

# Reciprocal Associations of Positive Youth Development and AI Literacy: Longitudinal Evidence from Filipino Adolescents

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## Abstract

Amid growing concerns regarding adolescents' readiness to navigate rapidly emerging technologies, scholars have highlighted the need to understand how digital competencies intersect with core developmental assets. Beyond technical skills, non-cognitive psychosocial resources may play a critical role in cultivating artificial intelligence (AI) literacy. Guided by the Positive Youth Development (PYD) framework, this study examined reciprocal longitudinal associations between the 5Cs of PYD (competence, confidence, connection, character, and compassion) and AI literacy dimensions (awareness, usage, evaluation, and ethics). Two waves of survey data from 612 Filipino secondary students were analysed using latent cross-lagged panel modelling with full longitudinal invariance. Results showed strong stability across all PYD dimensions and AI ethics. PYD attributes displayed domain-specific effects on AI literacy, while AI ethics exerted broader influences on socio-emotional Cs (connection and character). A bidirectional relationship emerged between character and AI ethics. Findings underscore the intertwined development of moral, relational, and digital competencies in youth.

**Keywords:** AI literacy, AI ethics, positive youth development, student thriving

## 1. Introduction

The rapid expansion of artificial intelligence (AI) technologies across social, economic, and educational sectors has intensified global concerns regarding adolescents' readiness to navigate AI-mediated environments. **AI literacy**, defined as the ability to identify, use, evaluate, and ethically engage with AI technologies, has emerged as a foundational 21st-century competence (Wang et al., 2023). Recent global surveys indicate that more than 80% of students use

AI for academic tasks, with over half engaging with AI tools daily or weekly (DEC, 2024). Despite this widespread adoption, nearly one in two students also feels unprepared to use AI technologies effectively; 58% report lacking adequate AI knowledge and skills, while 49% struggle to critically evaluate the trustworthiness of AI outputs (DEC, 2024). These trends reveal a widening gap between adolescents' high exposure to AI and their limited preparedness to use such tools critically and responsibly.

Current AI literacy initiatives are largely dominated by cognitive-technical approaches that emphasise operational skills, digital competencies, and algorithmic awareness (Wang et al., 2023). However, emerging research proposes that psychosocial factors such as self-efficacy, socio-emotional competencies, and ethical awareness may substantially shape students' engagement with emerging technologies (Martin-Barrado & Gomez-Baya, 2025; Palmquist et al., 2025). Adolescents must not only know how to use AI but also when and why to use it, how to judge the validity of AI-generated outputs, and how to uphold ethical standards in digital contexts. Integrating non-cognitive psychosocial strengths is therefore critical to fostering competent and responsible AI use (Palmquist et al., 2025).

The Positive Youth Development (PYD) framework offers a robust lens for examining how young people's psychosocial assets may support AI literacy development. PYD conceptualises youth thriving through five interrelated dimensions called the 5Cs: competence, confidence, connection, character, and caring (Buenconsejo & Datu, 2022; Lerner et al., 2010). **Competence** reflects perceived ability in academic, social, and task-specific domains; **confidence** refers to self-worth and self-efficacy; **connection** captures positive relationships with family, peers, and institutions; **character** encompasses integrity, moral reasoning, and respect for societal norms; and **caring or compassion** involves empathy and concern for others (Geldhof et al., 2014). Together, these dimensions underscore a holistic perspective on youth development, emphasising personal abilities, relational resources, and moral responsibility.

PYD strengths may influence the development of AI literacy in several ways. Competence and confidence can motivate adolescents to use AI tools to support learning, refine skills, and manage academic tasks more efficiently. Connection may foster collaborative AI use among teachers and peers. Character and compassion may underpin ethical AI practices, integrity in academic work, and sensitivity to issues such as fairness, privacy, and harm. Conversely, AI literacy may also shape PYD attributes by enabling students to engage more confidently with technology, strengthen academic competence, cultivate responsible decision-making, and deepen social connection through collaborative AI-mediated learning environments.

Despite these theoretical linkages, little empirical work has directly examined how adolescents' PYD psychosocial strengths and AI literacy competencies influence one another over time. Moreover, virtually all existing studies have been conducted in high-income Western or East Asian contexts. Investigating these processes in developing countries such as the Philippines is essential, given persistent inequalities in digital access, rapid AI adoption in education, and the heightened risk that students from low- and middle-income countries (LMICs) may be left behind in the accelerating AI-driven global landscape. Understanding how psychosocial strengths and AI competencies co-develop in such contexts can inform more equitable, contextually grounded educational interventions.

This study addresses these gaps by examining the reciprocal longitudinal associations between the 5Cs of PYD and the four dimensions of AI literacy (awareness, usage, evaluation, and ethics) among Filipino secondary school students. By integrating strengths-based developmental science with contemporary AI literacy frameworks, the study provides insight into how psychosocial and digital competencies jointly shape adolescents' readiness to engage with emerging technologies.

