Causal Analysis of Place-Based Community Learning on Digital Innovator Competencies of Upper Secondary School Students

Meka Deesongkram
Science and Technology Learning Area, Sakolrajwittayanukul School
Sakon Nakhon Province, Thailand
E-mail : Krumakskr@gmail.com

Received 28 December 2025; Revised 12 February 2026; Accepted 15 February 2026

Abstract

This quasi-experimental study investigated the causal effects of place-based community learning on digital innovator competencies among upper secondary school students. Using a non-equivalent control group design with pretest-posttest measurements, this study (N=120 urban secondary students, northern Thailand) compared place-based community learning (n=60) versus traditional instruction (n=60) using pretest-posttest design. Digital innovator competencies were measured across six dimensions: creativity and imagination, design thinking, digital technology skills, innovative problem-solving, collaboration and communication, and adaptability and lifelong learning. Data were analyzed using paired t-tests, independent t-tests, and ANCOVA to control for pretest scores, with effect sizes reported using Cohen's d and partial eta squared. Results indicated that students in the experimental group demonstrated significantly higher digital innovator competencies than those in the control group ($p < .05$), with medium to large effect sizes across all competency dimensions. ANCOVA analysis confirmed the causal relationship between place-based community learning and competency development after controlling for baseline differences. Results provide robust evidence (Cohen's d = 0.67-1.51) for place-based learning's effectiveness in developing 21st century competencies, with implications for curriculum design and teacher development.

Keywords: Place-based community learning, Digital innovator competencies, Causal analysis, 21st century skills

Introduction

1. Background and Rationale

The rapid transformations of the 21st century, characterized by the digital revolution and technological integration into daily life, necessitate educational systems to prepare students with competencies extending beyond traditional academic knowledge. Digital innovator competencies—encompassing creativity, design thinking, technological proficiency, and collaborative problem-solving—have emerged as critical outcomes for preparing students to navigate and contribute meaningfully to complex, technology-driven societies (Partnership for 21st Century Learning, 2019; Voogt & Roblin, 2012). These competencies enable learners to identify authentic problems, design innovations using digital tools, and implement beneficial changes within their communities.

Place-based community learning represents a pedagogical approach that connects classroom instruction with local contexts by engaging students in addressing authentic community challenges (Sobel, 2004; Smith & Sobel, 2010). By situating learning within genuine environments and leveraging community resources, this approach transforms students from passive knowledge recipients into active participants in knowledge creation and community development. The integration of digital tools within place-based learning further amplifies students' capacity for innovation, as technology serves as a powerful medium for research, design, communication, and solution implementation (Howley et al., 2011; Powers, 2004).

Despite growing interest in place-based community learning, existing research predominantly focuses on descriptive case studies, program development, or qualitative explorations of learning processes (Meichtry & Smith, 2007; Stevenson et al., 2013). While valuable, these contributions lack empirical evidence demonstrating causal relationships between place-based community learning interventions and specific learning outcomes. The absence of rigorous experimental or quasi-experimental studies limits the field's ability to make confident conclusions about this pedagogical approach's effectiveness and hinders evidence-based policy decisions regarding curriculum design and educational policy (Penuel et al., 2016).

This study addresses these gaps by employing a quasi-experimental research design to investigate the causal effects of place-based community learning on upper secondary school students' digital innovator competencies. By comparing students participating in structured place-based community learning experiences with those receiving traditional instruction, while controlling for baseline differences and potential confounding variables, this study aims to provide robust empirical evidence regarding this pedagogical innovation's effectiveness. The use of Analysis of Covariance (ANCOVA) strengthens causal inference by accounting for pre-existing differences between groups, while effect size reporting enables assessment of practical significance beyond statistical significance (Shadish et al., 2002; Slavin, 2008).

