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Research Article

The DIRIS model for extending reflective learning through knowledge sharing in digital ecosystems

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This study proposes the Design–Implement–Reflect–Improve–Share (DIRIS) framework and provides an initial empirical examination of its central reflective-sharing mechanism. A cross-sectional survey was conducted among 350 in-service secondary school teachers in Vietnam using purposive sampling methods. Data were collected using a structured questionnaire measuring reflective learning, knowledge sharing, and self-reported teacher professional development and analyzed using confirmatory factor analysis and structural equation modeling. The findings revealed positive associations between reflective learning and knowledge sharing and between knowledge sharing and perceived professional development. The direct association between reflective learning and professional development was not statistically significant, whereas the indirect association through knowledge sharing was significant. Although the measurement model showed a close fit, some limitations in construct validity were identified. These findings provide initial empirical support for the proposed reflective-sharing mechanism but do not establish causal mediation or validate the complete five-phase DIRIS framework. This study contributes an integrative conceptual framework and highlights the need for longitudinal research and further validation of the measurement.

Keywords: Digital ecosystems; DIRIS model; Knowledge sharing; Reflective learning; Teacher professional development

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1. Introduction

Teachers are increasingly expected to integrate digital technologies and continuously develop their pedagogical knowledge, professional practices and collaborative capacities (Darling-Hammond et al., 2017; OECD, 2022). UNESCO (2021) further emphasized the importance of rethinking education in response to changing social and technological contexts. Accordingly, teacher professional development (TPD) should not be understood merely as participation in formal

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training but as an ongoing process embedded in professional practice. Day (1999) emphasized the continuing nature of teachers' professional learning, while Avalos (2011) and Opfer and Pedder (2011) highlighted its connections with teachers' experiences, professional contexts, and learning processes.

Among the various theoretical perspectives on professional learning, reflective learning has long been recognized as one of the most influential foundations of teacher development. Reflective practice theory proposes that professionals can improve their competence through a systematic examination of their actions and experiences (Schön, 1983, 1987). Similarly, experiential learning theory conceptualizes professional growth as a cyclical process involving concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). Research on reflective practice and professional learning further emphasizes the importance of systematic reflection for teachers' pedagogical reasoning and professional development (Larrivee, 2008; Lee & Pedder, 2011). Lee and Kim (2014) additionally examined instructional design and technology integration, providing a related perspective on teachers' professional learning in technology-supported contexts. Through reflection, teachers become more capable of analyzing classroom events, interpreting evidence of student learning, and making informed decisions about instructional improvement.

Despite their substantial contributions, classical reflective learning models primarily explain learning at the individual level. Reflection helps teachers reinterpret experiences and improve practice; however, these models offer limited explanations of how individually generated reflective insights may be shared and developed within professional communities. This question is particularly relevant in digital environments, where teachers can exchange instructional resources, professional experiences, and reflective insights across professional networks (Trust, 2017; Trust et al., 2016). Thus, an important issue is not only how teachers learn from their own experiences, but also how the knowledge generated through reflection becomes available for professional exchange and collaborative learning.

Therefore, knowledge sharing (KS) represents a potential mechanism linking individual reflection with collaborative professional learning. Communities of practice (Wenger, 1998) and professional learning communities (DuFour, 2004; Vescio et al., 2008) emphasize participation, collaboration, and shared inquiry. Digital technologies provide additional opportunities to exchange, store, and reuse professional resources across institutional boundaries (Redecker, 2017; Trust, 2017). However, opportunities for digital exchange do not necessarily demonstrate that reflective learning is associated with knowledge-sharing practices or that these practices are related to teachers'perceived professional development. Examining these associations is therefore important for understanding the proposed connection between individual reflection and collaborative professional learning.

A related perspective is learning through design, which views professional learning as emerging from teachers' active engagement in designing, implementing, evaluating, and improving educational practices. Design activities provide authentic contexts in which teachers apply their professional knowledge, confront practical problems, and generate experiences for subsequent reflection. Nevertheless, learning through design, reflective learning, and knowledge sharing have largely developed as separate theoretical concepts. Although these perspectives are complementary, their integration into a framework that explicitly connects instructional design, reflection, improvement, and subsequent knowledge sharing remains insufficiently articulated in the literature. In particular, the transition from reflective insights to shareable professional knowledge requires greater conceptual attention and research.

