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Research Paper

Human Capital Profiling in Education: Teachers' Competence in Integrating AR Technology for Character Education Development

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Abstract

Teachers represent the core human capital within educational systems, serving as the pivotal agents in embedding character education into early childhood curricula framed by the principles of child-friendly schools. This study aims to identify teachers' competence following storytelling-based character education training and to examine their readiness to utilize Augmented Reality (AR) technology embedded in innovative storybooks as a medium for character formation among Early Childhood Education (ECE) students. Using a quantitative descriptive approach and cluster analysis, data were collected from ECE teachers who had completed training on storytelling and AR-based pedagogical practices. The descriptive findings reveal diverse levels of pedagogical knowledge, digital literacy, and creative implementation, while cluster analysis delineates teacher profiles based on readiness and competence dimensions. Grounded in Intellectual Capital Theory, this study conceptualizes teachers as strategic assets whose cognitive and relational capital underpin the effectiveness of educational innovation. Drawing on Experiential Learning Theory, the integration of AR storybooks is interpreted as a reflective and active learning process that enhances teachers' capability to design meaningful, technology-enhanced learning experiences. The study contributes to the literature on human capital development in education by offering managerial implications for differentiated professional learning strategies that foster innovation capability and sustain intellectual capital growth in ECE institutions.

Keywords: *Human Capital, Intellectual Capital Theory, Experiential Learning Theory, Augmented Reality, Character Education*

INTRODUCTION

Teachers constitute a fundamental element of the human capital within the education system (Aleandri & Refrigeri, 2014). In the context of early childhood education (ECE), the ability of teachers to integrate innovative technology into character education becomes increasingly important (Hatzigianni & Kalaitzidis, 2018; Undheim, 2022). From the perspective of Intellectual Capital Theory (Bontis, 1998; Iacoviello et al., 2019), teachers are conceptualized as dynamic assets whose human capital (competence, digital literacy, pedagogical creativity) and structural capital (school systems, interactive media) are crucial for driving educational innovation (Nerdrum & Erikson, 2001). In the field of emerging technologies, there is a growing scholarly focus on understanding how teacher proficiency in applying technology, such as Augmented Reality (AR), to character education can enhance school-level human capital (Zerrad & Schechter, 2025).

Empirical studies reveal ongoing challenges in early childhood education (ECE), underscoring the need to enhance teachers' human capital. Negative peer behaviors, including bullying, persist even in preschool contexts. For instance, research on children aged 3–5 indicated that approximately 50 % experienced peer negative acts (physical, verbal, relational) at least 2–3 times per month (Solberg et al., 2025), suggesting that existing character-education initiatives are not fully effective. Similarly, a review of early childhood bullying in Indonesia reported the presence of physical, verbal, and relational bullying, highlighting the importance of teachers fostering safe and supportive learning environments through structured character and values education (Fauzan & Sulaeman, 2024; Pratiwi et al., 2024). Concurrently, research on early

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childhood pre-service teachers found that while attitudes toward digital technologies were generally positive, their self-perceived digital competence (in the TPACK framework) was still developing (Merjovaara et al., 2024). Digital literacy remains moderate in Indonesia, with ICT adoption, such as AR, constrained by infrastructural limitations and teacher competencies (Sari et al., 2024). These findings indicate that the human capital embodied by ECE teachers is underutilized, particularly in leveraging technological tools to support character education.

Theoretically, several gaps remain in the literature regarding the integration of technology in early childhood education. Experiential Learning Theory (Kolb et al., 2014) posits that effective learning arises through a cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation. Applied to educational technology, this framework suggests that teachers' active engagement with digital tools, followed by reflection and adaptation, can enhance both their professional learning and students' learning outcomes (Burch et al., 2019; Colomer et al., 2020). However, empirical studies exploring how teachers translate these experiential processes into effective technology use are limited. Meanwhile, Intellectual Capital research underscores the value of teachers' intangible assets, such as knowledge, skills, and creativity (Bontis, 1998), in improving educational performance. Despite this, few studies have investigated how teachers' human and structural capital influence the successful integration of technology in early childhood settings (Daly et al., 2014; Yoon et al., 2017). Furthermore, research employing profiling or cluster-analysis methods to segment teachers by competence and technological readiness remains scarce.

To address these gaps, this study aims to (a) identify and profile ECE teachers' competence after a storytelling-based character-education training and (b) assess their readiness to utilise AR technology in role-play activities for early childhood children. By clarifying these objectives, the study seeks to support human capital development in ECE institutions and provide evidence to inform differentiated professional learning strategies. The research is guided by two specific questions: (1) To what extent are ECE teachers competent in integrating AR technology with character education within storytelling-based role-play activities? (2) What distinct clusters of teacher readiness and competence can be identified to inform differentiated human-resource development strategies in ECE institutions?

Theoretically, this study advances Human Capital Development and Experiential Learning Theory by illustrating how teachers' knowledge, skills, and experiential learning through AR-based role-play enhance their capacity to adopt innovative pedagogical practices. In practice, the identified readiness–competence clusters provide a basis for differentiated ECE teacher development and targeted human resource development strategies to support the effective integration of storytelling-based character education with AR technology in ECE institutions.

LITERATURE REVIEW

Intellectual Capital Theory

The concept of intellectual capital has increasingly become central to organisational studies, representing intangible assets that contribute to value creation and competitive advantage. Intellectual capital is frequently partitioned into three interrelated components: human capital (knowledge, skills, experience of individuals), structural capital (systems, processes, technologies, organisational routines), and social capital (networks, relationships, trust within and between organisations) (Bontis, 1998; Iacoviello et al., 2019). Within educational settings, the focus often turns to human capital insofar as teachers bring essential knowledge, pedagogical competence, and digital readiness to bear on institutional quality (Yadav, 2023). For example, empirical work indicates a strong positive relationship between teachers' intellectual capital and their professional development in higher education contexts, pointing to the strategic role of human capital in

knowledge-based organisations. In the school context, therefore, teachers represent central human-capital assets whose competence, innovation orientation, and adaptation to technology become critical for educational institutions striving to improve quality, relevance, and responsiveness (Hamed et al., 2024; Mubarik et al., 2022). Structural capital supports their efforts by providing media, infrastructure, and systems; social capital emerges in the collaborative networks among teachers, mentors, and educational stakeholders (Penuel et al., 2009). Thus, when investigating teacher readiness in applying advanced pedagogical tools such as Augmented Reality (AR), it is pertinent to view such capability within the broader frame of intellectual capital: teacher competence as human capital, digital learning media as structural capital, and collaborative networks (teacher communities of practice) as social capital.