Understanding the causal mechanisms through which place-based community learning develops digital innovator competencies holds significant implications for educational practice and policy. If evidence confirms that this approach substantially enhances student competencies, it provides rationale for resource allocation, teacher professional development, and curriculum reform. Furthermore, by examining impacts across multiple dimensions of digital innovator competencies, this research offers nuanced insights into which specific competencies benefit most from place-based community learning, informing more targeted instructional design.

2. Theoretical Foundations

Place-based community learning draws upon multiple theoretical traditions emphasizing the importance of context, experience, and social participation in human learning and development. Kolb's (1984) experiential learning theory proposes that learning occurs through a cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation. Place-based community learning operationalizes this cycle by engaging students in authentic community experiences that serve as concrete learning events, stimulating reflection on observations and experiences, guiding development of conceptual understanding, and providing opportunities to test ideas through active intervention in community contexts.

Lave and Wenger's (1991) situated learning theory emphasizes that learning is fundamentally social and context-dependent, occurring through legitimate peripheral participation in communities of practice. This perspective challenges assumptions that knowledge can be decontextualized and transferred across settings, instead arguing that competencies develop through authentic engagement in practices characterizing specific communities. Place-based community learning creates opportunities for students to engage in authentic community practices, interacting with community members, organizations, and challenges in ways that position learners as legitimate contributors rather than outsiders or observers.

Constructivist theories, including Piaget's cognitive constructivism and Vygotsky's social constructivism, emphasize that learners actively construct knowledge through interactions with their environment and through social negotiation of meaning (Fosnot, 2013; Vygotsky, 1978). Place-based community learning provides rich environments for knowledge construction by presenting complex, multifaceted problems requiring students to engage with multiple perspectives, synthesize diverse information sources, and develop solutions through iterative experimentation andrefinement.

3. Digital Innovator Competencies Framework

Digital innovator competencies represent a synthesis and extension of various 21st century competency frameworks, including the Partnership for 21st Century Learning (P21) Framework, OECD Learning Compass 2030, and UNESCO frameworks for transversal competencies (Partnership for 21st Century Learning, 2019; OECD, 2018; UNESCO, 2015). This study operationalizes digital innovator competencies through six interrelated dimensions:

Creativity and Imagination encompasses divergent thinking, originality, elaboration, and willingness to explore unconventional possibilities. Research indicates that creativity can be cultivated through pedagogical approaches providing open-ended challenges, encouraging risk-taking and experimentation, valuing multiple solutions, and creating psychologically safe environments (Beghetto & Kaufman, 2014; Runco, 2014).

Design Thinking represents a structured yet flexible approach to innovation, progressing through empathy, problem definition, ideation, prototyping, and testing (Brown, 2008; Razzouk & Shute, 2012). The human-centered focus of design thinking aligns naturally with place-based community learning, as both emphasize understanding stakeholder needs and developing solutions iteratively through community feedback.

Digital Technology Skills extend beyond basic operational competencies to critical evaluation of digital information, strategic selection and use of appropriate tools, creation of digital artifacts, and understanding how technology shapes communication and social interaction (Eshet-Alkalai, 2004; Van Laar et al., 2017).

Innovative Problem-Solving comprises problem identification, analysis, solution generation, implementation, and evaluation (Jonassen, 2011; Treffinger et al., 2008). Effective problem-solvers demonstrate systems thinking, recognizing connections and unintended consequences, while employing both analytical and creative cognitive processes.

Collaboration and Communication encompasses interpersonal skills, teamwork, conflict resolution, perspective-taking, and diverse modes of expression (Johnson & Johnson, 2009; Lai, 2011). Research demonstrates that collaborative learning enhances achievement, particularly for complex tasks requiring diverse expertise.

Adaptability and Lifelong Learning reflects metacognitive awareness, self-regulation, perseverance, growth mindset, and openness to feedback (Dweck, 2006; Zimmerman, 2002). These dispositions enable individuals to navigate uncertainty, learn from failure, and continuously develop new capabilities.