Recent studies in Vietnam have examined individual and collaborative reflections and professional learning communities (PLCs). Pham et al. (2023) investigated teachers' perspectives on reflection-on-action, and Dinh et al. (2026) examined professional learning community practices in primary schools in Vietnam. Vu et al. (2025) further explored the relationships among professional learning communities, teacher self-efficacy, and instructional practices in lower

secondary education. Together, these studies highlight the relevance of reflection and collaboration in the Vietnamese educational context. However, they did not directly examine the specific associations among reflective learning, knowledge sharing, and self-reported professional development within an integrated DIRIS framework.

To address this gap, this study proposes the DIRIS framework, integrating learning through design, reflective learning, and knowledge sharing into a proposed cycle of teacher professional learning. Its conceptual contribution is to position Share as an explicit extension of reflection and improvement: teachers may make their reflective insights and professional artifacts available for exchange and reuse. TPD is conceptualized as an outcome of professional learning rather than a DIRIS phase, while digital ecosystems provide the proposed context rather than a separately measured construct. The present study has two objectives: to articulate the five-phase DIRIS framework and to conduct an initial empirical test of the associations among reflective learning, knowledge sharing, and self-reported TPD. This empirical test does not assess the complete five-phase sequence, collective knowledge outcomes, or the effects of digital ecosystem characteristics.

The following theoretical framework develops hypotheses concerning the Reflective Learning (RL)–KS–Teacher professional development associations and examines the indirect statistical association between RL and TPD through KS.

2. Theoretical Framework and the DIRIS Model

2.1. Theoretical Foundations of DIRIS

The DIRIS model is grounded in the integration of three complementary theoretical traditions: learning through design, reflective learning and knowledge sharing. Learning through design explains how professional learning emerges through cycles of designing, implementing, and refining solutions to authentic educational problems (Brown, 1992; Kolodner, 2002; Wang & Hannafin, 2005). Reflective learning explains how professionals examine their experiences and evidence to improve their practice (Kolb, 1984; Schön, 1983, 1987). Knowledge sharing explains how professional knowledge is exchanged within communities and networks (DuFour, 2004; Trust et al., 2016; Wenger, 1998). DIRIS connects these perspectives through five proposed phases: Design, Implement, Reflect, Improve, and Share. Although the underlying traditions address different aspects of professional learning, their integration provides a conceptual basis for examining how reflective insights may become available for professional exchanges.

2.2. Learning through Design as the Starting Point of Professional Learning

The Design and Implementation phases are informed by learning through design, in which teachers actively analyze instructional problems, develop solutions, and enact them in authentic classroom contexts (Kali et al., 2015; Kolodner, 2002). Design activities differ from traditional professional development because teachers are not passive recipients of external knowledge; instead, they actively construct professional knowledge while developing instructional solutions (Brown, 1992; McKenney & Reeves, 2018). Implementation provides opportunities to test these solutions in real-world settings and generate evidence of their effectiveness. Consequently, these phases provide an experiential foundation for subsequent reflection and improvement.

2.3. Reflective Learning as an Improvement Mechanism

The Reflect and Improve phases are grounded in the reflective learning theory. Reflection enables teachers to critically examine their instructional decisions, evaluate evidence from practice, identify strengths and weaknesses, and formulate plans for improvement (Schön, 1983, 1987). Experiential learning theory further explains how reflection contributes to transforming experience into knowledge (Kolb, 1984), while research on reflective practice emphasizes its role in professional judgment and pedagogical reasoning (Gibbs, 1988; Larrivee, 2008). Within DIRIS, reflection is directly connected to improvement: teachers use evidence generated during implementation to refine their instructional designs and revise their pedagogical strategies. Thus,

the Reflect–Improve sequence represents the proposed connection between reflective learning and instructional improvements.

2.4. Knowledge Sharing as an Extension Mechanism

Although reflective learning theories emphasize the examination of professional experience, they provide less explicit guidance on how individually generated insights become available for wider professional exchange. DIRIS addresses this issue by positioning Share as an explicit phase within the proposed learning cycle.

Knowledge sharing refers to the exchange of professional experiences, instructional resources, reflective insights, and practical solutions among members of professional communities (Wenger, 1998; Trust et al., 2016). Such exchanges may involve lesson plans, digital learning resources, teaching videos, reflective journals, and other professional artifacts that colleagues can access, adapt, or reuse (Trust, 2017). The distinctive conceptual contribution of DIRIS is not the introduction of collaboration but its explicit connection to the preceding phases of reflection and improvement. Whether this process generates collective professional knowledge requires further empirical investigation.