Experiential Learning Theory

Experiential Learning Theory (ELT) posits that learning is a process whereby knowledge is created through the transformation of experience via a four-stage cycle: (1) concrete experience, (2) reflective observation, (3) abstract conceptualization, and (4) active experimentation (Kolb et al., 2014). In contemporary educational environments, immersive and interactive technologies such as Augmented Reality (AR) present rich opportunities to enact this cycle. AR provides learners and teachers with concrete, situated experiences that afford reflection, concept formation, and experimentation in authentic or scenario-based contexts (Crogman et al., 2025). Studies examining AR's role in experiential learning contexts demonstrate that AR can reduce cognitive load, offer real-time interactive visualization, and deepen engagement and retention of learning (Chen, 2025; Man et al., 2025). In primary and elementary settings, research indicates that AR-based simulations and activities enhance cultural understanding through experiential frameworks. For example, simulated AR tasks serve as mediators between learning activities and outcomes in cultural education (Ahdhianto et al., 2025). From a teacher-competence perspective, when teachers utilise AR tools in their pedagogical practice, they engage in experiential learning themselves. They undergo training (concrete experience), reflect on how to adopt and adapt the tools (reflective observation), conceptualise how AR aligns with character education (abstract conceptualization), and then enact AR storybooks or role-play activities with children (active experimentation). ELT thus provides a meaningful theoretical lens for examining how teacher training with AR supports competence development in early childhood character education.

Character Education for Early Childhood Education (ECE)

Character education in early childhood is increasingly recognised as foundational for moral, social-emotional, and behavioural outcomes of young learners (Elias et al., 2008; Roseth, 2015). In ECE settings, the objective is to embed values such as responsibility, empathy, cooperation, and respect into pedagogical practices and the physical learning environment (Bufalino, 2025; Melasalmi et al., 2022). Many jurisdictions now emphasise child-friendly school principles, which integrate inclusive, safe, participatory, and value-based learning (Godfrey et al., 2012; Nordtveit, 2016). Within this paradigm, teachers serve as culture-builders and role models, and curricula are expected to embed character-building activities, storytelling, role-play, and positive peer interaction.

BINOA Storybooks with Augmented Reality: A Technological Innovation in Character Education

A relatively recent innovation within early childhood character education is the deployment of interactive storybooks enhanced with AR (Nezhyva et al., 2021; Wang, 2022). One such example is the BINOA storybook series, published under an ISBN and comprising 22 narrative stories

(Hermawan et al., 2022, 2024). Each story includes a page marked with an AR logo. When scanned, the reader (teacher or student) triggers a 3D animation, video, or sound effect. Furthermore, the series features 17 developed characters that can be interacted with via the AR app, thereby expanding the traditional storytelling medium into an immersive, interactive experience.

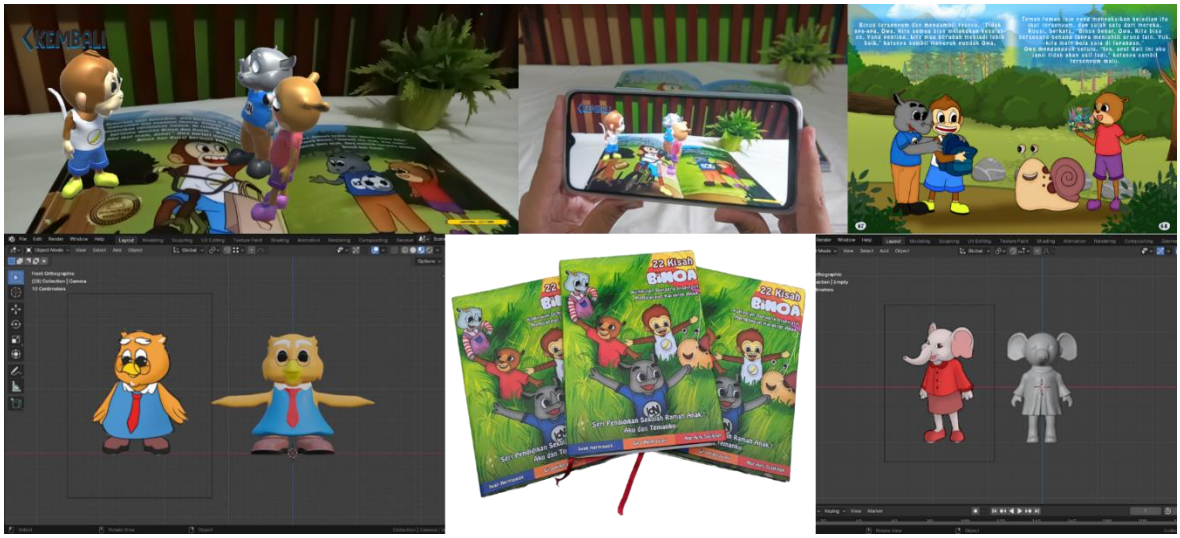

Figure 1. BINOA Storytelling Book Embedded with Augmented Reality

Based on the theoretical and empirical literature suggesting that teachers differ in both pedagogical competence and technological readiness, this study proposes an initial exploratory hypothesis that Early Childhood Education (ECE) teachers who have participated in storytelling-based character-education training will form distinct clusters according to their competence in integrating character education with AR technology and their readiness to utilise AR technology in role-play activities for children. These clusters are expected to reflect meaningful variation in professional capacity, which can inform differentiated human resource development strategies to support ECE institutions.