4. Research Gap and Study Contribution

While existing research suggests positive associations between place-based learning and various educational outcomes, the field lacks rigorous quasi-experimental or experimental studies establishing causal relationships with specific, well-defined competencies. Most studies rely on self-report data without independent verification of competency development and few employ validated instruments with established psychometric properties. This study contributes to the field by: (1) employing a rigorous quasi-experimental design with control group comparison, (2) using validated assessment instruments combining self-report and performance-based measures, (3) examining multiple dimensions of digital innovator competencies simultaneously, (4) utilizing ANCOVA to strengthen causal inference by controlling for baseline differences, and (5) reporting effect sizes to enable assessment of practical significance.

Research Objectives

This study pursues three primary objectives:

1. To compare students' digital innovator competencies before and after participating in place-based community learning, examining whether the intervention produces significant within-group changes in competency levels.

2. To compare digital innovator competencies between students receiving place-based community learning instruction and those receiving traditional instruction, determining whether significant between-group differences exist following the intervention period.

3. To analyze the causal effects of place-based community learning on upper secondary school students' digital innovator competencies, examining whether the intervention serves as a causal factor in competency development after controlling for baseline differences and potential confounding variables.

Research Scope

1. Population and Sample

This study focused on upper secondary school students (Grades 10-12) participating in either place-based community learning or traditional instruction over one academic semester. The intervention comprised four core components: (1) authentic community problems and contexts, (2) project-based learning activities, (3) digital tool integration, and (4) meaningful community engagement.

The population comprised approximately 3,200 upper secondary students in Sakon Nakhon Province urban schools. The sample consisted of 120 students from two urban secondary schools in northern Thailand, selected through purposive sampling of schools with similar demographic characteristics, academic performance levels, technological infrastructure, and proximity to communities suitable for place-based learning projects. Students were assigned to experimental (n=60) and control (n=60) groups based on existing classroom configurations.

2. Variables

Independent Variable: Instructional approach (place-based community learning vs. traditional instruction)

Dependent Variables: Digital innovator competencies comprising six core dimensions: (1) creativity and imagination, (2) design thinking, (3) digital technology skills, (4) innovative problem-solving, (5) collaboration and communication, and (6) adaptability and lifelong learning.

Control Variables: Grade level, prior technology experience, instructional time, content coverage, teacher characteristics

Duration and Assessment: The intervention lasted approximately 16 weeks, providing sufficient time for competency development while remaining feasible within typical school calendars. Digital innovator competency assessment utilized validated instruments incorporating self-report measures and performance-based evaluation to capture both perceived and demonstrated competencies. Data collection occurred at two time points: pretest (before intervention) and posttest (after intervention completion).

Study limitations include restriction to urban schools with adequate technology, limiting generalizability to rural or under-resourced settings. Results apply to upper secondary students in Thai contexts and may require adaptation for different educational systems or cultural contexts

Research Methodology

1. Research Design

This study employed a quasi-experimental non-equivalent control group design with pretest-posttest measurements to investigate the causal effects of place-based community learning on digital innovator competencies. Students in existing classroom groups were assigned to either the experimental group receiving place-based community learning instruction or the control group receiving traditional instruction. Both groups completed identical digital innovator competency assessments before and after the intervention period. The research design structure is presented in Table 1

Table 1

Research Design of the Study (Non-Equivalent Control Group Design)

Group	**Pretest (O_1)**	**Treatment (X)**	**Posttest (O_2)**
Experimental Group	O_1	X (Place-Based Community Learning)	O_2
Control Group	O_1	— (Conventional Instruction)	O_2

Note. O_1 = Pretest measurement of digital innovator competencies; X = Place-based community learning intervention; O_2 = Posttest measurement of digital innovator competencies; — = No experimental treatment (conventional instruction only).

Where O_1 represents pretest measurement, X represents place-based community learning intervention, and O_2 represents posttest measurement.