2.5. Digital Ecosystems as Enabling Environments

Digital ecosystems comprise interconnected technological infrastructures, professional communities, digital resources, and data systems that support professional knowledge exchange (OECD, 2022; UNESCO, 2021). These environments provide opportunities for teachers to exchange, store, adapt, and reuse professional artifacts beyond institutional and geographical boundaries (Redecker, 2017; Trust et al., 2016). Within DIRIS, digital ecosystems constitute the proposed context for professional learning rather than a separately measured construct. Their specific characteristics and effects were not empirically examined in this study.

2.6. The DIRIS Model

Based on the integration of learning through design, reflective learning, and knowledge sharing, the DIRIS model is proposed as a reflective learning framework for teacher professional development in digital ecosystems. The model conceptualizes professional learning as a continuous and iterative process through which teachers generate, refine, share, and reuse professional knowledge.

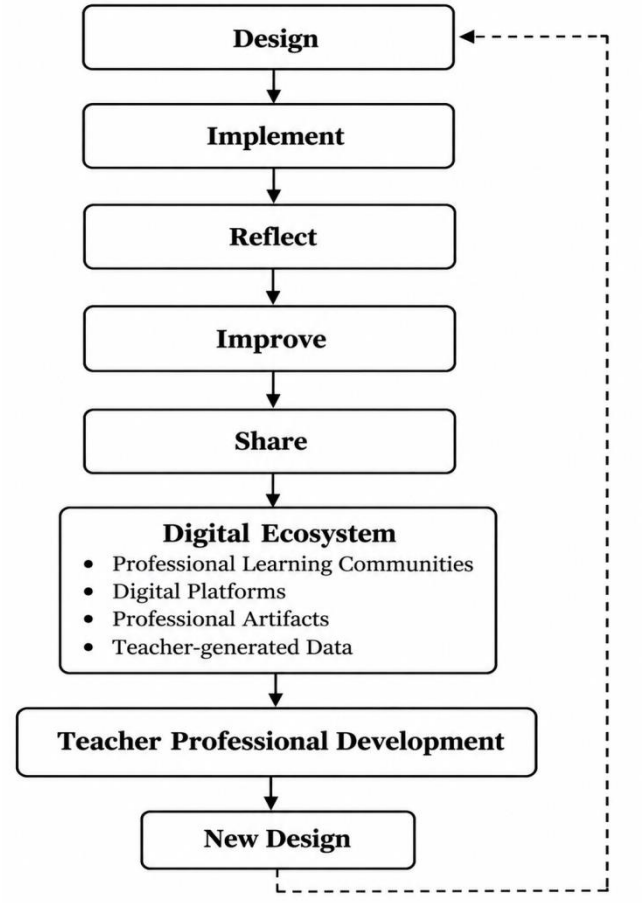
The DIRIS model consists of five interconnected phases: Design, Implementation, Reflection, Improvement, and Sharing. Design and Implement concern the development and enactment of instructional solutions; Reflect and Improve involve examining experiences and refining professional practice; and Share extends the proposed cycle through the exchange of professional knowledge and artifacts. Figure 1 illustrates these five phases, the contextual role of digital ecosystems, and the feedback loop connecting teacher professional development to the New Design.

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Teacher professional development is conceptualized as a potential outcome of participation in DIRIS cycles rather than as an additional phase. The feedback loop represents the proposition that professional learning may inform subsequent instructional designs. Importantly, the five phases constitute the conceptual architecture of DIRIS, whereas the empirical component of the present study examines only the associations among reflective learning (RL), knowledge sharing (KS), and self-reported teacher professional development (TPD). Design, Implement, and Improve were not

operationalized as separate latent constructs, and digital-ecosystem characteristics were not measured. Accordingly, the findings should be interpreted as an initial examination of the RL–KS–TPD pathway rather than validation of the complete five-phase DIRIS cycle.

Figure 1
Conceptual framework of the DIRIS model



Note. Adapted from Brown (1992), Kolb (1984), Kolodner, (2002) & Schön (1983, 1987).

Based on the theoretical framework, the empirical component focuses on the relationships among reflective learning, knowledge sharing, and teacher professional development.

Reflective learning enables teachers to examine their professional experiences, identify relevant knowledge, and articulate insights that can be shared with colleagues. Therefore:

H1: Reflective learning is positively associated with knowledge sharing.