RESEARCH METHOD

Research Design

This study adopts a robust methodological framework grounded in the Research Onion model (Saunders et al., 1970), which guides the layering of research philosophy, approach, strategy, methods, time-horizon, and techniques. Consistent with the requirements of practical relevance and applied outcomes in educational human resource development, the philosophy of pragmatism is adopted. Pragmatism emphasises choosing methods and paradigms that best address the research question rather than strict allegiance to a single traditional ontology or epistemology (Saunders et al., 1970). From this philosophical position, the research adopts a deductive approach: theoretical constructs drawn from frameworks such as Intellectual Capital Theory (Bontis, 1998) and Experiential Learning Theory (Kolb et al., 2014) are translated into measurable teacher-competence, readiness, and innovation constructs, which are then empirically tested through a training intervention and subsequent measurement. An experimental strategy is implemented, such as teachers receiving a training intervention (storytelling-based character education and AR technology orientation), focusing on a post-training cross-sectional evaluation design, which measures the level of competence and readiness to use AR in character education practice. The post-test serves to evaluate the effectiveness of the training intervention and profile teacher competencies. A multimethod (quantitative) design is used as follows: descriptive statistics

employing the three-box method and cluster analysis to segment teachers' readiness (James & Sugar, 2003). The time horizon of this research is cross-sectional, where data are collected at a single point in time following the intervention.

Participants

The sample comprises 20 teachers from 11 distinct Early Childhood Education (ECE) institutions in Semarang, Central Java, Indonesia. Semarang was selected because it is a mid-sized urban centre with a mix of public and private ECE settings, reflecting the educational dynamics of Central Java. Participants were selected purposively as follows: only teachers who had attended the designated training intervention were included to ensure comparable training exposure. The diversity across 11 different ECE institutions also allows for variation in institutional settings, contributing to the generalisability of the profiling results. Although limited in size, the inclusion of teachers from multiple ECE institutions provided contextual variation that supported exploratory profiling of teacher competence and readiness rather than statistical generalization.

Procedures

The study procedure followed four main phases: (1) Training Intervention: All participating teachers attended a training session consisting of storytelling for character education and instruction on using AR-enhanced storybooks in role-play scenarios with children. (2) Questionnaire Administration: Following the training, teachers completed a structured questionnaire designed to measure three dimensions: (a) pedagogical competence in character-education storytelling, and (b) digital readiness and competence in using AR technology, which was embedded in the storyteller book. All items were formulated as self-report statements reflecting teachers' understanding, experience, and perceived capability in relation to character education and instructional innovation. The first section is concern about Human Capital construct which consisted of seven items capturing teachers' cognitive understanding and professional awareness of character education, including comprehension of character education materials, implementation strategies, practical application in daily activities, and awareness of the school's role and responsibility in fostering students' character (Hermawan et al., 2020; Suri & Chandra, 2021). The second section is about the Storytelling Competence construct, which includes three items focusing on teachers' experiential aspects, such as experience in designing storytelling scenarios, creating character-focused narratives, and utilising online reading resources to support storytelling development (Rahiem, 2021; Saputri, 2024). The last section is about the AR Technology Readiness construct, which comprises three items assessing teachers' prior exposure and readiness to integrate digital tools into storytelling activities, including experience in designing AR-supported storytelling scenarios, developing digital story content, and using online resources to support AR-based instructional practices (Chen, 2025; Crogman et al., 2025). All items were measured using a Likert-type scale (1-10).

Next, responses were converted into percentage-based index scores to facilitate descriptive comparison across items and constructs by using (3) Three-box method: descriptive analysis to identify the perception of teachers based on the training experience (Ferdinand, 2006). (3) Cluster Analysis: The data were subjected to cluster analysis (e.g., k-means clustering) to identify distinct groups of teachers based on their competence and readiness scores (Hair et al., 2014). These clusters are then interpreted to inform differentiated professional development strategies.

Data Analysis

Data analysis proceeded in two major stages. Firstly, descriptive statistics using the three-box method (Ferdinand, 2006) were computed to identify the teacher competence and readiness

in implementing AR technology. Secondly, a cluster analysis (James & Sugar, 2003) was conducted to segment teachers into distinct profiles based on their composite scores. This clustering enables the identification of groups with differing levels of competence and readiness. Assumptions for clustering, including multicollinearity and ANOVA, were carefully checked to ensure the validity of the segmentation. In addition, artificial intelligence–based tools were used solely to enhance visual presentation and clarity of communication. All conceptualisation, research design, analytical decisions, and interpretation of findings were entirely developed and controlled by the authors.

Figure 2 presents the research framework outlining the sequential phases of the study, encompassing research design and philosophical grounding, data collection through a training intervention and post-training survey, and data analysis using descriptive and cluster-based approaches to generate teacher competence and readiness profiles.