## 2. Methodology

A two-wave longitudinal design was employed to examine the associations between PYD and AI literacy dimensions. Data were collected from 612 Filipino secondary school students ( $M^{\text{age}} = 16.86$ ,  $SD^{\text{age}} = .88$ ; 54% males) enrolled in one private school in Metro Manila. Surveys were administered in August 2024 (Time 1) and April 2025 (Time 2). Parental consent and student assent were obtained at both measurement points, and all procedures adhered to institutional ethical protocols.

PYD was assessed using the 15-item academic version of the 5Cs of PYD measure (Buenconsejo, In Press), which captures competence, confidence, connection, character, and compassion. AI literacy was measured using the 12-item AI Literacy Scale (Wang et al., 2023), assessing awareness, usage, evaluation, and ethics. All items were rated on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The survey was administered through Qualtrics during students' homeroom sessions. Preliminary analyses included descriptive statistics, reliability assessment, bivariate correlations, and confirmatory factor analyses (CFAs). Longitudinal measurement invariance (configural, metric, scalar, and strict) was tested for both PYD and AI literacy constructs to ensure consistency in factor structures over time.

As shown in Figure 1, a latent cross-lagged panel model (LCLPM) was estimated using the `lavaan` package in R (Mackinnon et al., 2022). Gender, age, and socioeconomic status were included as covariates to ensure the incremental validity of the PYD and AI literacy constructs. Goodness-of-fit indices were evaluated using standard criteria ( $CFI/TLI \geq .90$ ,  $RMSEA/SRMR \leq .08$ ). All analyses were conducted in R.

### 3. Results and Discussion

All PYD and AI literacy dimensions demonstrated adequate reliability at both time points. CFAs supported the validity of the five-factor PYD model and the four-factor AI literacy model, yielding adequate fit indices. As shown in Table 1, longitudinal measurement invariance was fully established for all PYD and AI literacy factors, permitting meaningful comparison of latent means and relationships across time.

The latent cross-lagged panel model demonstrated strong model fit ( $SB \chi^2(1413) = 2252.01$ ,  $p < .001$ ;  $CFI = .965$ ;  $TLI = .960$ ;  $RMSEA = .031$ ;  $SRMR = .048$ ). Autoregressive estimates revealed moderate stability for all PYD dimensions and AI ethics ( $\beta s \approx .23-.48$ ), indicating that PYD and moral characteristics remained relatively stable across the eight-month period. Conversely, AI awareness, usage, and evaluation exhibited weaker temporal stability, with non-significant autoregressive paths, suggesting that these dimensions may be more malleable or sensitive to rapid changes in AI tools or technologies. Given the accelerating adoption of AI tools in schools, students' exposure, usage patterns, and evaluative abilities may possibly shift in shorter time frames, contributing to their weak stability.

Several PYD attributes exhibited significant predictive associations with subsequent AI literacy domains. Competence predicted higher AI awareness ( $\beta = .16$ ) and evaluation ( $\beta = .07$ ), supporting the idea that strong academic and cognitive self-perceptions may help students engage more critically with AI tools. Confidence and connection predicted later AI usage ( $\beta = .06$ ;  $\beta = .10$ ), aligning with research suggesting that self-efficacy and positive relational contexts promote exploration and adoption of new digital technologies (Martin-Barrado & Gomez-Baya, 2025). These findings confirm that distinct PYD strengths facilitate domain-specific AI literacy competencies.

AI ethics emerged as the most influential AI literacy dimension, predicting gains in both socio-emotional PYD characteristics and other AI literacy skills. Time 1 AI ethics predicted increases in connection ( $\beta = .24$ ), character ( $\beta = .28$ ), awareness ( $\beta = .22$ ), usage ( $\beta = .17$ ), and evaluation ( $\beta = .30$ ) at Time

2. These results underscore the centrality of ethical sensitivity for navigating AI's risks, responsibilities, and social implications. Ethical orientations may strengthen relational qualities such as trust and respect, reinforce moral behaviour, and enhance students' ability to use AI tools responsibly (Wang et al., 2023).

Notably, character and AI ethics demonstrated a bidirectional relationship: Time 1 character predicted Time 2 AI ethics ( $\beta = .12$ ), while Time 1 AI ethics exerted a stronger reciprocal influence on Time 2 character ( $\beta = .28$ ). This mutually reinforcing pattern reflects the potential co-development of moral character and ethical AI practices, consistent with virtue-oriented perspectives in developmental science that emphasise how moral reasoning and ethical behaviour shape one another over time (Buenconsejo & Datu, 2022; Lerner et al., 2010). This finding also highlights the need for educational interventions that foster both ethical understanding and moral dispositions in AI-mediated learning environments.

Overall, the results indicate that PYD strengths, particularly competence, confidence, connection, and character, may serve as psychosocial resources that can bolster AI literacy development. Conversely, ethical AI literacy may function as a catalyst for both socio-emotional development and domain-specific AI skills. This reciprocal pattern supports a holistic perspective in which digital, moral, and relational competencies interrelate and co-develop, reinforcing calls to broaden AI literacy education beyond technical proficiencies (Palmquist et al., 2025).