Knowledge sharing enables teachers to exchange professional experiences, resources, and reflective insights within professional communities. Therefore, greater engagement in knowledge sharing is expected to be associated with professional learning and development. Thus:

H2: Knowledge sharing is positively associated with teacher professional development.

Reflective learning is also theoretically related to professional development because a systematic examination of professional experiences supports pedagogical reasoning and improvement. Therefore:

H3: Reflective learning is positively associated with teacher professional development.

The DIRIS framework further proposes Knowledge Sharing as an extension mechanism through which individual reflective learning is connected to broader professional development. Accordingly, the mediating role of Knowledge Sharing in the relationship between Reflective Learning and Teacher Professional Development was examined as an additional mechanism within the proposed structural model.

3. Method

3.1. Research Design

This study employed a quantitative cross-sectional survey design to examine the associations among RL, KS, and self-reported TPD within the proposed DIRIS framework using structural equation modeling (SEM).

The empirical analysis tested the Reflective Learning–Knowledge Sharing–Teacher Professional Development reflective-sharing mechanism, not the complete five-phase DIRIS cycle. Design, Implementation, and Improvement were conceptual phases and were not operationalized as separate latent constructs. As all variables were measured at a single time point, the findings were interpreted as associations rather than causal relationships.

3.2. Participants

The sample comprised 350 in-service teachers from 12 public secondary schools in Hanoi, Vietnam, including teachers from both lower and upper secondary schools. Participants were recruited through professional development programs and digital teacher learning communities using purposive sampling methods. Eligible participants were currently employed teachers with at least one year of teaching experience and recent participation in professional or digitally supported learning activities. Of the 386 teachers invited, 350 completed valid questionnaires, yielding a response rate of 90.7%. The participants represented diverse teaching subjects and had between 1 and 29 years of teaching experience. They also regularly used digital platforms for professional learning and resource sharing.

3.3. Instrument Development

Data were collected using a structured questionnaire measuring three latent constructs: reflective learning, knowledge sharing, and self-reported teacher professional development. As summarized in Table 1, the 12 measurement items were adapted and contextually modified for Vietnamese secondary school teachers from Larrivee (2008), van den Hooff and de Ridder (2004), and García-Martínez et al. (2019). All items were rated on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). The questionnaire was translated, back-translated, and reviewed by experts in teacher education for content validity and contextual appropriateness. A pilot test was conducted to assess item clarity before the main survey.

Table 1
Measurement Constructs and Sources

Construct	*Code*	*No. of items*	*Source*
Reflective Learning	RL	4	Larrivee (2008)
Knowledge Sharing	KS	4	van den Hooff and de Ridder (2004)
Teacher Professional Development	TPD	4	García-Martínez et al. (2019)

The final measurement items and their sources are provided in Appendix 1.

3.4. Data Collection

Data were collected from March to May 2026 using anonymous questionnaire surveys. Participation was voluntary. Before completing the questionnaire, the participants were informed of the study's purpose, confidentiality procedures, and their right to withdraw at any time. Informed consent was obtained from all participants before they completed the questionnaires. This study followed the institutional ethical guidelines for conducting educational research. Because the study involved an anonymous survey of adult teachers and collected no personally identifiable or sensitive information, a formal ethics review was not required under applicable institutional guidelines.

3.5. Data Analysis

Data were analyzed using R (version 4.4.2) with the lavaan, semTools, and psych packages. Descriptive statistics, Cronbach's alpha, confirmatory factor analysis (CFA), and SEM were performed. Construct validity was assessed using standardized factor loadings, composite reliability (CR), average variance extracted (AVE), the HTMT, and the Fornell–Larcker criterion.

CFA and SEM used the maximum likelihood (ML) estimation. The five-point Likert indicators were treated as approximately continuous because they showed minimal skewness and kurtosis, and no robust correction was applied. Model identification fixed the first loading of each latent construct to one. No correlated residuals or modification-driven changes were introduced into the model.

Model fit was evaluated using χ^2, CFI, TLI, and RMSEA with 90% confidence intervals, and SRMR. Indirect effects were examined using 5,000 bootstrap resamples and 95% confidence intervals. As a diagnostic for common method variance, the hypothesized three-factor CFA model was compared with a single-factor CFA model.

4. Results

4.1. Measurement Model Evaluation

Descriptive statistics for all 12 indicators (N = 350) showed means from 2.93 to 3.12, skewness from .14 to .17, and kurtosis from .41 to .23. Table 2 presents the internal consistency and convergent validity results for the three constructs. Cronbach's alpha and composite reliability ranged from .754 to .812.