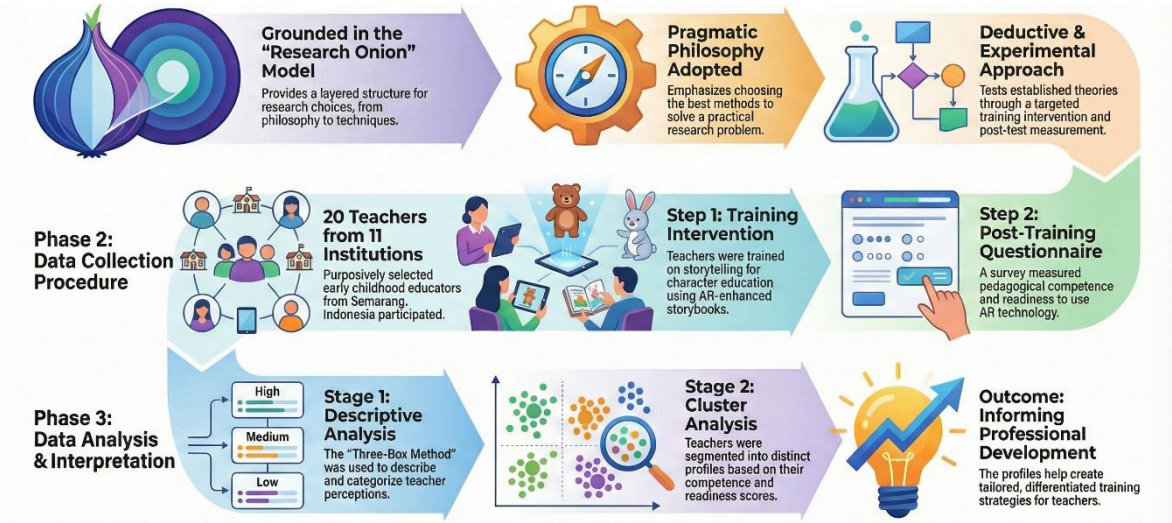

Figure 2. Research Framework

FINDINGS AND DISCUSSION

Three-box method Result and Analysis

These results show that, among the 20 ECE teachers from 11 institutions in Semarang, Indonesia, the highest proficiencies are in knowledge and comprehension of character-education materials (89.0%, 87.0%). Slightly lower but still high are their self-reported understanding of implementation (84.0%) and ability to practice such education in daily activities (84.0%). In contrast, awareness items related to the school's institutional responsibility (72.0% and 65.5%) are notably lower. The high scores in knowledge/comprehension of character-education materials (89.0% and 87.0%) indicate a strong human-capital base in terms of cognitive mastery of content. This suggests that the training intervention succeeded in equipping teachers with explicit knowledge and comprehension of character-education frameworks. From a human-capital investment perspective (e.g., considering training as an investment in teacher capabilities), this is a positive result – see Figure 3 (Becker, 1975; Hamed et al., 2024).

However, while the items measuring knowledge and comprehension are high, the awareness items, specifically the scores of 72.0 % and 65.5 % (awareness that developing virtuous character is the school's responsibility; awareness of the school's role in building virtuous character), exhibit a divergence. The 72.0 % score still lies in the High band but toward its lower boundary; the 65.5 % score falls just under the High threshold (and hence in the medium band according to the defined categorisation). This indicates a gap in translating individual competence into an institutional or systemic mindset. In human-capital terms, the teachers' individual capabilities (knowledge,

comprehension, application) are high, but the embeddedness of those capabilities within the organisational mission (i.e., structural and relational capital) may be weaker (Shafiee et al., 2024). According to the broader articulation of intellectual capital theory, human capital, on its own, is valuable, but its full effectiveness depends on how well it is supported, leveraged, and embedded through structural processes, organisational systems, and social networks (i.e., structural and relational capital).

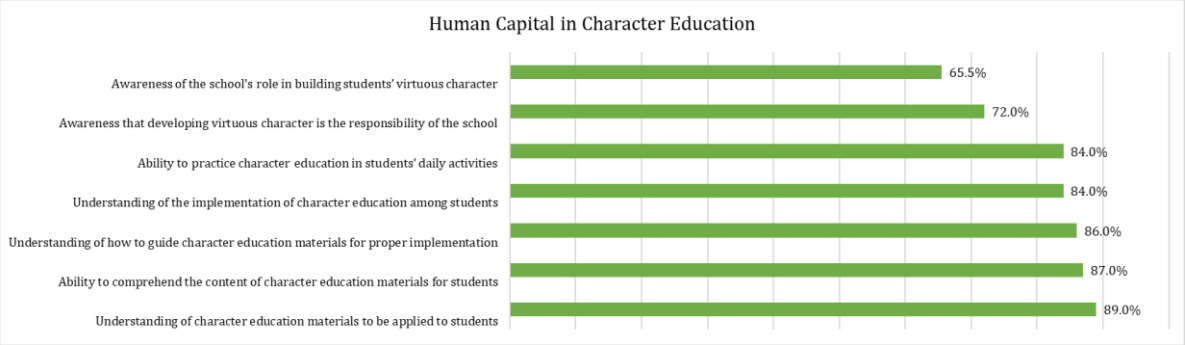

Figure 3. Human Capital in Character Education

The score for "ability to practise character-education in students' daily activities" stands at 84.0 %, which is again within the High category (≥ 66.67 %). This reflects that teachers are not only mastering the content cognitively but are actively applying it in everyday classroom settings, a strong indicator of human-capital activation (i.e., knowledge converted into performance). In human-capital research, it is often argued that training and skill-development lead to improved practice and productivity—here, the high application score aligns with that notion. Yet the gap between comprehension (86–89%) and awareness of institutional role (65.5%) highlights a potential misalignment: teachers may see themselves as competent practitioners but may not fully view their role or the school's role in a broader strategic or systemic sense. From a human-capital management viewpoint, this implies that further investment is needed not only in enhancing individual teacher capability (which appears to be strong) but also in aligning their mindset with the institutional mission, culture, and structural support (i.e., strengthening structural and relational capital). Only when all components of intellectual capital are aligned can the institution maximise the value derived from its human-capital assets (Pedrini, 2007; Zhou & Fink, 2003).

