"How do students in an English bilingual programme perceive pronunciation teaching during their English language lessons?"*

The teacher and the learners reflected differently on the role and importance of pronunciation teaching. While the teacher emphasised its importance in equipping learners with skills to independently improve their pronunciation through dictionary use, students expressed little need for focused pronunciation activities, viewing their current exposure as sufficient. However, the teacher's indirect approach, prioritizing dictionary-based tasks over direct phonological development, lacks sufficient guidance and fails to provide immediate improvements in learners' pronunciation. Pronunciation teaching, to be fully effective, should combine awareness-raising with systematic practice, incorporate content relevant to learners' linguistic background (e.g. focusing on Slovak interference aspects), and promote active production in meaningful communicative contexts.

Despite expressing confidence in their pronunciation teaching, the teacher's reliance on experience and intuition over formal training revealed notable gaps in their methodological knowledge and critical reflection. Their limited focus, lack of integration, and repetitive approach restricted opportunities for learners to engage with pronunciation in a comprehensive and motivating way. Similarly, students' perception of the current instruction as sufficient reflects a limited understanding of the broader benefits of structured pronunciation teaching, likely due to the narrow range of techniques, activities, and content they have experienced. Evidence from university-level courses supports this interpretation, that students are often surprised by the extent of their pronunciation gaps when taking phonetics and phonology courses. Similarly, in the methodology of pronunciation course, student teachers are frequently surprised how many engaging activities can be incorporated into English language classes at all proficiency levels. These insights suggest that both teachers and learners would benefit from a broader methodological repertoire, the greater awareness of the importance of pronunciation, and more purposeful integration of engaging pronunciation activities into classroom practice. The triangulated data therefore indicate that while the teacher's approach addresses some immediate learner needs, its narrow scope, limited communicative context, and lack of engaging techniques and activities fail to support systematic and long-term pronunciation development.

Table 4. Strengths and Weaknesses of the Teacher's Pronunciation Instruction analysed by Data Triangulation

The summary of data triangulation			
	Category	Strengths	Weaknesses
1	The extent of pronunciation teaching	Foundational skills intensively addressed in the first grade	Sporadic, inconsistent, reactive approach beyond the first grade
2	The content of pronunciation teaching	Covered pronunciation features relevant to the target learner	Overemphasis on segmental features Decontextualized language items The conflation of pronunciation with orthography
3	The materials used for pronunciation teaching	Targeted pronunciation practice by adapted materials in combination with semi-authentic materials	The lack of authentic materials The lack of context The lack of interactivity
4	Integration of the activities	Past tense task successfully integrated	Pronunciation activities disconnected from lesson objectives No meaningful application
5	Techniques used for pronunciation teaching	Awareness-raising potential of the techniques	Focus on receptive skills No meaningful practice in spoken production Unilateral, repetitive use of techniques
6	Models used for pronunciation teaching	Emphasis on the consistent use of neutral models for production Peripheral attention to regional English varieties for receptive purposes	Awareness of regional varieties of English perceived as unnecessary
7	Reflection on teaching competences	The teacher pays attention to pronunciation, based on their experience	Over-reliance on experience rather than formal training Confidence in the approaches used The lack of critical reflection
8	Reflections on the Importance of Pronunciation Teaching	The teacher recognizes the importance of pronunciation teaching The learners do not recognize the importance of pronunciation teaching	Learners' acceptance of the teacher's approach The teacher's misunderstanding of the learners' needs

Conclusion, Limitations and Implications

This study has provided valuable insights and a deep understanding of the teacher's pronunciation teaching practices, their motivations, attitudes as well as

the learners' perspective on the subject matter. Despite these contributions, the findings cannot be generalised to broader contexts due to the small-scale, case study design. However, generalizability is not the primary aim of qualitative research. To ensure greater reliability and validity of data in this field, future research should involve a larger and more diverse sample (addressing multiple variables, such as different target learners, types of teaching programmes, or years of experience of the teachers), allowing for a more comprehensive exploration of pronunciation teaching across various settings. Nonetheless, despite its limited generalizability, several broadly applicable recommendations for pedagogical practice can be formulated based on the results of this case study:

- Pronunciation should be incorporated as a regular and systematic component of language learning across all grade levels rather than being limited to specific periods of learning or addressed only according to immediate needs. This approach ensures continuous skill development, helping learners build a strong phonological foundation.
- A variety of content should be included, with equal focus on segmental and suprasegmental features, ensuring learners' improvement in both areas, as these are equally crucial for intelligibility in speech. Additionally, it is essential to address pronunciation issues arising from language interference at both levels to help learners overcome potential difficulties.
- Adapted materials should be complemented with a broader range of multimodal and authentic resources, such as videos, podcasts, movies or recordings, to provide learners with exposure to natural language and create a more engaging and practical learning experience.
- Pronunciation practice should naturally emerge from the content of the lesson, aiming to provide a more comprehensive understanding of the subject matter, whether grammar, vocabulary, or other language skills. Selecting materials that align with the lesson's content and broader objectives facilitates the natural integration of pronunciation tasks. Easily adaptable, "universal" pronunciation teaching materials and techniques, including various pronunciation games, are well-suited for this purpose.
- Receptive and productive pronunciation teaching techniques should be combined in contextualized and communicative activities, such as tongue twisters, drills, pronunciation games, quizzes, role-plays, or analyses of authentic speech. These approaches encourage active practice in meaningful contexts, thereby enhancing the effectiveness and engagement of pronunciation teaching.
- Neutral, standardised and commonly used accents of English (such as Received Pronunciation or General American) are suitable models for production, whereas exposing learners to a wider range of English varieties for receptive purposes is essential to prepare them for communication in international contexts.
- Professional development opportunities for teachers are crucial to addressing gaps in methodological preparedness and equipping them with innovative, evidence-based strategies for effective pronunciation teaching.

- Teachers should focus on raising learners' awareness of the importance of accurate pronunciation for improving intelligibility by regularly integrating meaningful pronunciation tasks into their lessons.

This research aimed to highlight the importance of pronunciation teaching, identify its weaknesses, explore the underlying causes of these challenges, and propose areas for improvement along with potential solutions. Although the study focused on a teacher who demonstrated confidence in teaching pronunciation, the findings revealed that the instruction, while present, was unsystematic and lacked clear focus. These results are consistent with previous research studies (Scrivener, 2011; Gilbert, 2008; Murcia, Brinton & Goodwin, 2010; Vančová, 2020; Reid & Debnarova, 2023).

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