Table 2
Reliability and Convergent Validity

Construct	*Cronbach's α*	*CR*	*AVE*
Reflective Learning (RL)	.812	.812	.520
Knowledge Sharing (KS)	.754	.754	.433
Teacher Professional Development (TPD)	.779	.780	.470

Note. CR = composite reliability; AVE = average variance extracted. AVE values below .50 for KS and TPD indicate limitations in the convergent validity.

Table 3 presents the standardized factor loadings and indicator reliability. All standardized loadings were statistically significant (p < .001), ranging from .620 to .775.

Table 3
Standardized Factor Loadings and Indicator Reliability

Construct and Indicator	*Standardized Loading*	R^2
Reflective Learning (RL)		
RL1	.700	.490
RL2	.775	.601
RL3	.725	.526
RL4	.680	.462
Knowledge Sharing (KS)		
KS1	.635	.403
KS2	.683	.467
KS3	.648	.420
KS4	.666	.443
Teacher Professional Development (TPD)		
TPD1	.719	.517
TPD2	.707	.500
TPD3	.620	.385
TPD4	.692	.479

Note. R^2 represents the proportion of indicator variance explained by the corresponding latent construct.

Table 4 presents the fit indices for the three-factor measurement model. The model showed close fit, $\chi^2(51) = 41.135$, p = .837, CFI = 1.000, TLI = 1.009, RMSEA = .000, 90% CI [.000, .021], and SRMR = .026. The TLI value slightly exceeded 1 because of the fit-index calculation.

Table 4
Measurement Model Fit Indices

Fit Index	*Obtained*
χ^2	41.135
df	51
CFI	1.000
TLI	1.009
RMSEA	.000
RMSEA 90% CI	[.000, .021]
SRMR	.026

Note. CFI, comparative fit index; TLI, Tucker– Lewis index; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residual; CI, confidence interval.

Table 5 presents the latent construct correlations and heterotrait–monotrait (HTMT) ratios used to assess discriminant validity. The latent correlations were .716 (RL–KS), .550 (RL–TPD), and .691 (KS–TPD). The HTMT values from the latest reported output ranged from .551 to .706 and remained below .85 (see Table 5). Nevertheless, the KS–TPD correlation (.691) exceeded the square roots of AVE for both KS (.658) and TPD (.686); therefore, the Fornell–Larcker criterion was not fully satisfied. These findings indicate a partial measurement overlap between KS and TPD.

Table 5
Latent Construct Correlations and HTMT Ratios

Measure	*RL–KS*	*RL–TPD*	*KS–TPD*
Latent correlation	.716	.550	.691
HTMT	.706	.551	.688

Note. RL = reflective learning; KS = knowledge sharing; TPD = teacher professional development; HTMT = heterotrait–monotrait ratio. All HTMT values were below .85. However, the Fornell–Larcker criterion was not fully satisfied for the KS–TPD pair, suggesting a potential construct overlap.

Table 6 presents the structural path estimates, bootstrap standard errors, confidence intervals, and significance tests for the three hypothesized relationships. The single-factor CFA fit substantially worse than the three-factor model, $\chi^2(54) = 280.745$, CFI = .832, TLI = .794, RMSEA = .110, and SRMR = .076. This diagnostic does not rule out common method variance. An alternative structural specification yielded the same fit as the proposed SEM ($\chi^2(51) = 41.135$; CFI = 1.000; RMSEA = .000), indicating that the cross-sectional model fit could not establish a directional ordering. As an ordinal data sensitivity check, WLSMV produced similar standardized paths (RL→KS = .715; KS→TPD = .613; RL→TPD = .112) and comparable fit (CFI = 1.000; RMSEA = .000; SRMR = .029).

4.2. Structural Model Evaluation

In the primary ML model, RL was positively associated with KS (β = .716), supporting H1, and KS was positively associated with self-reported TPD (β = .609), supporting H2. The direct RL–TPD path was small and not statistically significant (β = .114); H3 was not supported (see Table 6). The final estimated structural paths were RL → KS (.716), KS → TPD (.609), and RL → TPD (.114). The reported R^2 values were .512 for KS and .484 for TPD.

Table 7 presents the direct, indirect, and total associations between reflective learning and self-reported professional development.