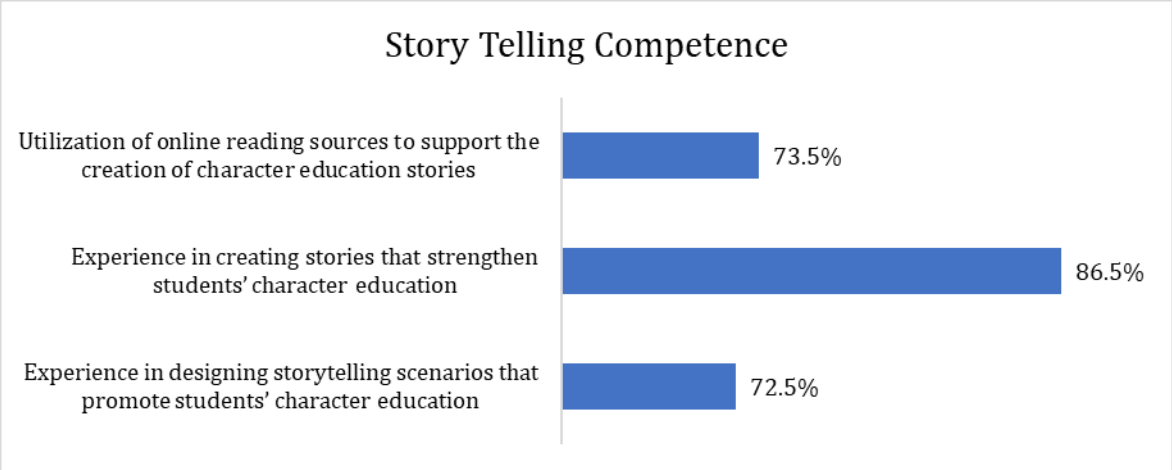

Figure 4. Storytelling Competence

Figure 4 shows that participating teachers reported a 72.5% level of experience in designing storytelling scenarios to promote students' character education. This score falls into the High category. This suggests that a majority of teachers are actively engaged in creating structured storytelling frameworks, indicating substantial capacity in pedagogical design (Davis et al., 2011; Kearney, 2013). From a human-capital perspective, it indicates that teachers have moved beyond mere content delivery to scenario-planning, indicative of a mature competency in harnessing narrative methodology for character formation (Ahmad, 2020).

In relation to the next metric, experience in creating stories that strengthen students' character education, the score of 86.5% is clearly within the High range and is the highest among the three items. This indicates that teachers not only design scenarios but also feel confident in crafting full narrative stories tailored for character education (Butcher, 2006; Skouge & Rao, 2009). This level of creative competence is important because it points to autonomy and innovation in content development. In human-capital terms, it signals that the investment in teacher training has yielded professionals capable of producing original materials, thereby enhancing the institution's intellectual asset base.

Thirdly, the utilisation of online reading sources to support the creation of character-education stories scored 73.5%, again in the High category. This result illustrates that teachers are leveraging digital and online resources to underpin their storytelling practices. From a human-capital lens, it suggests that teachers possess not only storytelling skills but also information-seeking behaviour, digital literacy, and resourcefulness, which are increasingly essential in contemporary educational settings.

Finally, although the scores are high and indicative of strong teacher capability, the fact that scenario design and resource utilisation scores are somewhat lower than story creation suggests that continuous professional development should focus not only on story-writing but also on the upstream and downstream parts of the process, scenario planning, digital-resource discovery, story-integration into daily practice and peer sharing. This ensures that the human capital is fully leveraged, optimally aligned with institutional goals, and sustainably utilised.

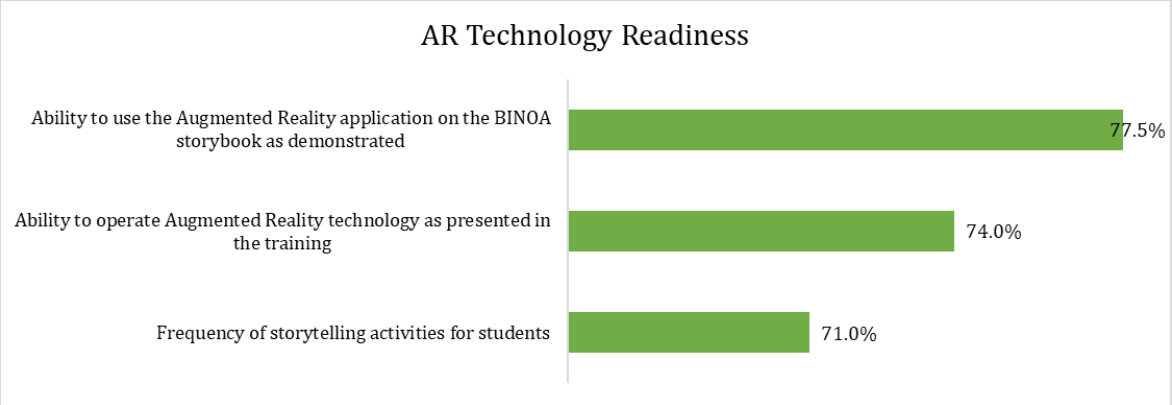

Figure 5. AR Technology Readiness

Figure 5 shows that teachers reported a frequency score of 71.0% for storytelling activities with students. This falls into the High category. This indicates that the majority of teachers are engaging fairly frequently in storytelling as part of their early childhood education practice. Given the established benefits of storytelling, such as supporting language development, cognitive skills, imagination, and value formation in young children. This is a positive sign for character-education efforts in ECE settings. From the perspective of ELT, these high scores reflect teachers' progression through this cycle (Kolb et al., 2014). For instance, the high frequency of storytelling corresponds

to concrete experience, while their ability to operate and apply AR technology corresponds to both active experimentation and the integration of new pedagogical concepts. Nevertheless, while the scores indicate strong practice and capability, the variation among them points to an evolving phase of the experiential learning cycle, specifically, the shift from abstract conceptualisation and experimentation into habitual routine practice. The fact that storytelling frequency lags slightly behind technological competency may indicate that teachers are comfortable with the tools but are still consolidating how to integrate storytelling and AR seamlessly into everyday teaching. In ELT terms, this suggests that the cycle is active but not yet fully mature; additional support for reflection and experimentation, such as peer debriefs, collaborative story development with AR, and documentation of outcomes, could strengthen the transition into sustained, embedded practice.

Moreover, teachers reported scores of 74.0% for their ability to operate Augmented Reality (AR) technology as presented in the training, and 77.5% for their ability to use the AR application on the storybook (the "BINOA" storybook). Both of these also fall into the High band. These results suggest that after the training intervention, teachers felt sufficiently capable (Richards et al., 2007) to handle the AR tools and integrate them into their practice. This is consistent with findings in the literature: for example, studies of AR storybooks show that teacher readiness and positive perceptions of AR correlate with adoption and enhanced student engagement.