This design enabled three types of comparisons: (1) within-group pretest-posttest comparisons assessing changes within each group, (2) between-group posttest comparisons examining differences in final outcomes, and (3) covariance analysis comparing adjusted posttest means while controlling for pretest scores to strengthen causal inference.

2. Intervention Implementation

Experimental Group: Students engaged in structured place-based community learning incorporating four essential components:

2.1 Authentic Community Problems and Contexts: Students investigated genuine challenges identified through collaboration with community partners, including environmental issues, public health concerns, economic development opportunities, or social welfare needs.

2.2 Project-Based Learning Structure: Instruction was organized around extended projects following iterative cycles of problem identification, investigation, solution design, implementation, and reflection.

2.3 Digital Tool Integration: Students strategically employed digital technologies throughout projects for research, data collection and analysis, communication and collaboration, design and prototyping, and dissemination of findings.

2.4 Meaningful Community Engagement: Community members, organizations, and stakeholders actively participated as partners in problem identification, providing expertise and resources, offering feedback on student work, and collaborating in solution implementation.

Control Group: Students received traditional instruction with teacher-led lectures (60% of class time), textbook-based learning, and individual assignments. While brief group discussions occurred (15-20% of time), these focused on textbook concepts without extended projects, authentic problem-solving, or community engagement. Assessment relied on traditional tests and individual homework, ensuring observed differences reflect place-based learning specifically rather than mere collaborative activity presence.

3. Data Collection Instruments

Digital innovator competencies were assessed using a validated multi-method instrument combining:

3.1 Self-Report Questionnaire: Students rated their perceived competency levels across the six dimensions using Likert-scale items (1=Strongly Disagree to 5=Strongly Agree). The instrument demonstrated strong psychometric properties with Cronbach's alpha coefficients ranging from .82 to .91 across dimensions.

3.2 Performance-Based Assessment: Students completed authentic tasks requiring demonstration of competencies, evaluated using analytical rubrics with clearly defined performance levels. Tasks included: designing solutions to hypothetical community problems, creating digital prototypes, demonstrating collaborative problem-solving, and reflecting on learning processes. To ensure scoring consistency, performance-based assessments were independently evaluated by three trained raters with calibration sessions conducted prior to scoring. Inter-rater reliability assessed using intraclass correlation coefficient (ICC) showed excellent agreement (ICC = .84 to .92 across dimensions; Koo & Li, 2016).

4. Data Analysis

Data were analyzed using SPSS Version 28.0 through the following procedures:

4.1 Descriptive Statistics: Means, standard deviations, and frequency distributions characterized sample demographics and competency scores.

4.2 Paired t-tests: Within-group comparisons examined significant changes from pretest to posttest for both experimental and control groups.

4.3 Independent t-tests: Between-group comparisons examined significant differences in posttest scores between experimental and control groups.

4.4 Analysis of Covariance (ANCOVA): Adjusted posttest means were compared while controlling for pretest scores as covariates, strengthening causal inference by accounting for baseline differences. Assumptions of linearity, homogeneity of regression slopes, independence of covariate and treatment, and standard ANOVA assumptions were verified before analysis.

4.5 Effect Sizes: Cohen's d was calculated for mean differences and partial eta squared (η^2p) for ANCOVA effects, enabling interpretation of practical significance using standard benchmarks (Cohen, 1988; small=0.2, medium=0.5, large=0.8 for Cohen's d).

Statistical significance was determined at α = .05 for all analyses.

Research Results

1. Sample Characteristics and Baseline Equivalence

The final sample comprised 120 upper secondary students (experimental group n=60, control group n=60) with mean age 16.4 years (SD=0.9). Gender distribution was balanced (52% female, 48% male) and similar across groups (χ^2=0.27, p=.60). Baseline comparisons revealed no significant differences between groups in grade level distribution (χ^2=1.43, p=.49), prior technology experience scores (t=0.84, p=.40), or prior academic achievement (t=1.12, p=.27), supporting group equivalence on key characteristics. Table 2 presents the demographic characteristics and baseline equivalence testing results.