Table 6
Structural Model Results

Path	B	*Bootstrap SE*	β	*95% CI for* B	*Bootstrap p*
H1: RL → KS	.605	.070	.716	[.478, .753]	< .001
H2: KS → TPD	.714	.140	.609	[.472, 1.026]	< .001
H3: RL → TPD	.113	.101	.114	[−.092, .305]	.263

Note. B = unstandardized estimate; β = standardized coefficient. Bootstrap *p*-values and percentile 95% CIs are based on 5,000 resamples; the CIs refer to B, not β. The bootstrap p-value for H3 (.263) differed slightly from the previously reported ML *p*-value and did not change the inference.

4.3. Indirect Association through Knowledge Sharing

The indirect association of RL with TPD through KS was β = .436 (unstandardized B = .432, bootstrap SE = .093, 95% CI for B [.278, .638], $p < .001$). The direct association was β = .114 (bootstrap 95% CI for B [−.092, .305]), and the total association was β = .550.

Table 7
Indirect and Total Associations

Association	*B*	*Bootstrap SE*	*β*	*95% CI for B*	*Bootstrap p*
Direct: RL → TPD	.113	.101	.114	[−.092, .305]	.263
Indirect: RL → KS → TPD	.432	.093	.436	[.278, .638]	< .001
Total: RL → TPD	.545	.074	.550	[.413, .705]	< .001

Note. B and bootstrap percentile confidence intervals were unstandardized, and β values were standardized. The indirect result is a statistical association, not evidence of a causal mediation.

The interval excluding zero supports an indirect statistical association because the data are cross-sectional; it does not establish causal mediation or the temporal DIRIS sequence.

Table 8 compares the fit of the proposed DIRIS structural model with an alternative structural specification and contrasts the three-factor measurement model with the single-factor CFA model.

Table 8
Alternative Model and Single-Factor CFA Diagnostics

Model	χ^2	*df*	*CFI*	*TLI*	*RMSEA*	*SRMR*	*AIC*	*BIC*
DIRIS SEM	41.135	51	1.000	1.009	.000	.026	8013.561	8117.725
Alternative SEM	41.135	51	1.000	1.009	.000	.026	8013.561	8117.725
Three-factor CFA	41.135	51	1.000	1.009	.000	.026	—	—
Single-factor CFA	280.745	54	.832	.794	.110	.076	—	—

Note. CFA: confirmatory factor analysis; SEM: structural equation modeling; AIC: Akaike information criterion; BIC: Bayesian information criterion. Identical fit indices for the two structural specifications do not establish directional ordering. The poorer fit of the single-factor CFA does not eliminate the possibility of a common method variance. Dash indicates that the value is not reported.

As shown in Table 8, the alternative SEM produced fit indices identical to those of the proposed DIRIS model, indicating that model fit alone cannot establish the directional ordering among RL, KS, and TPD in cross-sectional data. In contrast, the single-factor CFA showed a substantially poorer fit than the three-factor model, suggesting that the observed covariance could not be adequately represented by a common latent factor. However, this diagnostic does not eliminate the possibility of common-method variance.

5. Discussion

These findings provide initial empirical support for the central reflective-sharing mechanism in the DIRIS framework. Reflective learning was strongly associated with knowledge sharing (β = .716), indicating that teachers who reported stronger reflective practices also tended to report more knowledge-sharing activities. This finding is consistent with reflective practice and professional learning network perspectives (Schön, 1983; Trust et al., 2016) and Vietnamese research on teachers' reflections and professional learning communities (Dinh et al., 2026; Pham et al., 2023).

From a theoretical perspective, reflective learning may help teachers articulate pedagogical experiences, identify transferable insights, and recognize knowledge that could be useful to colleagues. This interpretation extends Schön's (1983) account of professional reflection by considering its relationship with interpersonal knowledge exchange. It is also compatible with Wenger's (1998) view of professional learning as participation in shared practices and Trust et al.'s (2016) emphasis on professional learning networks. However, the observed association does not establish that reflection preceded or generated knowledge-sharing behavior.

Knowledge sharing was positively associated with self-reported teacher professional development, whereas the direct association between reflective learning and TPD was not significant. The indirect statistical association through KS was significant (β = .436; unstandardized B = .432, bootstrap 95% CI [.278, .638]). This pattern suggests that knowledge sharing deserves particular theoretical attention when examining the relationship between individual reflection and perceived professional learning. Professional learning community perspectives emphasize that teachers can develop their professional understanding through collaborative inquiry, the exchange of teaching experiences, and discussion of instructional practices (DuFour, 2004; Vescio et al., 2008). Accordingly, the positive KS–TPD association is compatible with the proposition that sharing professional knowledge constitutes an important dimension of teachers'reported professional learning.