Together, these three metrics (storytelling frequency, ability to operate AR technology, and ability to use the AR storybook application) paint a promising picture. Teachers are not only telling stories frequently but are also technologically prepared and able to apply innovative media (AR) in their practice. From a human-capital viewpoint, this implies that teacher competencies are being activated: frequency indicates practice, technological ability indicates readiness and capability, and actual use of AR applications indicates translation of training into classroom behaviour.

Cluster Analysis

Assumptions

The multicollinearity diagnostics indicate that each predictor maintains adequate independence, reducing the risk of biased estimates caused by overlap between variables (Hair et al., 2014). Specifically, all Tolerance values exceed 0.1 and all VIF values fall within the acceptable range of 0.2–10, confirming that none of the predictors are highly correlated (Menard, 1995; Schroeder et al., 1990). The highest VIF (3.915 for "Experience in creating story scenarios") is still well below the upper limit of 10, suggesting that this variable retains unique explanatory power. Therefore, these variables are suitable for inclusion in the cluster analysis.

Table 1. Multicollinearity Test

Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.265	1.640		1.381	.188		
	School awareness of character building	.959	.280	.912	3.430	.004	.315	3.177
	Experience in creating story scenarios	.005	.372	.004	.014	.989	.255	3.915
	Access to online reading resources	-.004	.219	-.004	-.020	.984	.604	1.656

AR application skills	-.175	.180	-.186	-.972	.346	.607	1.648

a. Dependent Variable: Awareness of school's responsibility for character building

Hierarchical Cluster Analysis

The dendrogram (*See Figure 6*) generated using an average-linkage (between groups) method displays the hierarchical fusion of the 20 teacher cases by rescaled distance of cluster combination (Hair et al., 2014). The horizontal axis captures the degree of dissimilarity (rescaled distance) at which clusters are merged and the vertical axis lists the individual cases. Notably, the longest horizontal branch appears when case 20 merges with the remainder of the sample, indicating that this case is substantially distinct compared to the other 19 cases (i.e., a large dissimilarity threshold precedes its combination). At shorter distances many cases cluster together early, most of the sample forms a fused cluster well before the final merging steps.

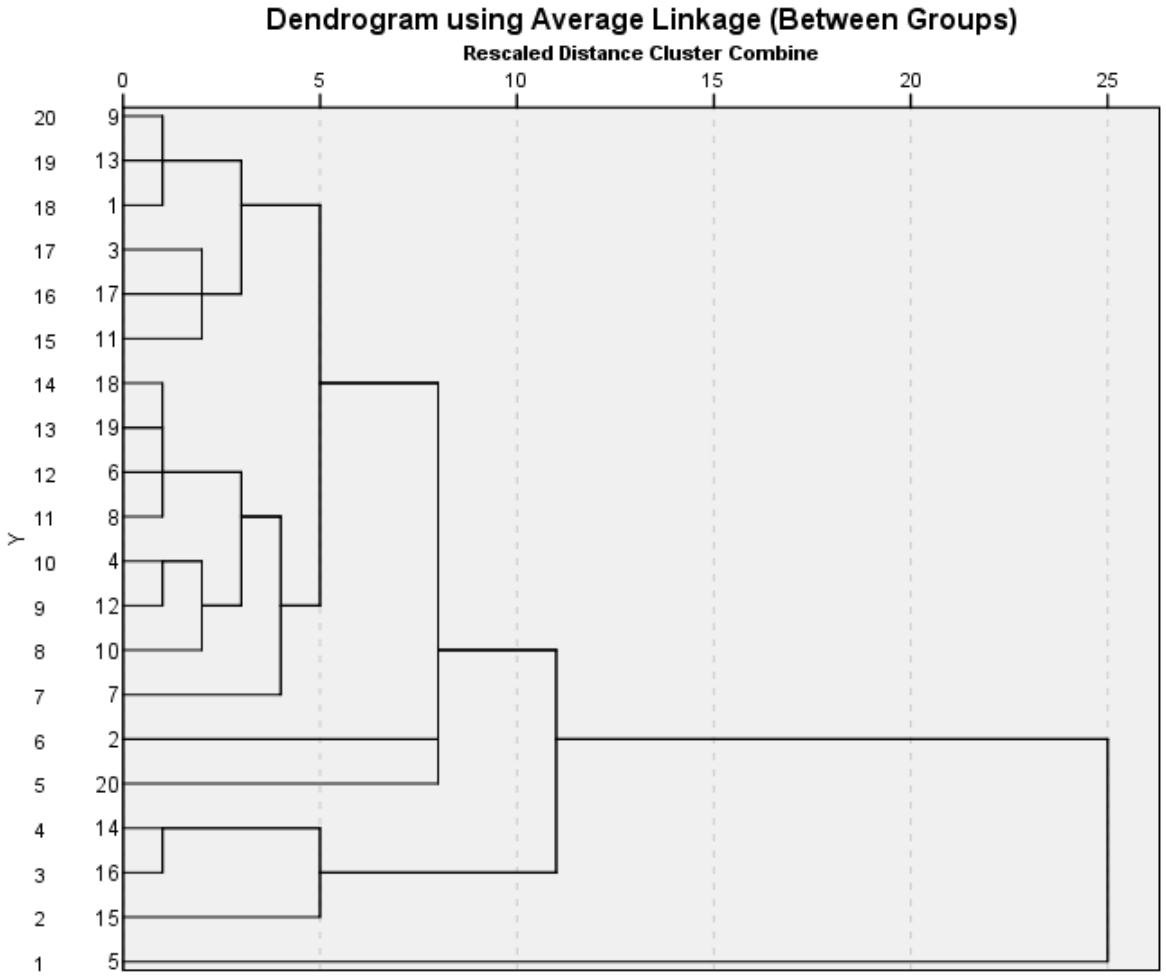

Figure 6. Dendogram Result

This pattern is consistent with the cluster-membership table: in the 4-cluster solution, case 20 stands alone in Cluster 4, while the bulk of other cases merge into Cluster 1 or the smaller clusters (e.g., cases 14-16 forming Cluster 3, case 5 in Cluster 2). The dendrogram thus visually validates the decision to adopt a four-cluster solution: a meaningful "gap" in distance before merging suggests the existence of at least one distinct subgroup.