Table 2

Demographic Characteristics and Baseline Equivalence Testing (N=120)

Characteristic	Experimental Group (n=60)	Control Group (n=60)	Statistical Test	p-value
Age M(SD)	16.3(0.9)	16.5(0.9)	t=1.21	.228
Gender (% Female)	53.3%	50.0%	χ^2=0.27	.603
Grade Level Distribution			χ^2=1.43	.489
- Grade 10	21 (35.0%)	18 (30.0%)		
- Grade 11	20 (33.3%)	24 (40.0%)		
- Grade 12	19 (31.7%)	18 (30.0%)		
Prior Technology Experience M(SD)	3.42(0.71)	3.51(0.68)	t=0.84	.403
Prior Academic Achievement M(SD)	3.28(0.64)	3.38(0.59)	t=1.12	.265

Note. All baseline comparisons were non-significant ($p > .05$), supporting group equivalence prior to intervention.

2. Within-Group Changes: Pretest to Posttest Comparisons

2.1 Experimental Group Results

Paired t-test results indicated significant improvements across all six competency dimensions from pretest to posttest ($p < .001$ for all dimensions). Mean increases ranged from 0.68 to 1.24 points on the 5-point scale, with Cohen's d effect sizes ranging from 0.79 (collaboration and communication) to 1.42 (design thinking), indicating medium to large practical effects. Table 3 presents the detailed within-group comparison results for the experimental group.

Table 3

Experimental Group Pretest-Posttest Comparisons on Digital Innovator Competencies (n=60)

Competency Dimension	Pretest M(SD)	Posttest M(SD)	Mean Difference	t	p	Cohen's d
Creativity & Imagination	3.12 (0.64)	4.01 (0.58)	0.89	10.23*	<.001	1.32
Design Thinking	2.89 (0.71)	4.13 (0.62)	1.24	12.47*	<.001	1.42
Digital Technology Skills	3.34 (0.68)	4.21 (0.54)	0.87	9.87*	<.001	1.27
Innovative Problem-Solving	2.97 (0.73)	3.96 (0.66)	0.99	10.45*	<.001	1.35
Collaboration & Communication	3.45 (0.59)	4.13 (0.61)	0.68	8.12*	<.001	0.79
Adaptability & Lifelong Learning	3.21 (0.67)	4.07 (0.59)	0.86	9.34*	<.001	1.21
Overall Digital Innovator Competency	3.16 (0.58)	4.09 (0.52)	0.93	11.89*	<.001	1.54

Note. All comparisons significant at *p < .001. Cohen's d effect size interpretation: small=0.2, medium=0.5, large=0.8.

2.2 Control Group Results

Paired t-test results showed modest but significant improvements in four of six dimensions, with smaller effect sizes (Cohen's d ranging from 0.18 to 0.43). Design thinking and innovative problem-solving showed non-significant changes (p > .05). Table 4 presents the detailed within-group comparison results for the control group.

Table 4

Control Group Pretest-Posttest Comparisons on Digital Innovator Competencies (n=60)

Competency Dimension	Pretest M (SD)	Posttest M (SD)	Mean Difference	t	p	Cohen's d
Creativity & Imagination	3.09 (0.61)	3.36 (0.59)	0.27	3.21*	.002	0.41
Design Thinking	2.91 (0.69)	3.08 (0.72)	0.17	1.67*	.099	0.22
Digital Technology Skills	3.31 (0.64)	3.52 (0.61)	0.21	2.45*	.017	0.32
Innovative Problem-Solving	3.01 (0.70)	3.15 (0.68)	0.14	1.43*	.157	0.18
Collaboration & Communication	3.42 (0.62)	3.69 (0.58)	0.27	3.12*	.003	0.40
Adaptability & Lifelong Learning	3.18 (0.65)	3.47 (0.63)	0.29	3.34*	.001	0.43
Overall Digital Innovator Competency	3.15 (0.56)	3.38 (0.54)	0.23	3.01*	.004	0.39

Note. Non-significant comparisons (*p > .05) are indicated in regular font. Significant comparisons (*p < .05) were displayed in all dimensions except Design Thinking and Innovative Problem-Solving.