The nonsignificant direct RL–TPD association also requires careful interpretation. Reflective practice theory recognizes the potential contribution of reflection to professional judgment and instructional improvement (Schön, 1987; Larrivee, 2008). However, this theoretical relationship does not necessarily correspond to a statistically significant direct association in every empirical specification. When RL and KS are included simultaneously in the present model, the direct RL–TPD coefficient represents the association remaining after accounting for KS. Its nonsignificance may therefore reflect shared variance among the constructs, characteristics of the self-report measures, or other unmeasured relationships. It should not be interpreted as evidence that reflective learning is unimportant for teacher professional development.

Although this pattern is consistent with the proposed Share mechanism, the nonsignificant direct path is not definitive confirmation of that mechanism: shared covariance, measurement overlap, and alternative directional relationships may also explain the results. An alternative structural specification showed identical fit, while the Weighted Least Squares Mean and Variance Adjusted (WLSMV) estimation produced similar standardized path coefficients to Maximum Likelihood (ML) estimation. However, neither analysis established temporal ordering or a causal mediation.

These findings should not be interpreted as validation of the complete five-phase DIRIS cycle. Design, Implementation, and Improvement were conceptual components rather than separately measured constructs in the present SEM. The results provide an initial empirical test of the RL–KS–TPD pathway. Collective professional knowledge and digital ecosystem characteristics were not directly measured; these aspects of the DIRIS remain theoretical propositions that require further investigation.

5.1. Theoretical Implications

The principal theoretical contribution of DIRIS is the integration of reflective learning and knowledge sharing within a continuous professional learning framework. Its distinctive conceptual proposition is the explicit Share phase, through which reflective insights and professional artifacts may be exchanged, adapted, and reused (Schön, 1983; Trust et al., 2016). This proposition connects the individual orientation of reflective practice with the collaborative orientation of professional learning communities. In experiential learning theory, reflection contributes to the interpretation of experience and the development of new understanding (Kolb, 1984). Within communities of practice, professional knowledge is also shaped through participation and interaction (Wenger, 1998). DIRIS brings these perspectives together by explicitly

positioning knowledge sharing after reflection and improvement in its proposed conceptual sequence.

The empirical findings are consistent with one component of this integration: teachers who reported greater reflective learning also reported greater knowledge sharing, which was associated with perceived professional development. Therefore, the contribution of DIRIS lies primarily in articulating a theoretically coherent connection among these processes rather than establishing a new causal mechanism. Furthermore, the Share phase should not be interpreted as a claim that earlier reflective learning or professional learning community frameworks excluded collaboration. Rather, DIRIS makes the transition from individual reflective activity to professional knowledge exchange an explicit element of its proposed five-phase architecture.

However, the present individual-level self-reported data do not demonstrate that shared insights become collective professional knowledge.

The relatively low AVE values for KS (.433) and TPD (.470), together with their latent correlation (.691), indicate possible conceptual and measurement overlap. Although HTMT remained below .85, the Fornell–Larcker criterion was not satisfied for this pair. These findings suggest that KS and TPD may not be sufficiently differentiated by the current measures. Consequently, their observed association may partly reflect shared item content or overlapping perceptions rather than entirely distinct aspects of professional learning. This limitation warrants caution when interpreting the strength of the KS–TPD relationship. Moreover, the TPD scale captures self-reported professional learning engagement and perceived development, not independently verified professional growth or instructional effectiveness.

This measurement issue has several theoretical implications for research. Knowledge sharing concerns teachers' reported exchanges of professional information and experiences, whereas professional development encompasses a broader range of learning and changes in professional practice. As the present TPD indicators include collaboration and engagement in professional learning, these two constructs may share substantial content. Future conceptual and measurement refinements should, therefore, distinguish knowledge-sharing behaviors from perceived learning outcomes more clearly before stronger claims are made regarding their relationships.

5.2. Practical Implications

The findings suggest that teacher professional development should provide opportunities for reflection and systematic knowledge sharing. Schools and professional learning communities can support this process by enabling teachers to share reflective insights, lesson plans, digital resources, and other professional artifacts. In practice, professional learning activities can encourage teachers to document instructional challenges, discuss the evidence informing their reflections, and exchange possible improvements with colleagues. Such activities are consistent with the collaborative learning principles emphasized in research on professional learning communities (Vescio et al., 2008).