Table 2. Cluster Membership from Hierarchical Cluster Analysis

Cluster Membership			
Case	4 Clusters	3 Clusters	2 Clusters
1	1	1	1
2	1	1	1
3	1	1	1
4	1	1	1
5	2	2	2
6	1	1	1
7	1	1	1
8	1	1	1
9	1	1	1
10	1	1	1
11	1	1	1
12	1	1	1
13	1	1	1
14	3	3	1
15	3	3	1
16	3	3	1
17	1	1	1
18	1	1	1
19	1	1	1
20	4	1	1

K-Means Cluster Analysis

The cluster-membership analysis revealed distinct patterns in the sample's distribution, highlighting both homogeneity and heterogeneity among respondents (Hair et al., 2014). Cluster 3 emerged as the largest group, encompassing ten cases (1, 4, 6, 7, 8, 9, 11, 13, 17, 18) with inter-case distances ranging from 1.037 to 3.883. This indicates a relatively coherent subgroup sharing key characteristics, although some internal variation suggests the presence of subtle differences among members. Clusters 1 (cases 10, 14, 15, 16) and 2 (cases 2, 3, 12, 20) displayed broader distance ranges, pointing to greater heterogeneity within these clusters. In contrast, Cluster 4, consisting solely of case 5 with a distance of 0.000, reflects a unique profile that is markedly distinct from the other cases, signaling either a singular characteristic or potential outlier within the dataset.

Table 3. Cluster Membership in K-Means Cluster Analysis

Cluster Membership		
Case Number	Cluster	Distance
1	3	2.041
2	2	3.929
3	2	2.727
4	3	2.390
5	4	.000
6	3	3.102
7	3	3.883
8	3	1.037
9	3	2.625

Cluster Membership		
Case Number	Cluster	Distance
10	1	2.773
11	3	3.160
12	2	3.455
13	3	2.625
14	1	2.586
15	1	3.631
16	1	2.165
17	3	3.160
18	3	2.465
19	3	2.170
20	2	4.521

Validation

The ANOVA results provide a descriptive overview of the differences among clusters across several key variables (Hair et al., 2014; Sekaran & Bougie, 2016). Notably, mean-square values indicate substantial variation among clusters in terms of awareness of the school's responsibility for character building ($F = 8.128$, $p = .003$), school awareness of character building ($F = 25.755$, $p < .001$), experience in creating story scenarios ($F = 11.417$, $p = .001$), access to online reading resources ($F = 4.001$, $p = .038$), and AR application skills ($F = 10.644$, $p = .001$). These values suggest that the clusters differ meaningfully on these dimensions, reflecting the characteristics used to define the groups.

Table 4. ANOVA Test

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
Awareness of school's responsibility for character building	26.200	2	3.224	17	8.128	.003
School awareness of character building	36.446	2	1.415	17	25.755	.000
Experience in creating story scenarios	19.418	2	1.701	17	11.417	.001
Access to online reading resources	13.211	2	3.302	17	4.001	.038
AR application skills	33.846	2	3.180	17	10.644	.001

A K-Means cluster analysis was performed to classify educators based on five key indicators: awareness of the school's responsibility for character building, overall school awareness of character education, experience in creating story scenarios, access to online reading resources, and AR application skills. A four-cluster solution was selected for its interpretability and theoretical relevance. The final cluster centers reveal clear distinctions among the groups. **Cluster 1** shows moderate scores across all indicators (4.25–6.25), representing teachers with balanced but

developing engagement in character education and moderate familiarity with technology. **Cluster 2** displays consistently high awareness and experience (6.25–9.25), with balanced competencies in AR use and storytelling design, reflecting proactive educators who actively integrate both pedagogical and digital strategies in character-building activities. **Cluster 3** records the highest scores in AR application (9.45) and scenario creation (8.18), identifying a group of technologically adept teachers who demonstrate advanced instructional design and a strong understanding of character education principles. In contrast, **Cluster 4** exhibits very low levels of awareness and AR proficiency (1.00–4.00), despite the highest access to online resources (9.00). This pattern suggests a group of educators who, while digitally connected, remain minimally engaged in the pedagogical aspects of character education.

Table 5. Final Cluster Centers

	Cluster			
	1	**2**	**3**	**4**
Awareness of school's responsibility for character building	5.75	9.25	7.55	1.00
School awareness of character building	4.25	8.00	7.36	1.00
Experience in creating story scenarios	5.00	7.75	8.18	4.00
Access to online reading resources	5.00	6.50	8.36	9.00
AR application skills	6.25	6.25	9.45	1.00

Cluster 1: Moderate Engagers

Teachers in Cluster 1 demonstrate moderate human capital development: their awareness of the school's responsibility for character building is 5.75, school awareness 4.25, experience in creating story scenarios 5.00, access to online reading resources 5.00, and AR application skills 6.25. According to Experiential Learning Theory, these teachers are likely at the stage of concrete experience and reflective observation but have not yet fully engaged in active experimentation with AR technology. Development strategies should focus on structured training that integrates awareness enhancement, scenario design practice, and AR skill-building. From an institutional perspective, strengthening structural capital via school-wide character education frameworks and providing dedicated time for AR experimentation can improve their readiness and confidence.

Cluster 2: Active Advocates

Teachers in Cluster 2 exhibit high awareness and school awareness (9.25 and 8.00, respectively), strong experience in creating story scenarios (7.75), but moderate access to online reading resources (6.50) and AR skills (6.25), reflecting strong human capital with emerging practical engagement. In terms of Experiential Learning, they are actively reflecting on experiences and experimenting, yet there is room to formalize and scale their practices. Recommendations include positioning these teachers as mentors within professional learning communities, encouraging peer knowledge-sharing, and providing institutional recognition or support (e.g., innovation grants) to reinforce structural capital and consolidate their leadership in character education initiatives.