3. Between-Group Comparisons: Posttest Differences

Independent t-tests comparing posttest scores between experimental and control groups revealed significant differences favoring the experimental group across all six competency dimensions ($p < .001$ for all comparisons). Effect sizes ranged from d=0.67 (collaboration and communication) to d=1.51 (design thinking), indicating medium to large practical effects. Table 5 presents the between-group comparison results.

Table 5

Between-Group Comparisons of Posttest Digital Innovator Competencies (N=120)

Competency Dimension	Experimental Group M(SD)	Control Group M(SD)	Mean Difference	t	p	Cohen's d	Effect Size Interpretation
Creativity & Imagination	4.01 (0.58)	3.36 (0.59)	0.65	6.12*	<.001	1.12	Large
Design Thinking	4.13 (0.62)	3.08 (0.72)	1.05	8.54*	<.001	1.51	Large
Digital Technology Skills	4.21 (0.54)	3.52 (0.61)	0.69	6.57*	<.001	1.20	Large
Innovative Problem-Solving	3.96 (0.66)	3.15 (0.68)	0.81	6.72*	<.001	1.23	Large
Collaboration & Communication	4.13 (0.61)	3.69 (0.58)	0.44	4.02*	<.001	0.67	Medium -Large
Adaptability & Lifelong Learning	4.07 (0.59)	3.47 (0.63)	0.60	5.23*	<.001	0.95	Large
Overall Digital Innovator Competency	4.09 (0.52)	3.38 (0.54)	0.71	7.34*	<.001	1.34	Large

Note. All comparisons significant at *p < .001. df=118 for all t-tests. Cohen's d effect size interpretation: small=0.2, medium=0.5, large=0.8.

4. ANCOVA Results: Causal Effects After Controlling for Baseline Differences

ANCOVA was conducted to examine group differences in posttest scores while controlling for pretest scores as covariates. Preliminary assumption testing confirmed linearity between covariates and dependent variables (r ranging from .54 to .68, all $p<.001$), homogeneity of regression slopes (all interaction $F<2.3$, all $p>.10$), and homogeneity of variance (Levene's tests all $p>.05$).

Results demonstrated significant main effects of instructional approach (experimental vs. control) on all six competency dimensions after controlling for pretest scores ($p < .001$ for all dimensions). Partial eta squared values ranged from .31 to .58, indicating that the instructional approach accounted for 31% to 58% of variance in posttest scores after controlling for baseline competency levels—representing medium to large practical effects. Table 6 presents the ANCOVA results.

Table 6

ANCOVA Results: Effects of Instructional Approach on Digital Innovator Competencies Controlling for Pretest Scores (N=120)

Competency Dimension	F	df	p	Partial η^2p	Variance Explained	Effect Size Interpretation
Creativity & Imagination	47.23	1, 117	<.001	.39	39%	Large
Design Thinking	78.45	1, 117	<.001	.58	58%	Large
Digital Technology Skills	52.67	1, 117	<.001	.43	43%	Large
Innovative Problem-Solving	54.89	1, 117	<.001	.45	45%	Large

Competency Dimension	F	df	p	Partial η²p	Variance Explained	Effect Size Interpretation
Collaboration & Communication	38.12	1, 117	<.001	.31	31%	Medium-Large
Adaptability & Lifelong Learning	43.56	1, 117	<.001	.37	37%	Large
Overall Digital Innovator Competency	69.34	1, 117	<.001	.52	52%	Large

Note. All F-tests significant at *p < .001. Partial eta squared (η²p) interpretation: small=.01, medium=.06, large=.14. Covariate (pretest scores) was significant for all models (p < .001).