Digital platforms may facilitate the exchange and reuse of these resources; however, this study did not test whether specific platform characteristics improved sharing or professional development outcomes. Accordingly, these recommendations should be regarded as the implications of the proposed framework rather than the demonstrated effects of digital platforms.

6. Limitations and Future Research

This study had several limitations that should be considered. First, its cross-sectional design does not allow for causal or temporal conclusions. Second, all substantive variables were collected through individual self-reports at a single time. Although the single-factor CFA fit substantially worse than the three-factor model, common method variance cannot be ruled out. Third, the low AVE values for KS and TPD and incomplete discriminant validity suggest measurement overlap; the RL item describing teaching adjustments may also overlap conceptually with the unmeasured improve phase. Future measurement studies should examine the conceptual boundaries between

knowledge-sharing behaviors and perceived professional development, including potential item-content overlap. Fourth, the purposive recruitment of digitally engaged teachers from 12 Hanoi schools limits transferability, and possible within-school clustering was not assessed, potentially affecting the standard errors.

Finally, the empirical model examined only the RL–KS–TPD mechanism rather than the full five-phase DIRIS cycle. Future studies should use longitudinal process data across complete DIRIS cycles, more differentiated measures, school-level clustering checks, and multiple sources, such as professional artifacts, observed sharing practices, and peer or supervisor assessments. They should directly measure digital-ecosystem characteristics and collective learning outcomes.

7. Conclusion

This study proposes DIRIS as an integrative framework linking reflective learning, knowledge sharing, and teacher professional development in digital ecosystems. The findings provide initial empirical support for one mechanism derived from this framework: reflective learning was positively associated with knowledge sharing, which was in turn associated with self-reported professional-learning engagement and perceived development. The significant indirect statistical association is consistent with the proposed role of knowledge sharing but does not establish causal mediation or demonstrate the transformation of individual reflection into collective professional knowledge. The complete five-phase DIRIS cycle and the contribution of digital-ecosystem characteristics remain untested. Future longitudinal research should evaluate the temporal sequence of all five phases using differentiated measures and multiple sources of evidence.

Data availability: The dataset is not publicly available because it contains teachers' survey responses. De-identified data may be made available upon reasonable request and are subject to institutional ethical requirements.

Declaration of generative AI and AI-assisted technologies: AI-assisted tools, including ChatGPT (OpenAI), were used only to support English-language refinement, grammar checking, readability, and formatting consistency. They were not used to generate data, perform statistical analyses, create figures, or make substantive research decisions. The author reviewed and verified the manuscript and remains responsible for the accuracy of the data analysis, citations, interpretation, and conclusions.

Declaration of interest: The author declares no conflicts of interest.

Ethical approval and consent to participate: This study was conducted as an anonymous, minimal risk, educational survey. At the time of data collection, the participating institutions did not have a dedicated Institutional Review Board or Research Ethics Committee for this type of survey research; therefore, no formal ethical approval was obtained. Participation was voluntary, and the participants were informed of the academic purpose of the study before they completed the questionnaire. No personally identifiable information was collected, and all data were analyzed and reported in aggregate.

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Appendix 1. Measurement Items and Sources

Construct and Code	*Adapted measurement item*	*Source*
Reflective Learning (RL)		
RL1	I critically examined my teaching practices.	Larrivee (2008)
RL2	I analyze the relationship between my teaching practices and students' learning.	Larrivee (2008)
RL3	I use evidence from my experience to evaluate my teaching practice.	Larrivee (2008)
RL4	I adjust my teaching based on my previous experiences and reflections.	Larrivee (2008)
Knowledge Sharing (KS)		
KS1	I share my professional knowledge with colleagues when requested.	van den Hooff & de Ridder (2004)
KS2	I share useful teaching experiences and skills with my colleagues as well.	van den Hooff & de Ridder (2004)
KS3	I exchanged professional knowledge and information with my colleagues.	van den Hooff & de Ridder (2004)
KS4	I seek and obtain professional knowledge from my colleagues when necessary.	van den Hooff & de Ridder (2004)
Teacher Professional Development (TPD)		
TPD1	I continuously improve my professional knowledge and my teaching practices.	Adapted from García-Martínez et al. (2019)
TPD2	I collaborate with my colleagues to improve my professional practices.	Adapted from García-Martínez et al. (2019)
TPD3	I use digital technologies to support my professional practice and development in this field.	Adapted from García-Martínez et al. (2019)
TPD4	I actively organized and engaged in continuous professional learning.	Adapted from García-Martínez et al. (2019)