Cluster 3: Tech-Savvy Champions

Cluster 3 teachers are distinguished by high AR application skills (9.45), strong storytelling experience (8.18), substantial awareness (7.55), school awareness (7.36), and access to online reading resources (8.36), representing advanced human capital. They engage in active experimentation and abstract conceptualisation in line with ELT (Kolb et al., 2014), effectively generating new knowledge and learning cycles. These educators are ideal change agents for leading pilot programs, designing knowledge repositories, and disseminating innovations across the school or district. Human capital development for this group should focus on advanced pedagogical technology, leadership training, action research, and formal knowledge management systems to maximize their impact (Aleandri & Refrigeri, 2014; Kucharčíková et al., 2018).

Cluster 4: Minimal Engagers

Teachers in Cluster 4 show low awareness and school awareness (1.00 each), limited storytelling experience (4.00), very low AR skills (1.00), but high access to online reading resources (9.00). This indicates that while relational capital (access) is present, human and structural capital are lacking. According to Experiential Learning Theory (Kolb et al., 2014), they need guided concrete experiences and structured reflective observation to progress toward experimentation. Development strategies should start with foundational awareness interventions (workshops on character education roles), simple scenario design exercises, introductory AR tasks, and mentor-buddy systems. Institutional support is crucial: school leadership should signal the importance of character education and allocate sufficient time, resources, and structural guidance.

The present findings clearly address both research questions. Regarding the first research question, which examined the level of ECE teachers' competence in integrating storytelling-based character education with AR technology, the results indicate that teachers generally demonstrate strong competence in understanding and applying character education materials, well-developed storytelling skills, and a moderate level of readiness to adopt AR in role-play activities. Addressing the second research question, the cluster analysis revealed four distinct profiles of teacher readiness and competence: Moderate Engagers, Active Advocates, Tech-Savvy Champions, and Minimal Engagers. Each characteristic differs in the levels of school responsibility awareness, institutional character awareness, storytelling scenario experience, online resource access, and AR application skills. Teachers in the higher-readiness clusters exhibited stronger institutional and professional awareness, coupled with more extensive storytelling experience and greater proficiency in applying AR tools. In contrast, lower-readiness clusters were characterised by limited awareness of the school's role in character development and weaker practical experience in scenario design and AR application, despite in some cases having access to online resources. These differentiating dimensions underscore that access to digital resources alone is insufficient, and that institutional awareness and pedagogical experience are critical in shaping teachers' readiness to integrate AR-supported storytelling for character education.

CONCLUSIONS

This study successfully achieved its objectives by profiling the competence of early childhood education (ECE) teachers following storytelling-based character-education training and by examining their readiness to utilise augmented reality (AR) technology in role-play activities. The findings reveal that, overall, teachers exhibit strong competence in understanding and applying character education materials, solid storytelling skills, and moderate readiness to integrate AR technology into their practice. Importantly, the analysis identified four distinct clusters of teacher profiles: Cluster 1 (Moderate Engagers), Cluster 2 (Active Advocates), Cluster 3 (Tech-Savvy Champions), and Cluster 4 (Minimal Engagers). Teachers in Cluster 3 consistently demonstrated

the highest levels of competence across awareness, storytelling experience, AR application skills, and access to digital resources, whereas Cluster 4 reflected minimal engagement and low human and structural capital, despite high access to online resources. These findings provide a nuanced understanding of teacher competencies, highlighting both strengths and gaps in integrating AR technology and character-education practices.

The implications of these findings are both theoretical and managerial. From a theoretical standpoint, the study contributes to Human Capital Development by demonstrating how teacher knowledge, skills, and experiential learning opportunities influence their capacity to adopt innovative pedagogical approaches. It also reinforces Experiential Learning Theory, showing how AR-based role-play facilitates learning cycles encompassing concrete experience, reflective observation, and active experimentation. From a managerial perspective, the distinct cluster profiles offer actionable guidance for differentiated professional learning strategies: Moderate Engagers (Cluster 1) benefit from structured training programs and institutional support to enhance both competence and confidence. It is recommended to implement short-cycle, hands-on workshops focused on structured storytelling templates and guided AR demonstrations, accompanied by regular coaching sessions to strengthen confidence and classroom application; Active Advocates (Cluster 2) are well-positioned to serve as mentors within professional learning communities, tasked with leading monthly sharing sessions, co-developing storytelling resources, and supporting colleagues during early implementation phases.; Tech-Savvy Champions (Cluster 3) can lead pilot projects, develop knowledge repositories (e.g., story banks, AR use guides), and drive innovation dissemination; and Minimal Engagers (Cluster 4) require step-by-step foundational interventions supported by institutional leadership, including awareness on the role of character education, basic storytelling exercises, and scaffolded AR exposure supported by clear operational guidelines. Collectively, these insights enable targeted human-resource development within ECE institutions, supporting teacher readiness and the effective integration of storytelling-based character education with AR technology.

LIMITATION & FURTHER RESEARCH

This study has several limitations that should be considered when interpreting the findings. First, the sample was limited to teachers who participated in a specific storytelling-based character-education training, which may affect the generalizability of the results to other ECE contexts or populations. Second, the study relied primarily on self-reported measures of competence and AR readiness, which may introduce response bias and may not fully capture actual classroom practices. Third, the cross-sectional design provides a snapshot of teacher competence and readiness but does not allow for assessment of changes over time or the long-term impact of training interventions.

Future research could address these limitations by employing longitudinal designs to track changes in teacher competence and AR integration over time. Expanding the sample to include diverse ECE institutions across different regions would enhance generalizability. Additionally, incorporating classroom observations or performance-based assessments could provide a more objective measure of teachers' application of character education and AR technology. Further studies might also explore the impact of targeted interventions designed for specific cluster profiles, assessing how differentiated professional learning strategies influence human capital development and student outcomes in character education programs.

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