5. Adjusted Means Comparison

After controlling for pretest scores, experimental group adjusted posttest means exceeded control group adjusted means across all competency dimensions, with differences ranging from 0.52 to 0.97 points on the 5-point scale (all differences p<.001). Table 7 presents the adjusted means and standard errors.

Table 7

Adjusted Posttest Means by Group After Controlling for Pretest Scores (N=120)

Competency Dimension	Experimental Group Adjusted M (SE)	Control Group Adjusted M (SE)	Mean Difference	95% CI
Creativity & Imagination	4.03(0.07)	3.34(0.07)	0.69	[0.52, 0.86]

Competency Dimension	Experimental Group Adjusted M (SE)	Control Group Adjusted M (SE)	Mean Difference	95% CI
Design Thinking	4.15(0.08)	3.06(0.08)	1.09	[0.89, 1.29]
Digital Technology Skills	4.19(0.06)	3.54(0.06)	0.65	[0.50, 0.80]
Innovative Problem-Solving	3.98(0.07)	3.13(0.07)	0.85	[0.67, 1.03]
Collaboration & Communication	4.11(0.07)	3.71(0.07)	0.40	[0.23, 0.57]
Adaptability & Lifelong Learning	4.09(0.07)	3.45(0.07)	0.64	[0.47, 0.81]
Overall Digital Innovator Competency	4.09(0.06)	3.37(0.06)	0.72	[0.57, 0.87]

Note. Adjusted means control for pretest scores. SE = Standard Error. CI = Confidence Interval. All mean differences significant at $p < .001$.

Effect sizes (d = 0.67-1.51) indicate the average experimental student outperformed approximately 75-93% of control students—gains substantial enough to justify instructional time reallocation from traditional content coverage to community-based projects. For policymakers, these results (explaining 31-58% of variance beyond baseline) support resource investment in teacher development and community partnership infrastructure.

6. Dimension-Specific Effect Patterns

Analysis of effect size patterns across competency dimensions revealed differential intervention impacts. Table 8 summarizes the comparative effect sizes across all three analytical approaches (within-group experimental, between-group, and ANCOVA), facilitating interpretation of which competencies benefited most from place-based community learning.

Table 8

Summary of Effect Sizes Across Analytical Approaches for Each Competency Dimension

Competency Dimension	Experimental Within-Group Cohen's d	Between-Group Cohen's d	ANCOVA Partial $\eta^2 p$	Relative Effect Magnitude
Design Thinking	1.42	1.51	.58	Largest
Overall Digital Innovator Competency	1.54	1.34	.52	Very Large
Innovative Problem-Solving	1.35	1.23	.45	Large
Creativity & Imagination	1.32	1.12	.39	Large
Digital Technology Skills	1.27	1.20	.43	Large
Adaptability & Lifelong Learning	1.21	0.95	.37	Large
Collaboration & Communication	0.79	0.67	.31	Medium-Large (Smallest)

Note. Effect sizes consistently demonstrate medium to large intervention effects across all competencies, with Design Thinking showing the largest effects across all analytical approaches.

The convergent evidence across multiple statistical approaches—within-group comparisons, between-group comparisons, and covariance analyses—provides robust support for the causal effectiveness of place-based community learning in developing digital innovator competencies. The consistent pattern of medium to large effect sizes strengthens confidence in causal interpretation despite the quasi-experimental design's inherent limitations.

Discussion of Results

1. Interpretation of Causal Effects

The convergent evidence from within-group comparisons, between-group comparisons, and ANCOVA analyses provides robust support for the causal effectiveness of place-based community learning in developing digital innovator competencies among upper secondary students. The consistent pattern of large effect sizes across multiple statistical approaches strengthens confidence in causal interpretation, as recommended by contemporary quasi-experimental methodology (Shadish et al., 2002; Reichardt, 2019).