#### **4. Implications**

The findings highlight the importance of integrating PYD and AI literacy frameworks to support adolescents' development in increasingly AI-mediated learning environments, especially in LMIC educational settings. Educational interventions that cultivate ethical sensitivity alongside self-efficacious and socio-emotional competencies may be particularly effective in promoting competence and responsible engagement with AI. Given the strong predictive role of AI ethics, programmes should incorporate explicit instruction on fairness, privacy, responsible use, and moral reasoning related to AI. In addition to cognitive predictors such as digital literacy, critical thinking, and technological proficiency, educators and policymakers should recognise the value of psychosocial resources in promoting AI awareness, usage, evaluation, and ethical engagement. A holistic educational approach that strengthens both cognitive and non-cognitive developmental assets can enhance students' capacity to navigate AI tools critically and responsibly.

The present study underscores the urgent need for more research on AI literacy in LMIC contexts. Students in developing countries often have limited access to digital infrastructure and AI-related training, increasing the risk of being excluded from the rapidly evolving AI-driven world. Investing in both psychosocial and digital competencies is therefore critical to ensuring that young people from underrepresented and under-resourced communities are not left behind. By revealing how PYD strengths and AI literacy competencies influence one another over time, the study offers a new developmental perspective on preparing the next generation for AI-mediated futures. Strengthening psychosocial resources alongside digital competencies may provide more equitable, developmentally grounded pathways for supporting youth thriving in an AI-driven society.

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## **Ethical Declaration Statement**

The project has been approved by the Human Research Ethics Committee of The Education University of Hong Kong (Reference Number: 2024-2025-0181).

## **Generative AI Policy**

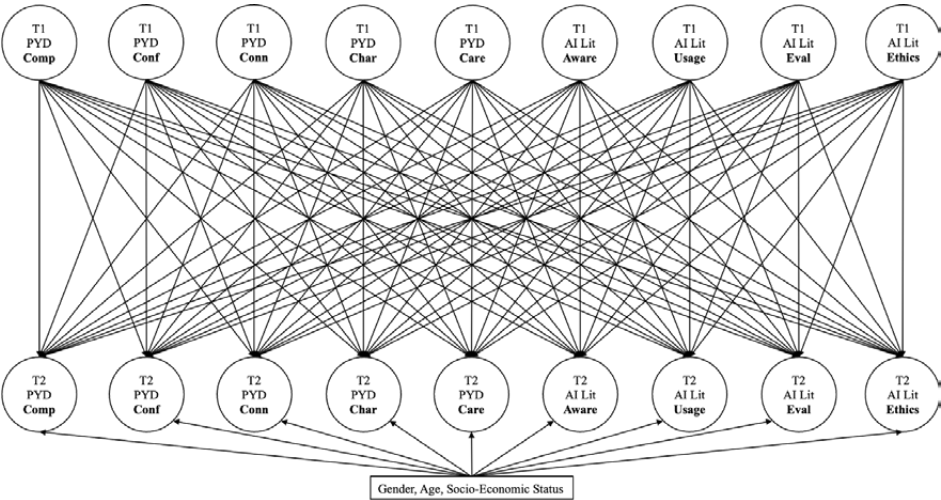
The first author used Grammarly during the preparation of this work to shorten the report and meet word limits. After utilising the tool, the authors thoroughly reviewed and edited the content as necessary and assumed full responsibility for the publication's content.

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**Figure 1.** Conceptual model of the latent cross-lagged panel model between PYD and AI literacy dimensions.



**Table 1.** Results of the longitudinal measurement invariance on the 5Cs model of PYD and the four-factor model of AI literacy across Time 1 and Time 2 (n = 612).

| Model      | SB $\chi^2$ (df) | CFI   | RMSEA | SRMR  | $\Delta$ CFI | $\Delta$ RMSEA | $\Delta$ SRMR | Invariant? |
|------------|------------------|-------|-------|-------|--------------|----------------|---------------|------------|
| Configural | 1514.06 (1197)   | 0.997 | 0.018 | 0.028 | –            | –              | –             | Baseline   |
| Metric     | 1576.34 (1224)   | 0.995 | 0.021 | 0.032 | -.002        | +.003          | +.004         | Yes        |
| Scalar     | 1614.05 (1251)   | 0.995 | 0.022 | 0.032 | .000         | +.001          | .000          | Yes        |
| Strict     | 1660.61 (1278)   | 0.994 | 0.023 | 0.035 | -.001        | +.001          | +.003         | Yes        |

*Note:* SB  $\chi^2$  = Satorra–Bentler scaled chi-square test statistic; *df* = degrees of freedom; CFI = Comparative Fit Index; RMSEA = root mean square error of approximation; SRMR, standardized root mean square residual;  $\Delta$  = change.