The ANCOVA results are particularly compelling, as they address the primary limitation of non-random assignment by statistically controlling for baseline differences. The substantial partial eta squared values (.31 to .58) indicate that instructional approach explains considerable variance in outcomes beyond what pre-existing competency levels explain. This pattern suggests that observed differences genuinely reflect intervention effects rather than selection bias or pre-existing group differences.

2. Mechanisms of Impact

Several theoretical mechanisms may explain how place-based community learning enhances digital innovator competencies:

2.1 Authentic Context and Purpose: Engagement with genuine community needs creates intrinsic motivation and meaningful learning contexts, aligning with self-determination theory (Deci & Ryan, 2000). Students reported higher engagement when addressing real problems affecting their communities compared to hypothetical classroom exercises.

2.2 Experiential Learning Cycles: The intervention's structure operationalized Kolb's (1984) experiential learning cycle, providing concrete experiences (community engagement), reflective observation (structured reflection activities), abstract conceptualization (connecting experiences to frameworks), and active experimentation (iterative solution development).

2.3 Legitimate Peripheral Participation: Following Lave and Wenger (1991), students' authentic engagement with community practices positioned them as legitimate contributors rather than peripheral observers, fostering identity development as capable problem-solvers and change agents.

2.4 Social Construction of Knowledge: The collaborative, community-embedded nature of projects facilitated Vygotskian social construction of knowledge through interaction with more knowledgeable others (community mentors, teachers, peers) within zones of proximal development (Vygotsky, 1978).

2.5 Design Thinking Integration: The intervention's explicit incorporation of design thinking processes—empathy, problem definition, ideation, prototyping, testing—provided structured approaches to innovation while maintaining flexibility for creative exploration (Brown, 2008; Razzouk & Shute, 2012).

3. Differential Effects Across Competency Dimensions

The varying effect sizes across competency dimensions offer insights into which capabilities benefit most from place-based community learning:

3.1 Design thinking's exceptionally large effects (d=1.51) likely reflect the intervention's explicit emphasis on human-centered, iterative problem-solving aligned with community needs. Traditional instruction rarely provides systematic exposure to design processes or opportunities for iterative refinement based on authentic stakeholder feedback.

3.2 Collaboration and communication: The relatively smaller, though still statistically significant, effect observed for collaboration and communication may be attributed to the fact that traditional instruction already incorporates group work and classroom presentations, providing students with a baseline level of these skills. The smaller effect size for collaboration (d = 0.67) may also reflect cultural factors in the Thai context that emphasize collective work, leading to higher initial competency levels and potential ceiling effects. In addition, the assessment instrument may not have fully distinguished basic classroom teamwork from more complex collaboration and communication skills developed through authentic engagement with community stakeholders in place-based learning contexts.

3.3 Digital technology skills and innovative problem-solving's large effects support the premise that authentic challenges requiring strategic tool use enhance both technological competencies and innovation capabilities more effectively than decontextualized skill instruction.

3.4 Creativity and adaptability's large effects align with research showing that open-ended, authentic challenges with uncertain outcomes foster creative thinking and adaptive dispositions more effectively than structured, predetermined classroom activities (Beghetto & Kaufman, 2014; Zimmerman, 2002).

4. Implications for Educational Practice

These findings carry several practical implications:

4.1 Curriculum Design: Results support integrating place-based community learning as a core pedagogical approach rather than supplementary enrichment. The substantial competency gains justify allocating instructional time to community-engaged projects, particularly for developing 21st century skills that traditional instruction addresses less effectively.

4.2 Teacher Professional Development: Effective implementation requires teacher preparation in facilitation of project-based learning, community partnership development, design thinking processes, and formative assessment of complex competencies. Professional development should emphasize shifts from knowledge transmission to learning facilitation roles.

4.3 Technology Integration: Findings support strategic digital tool integration within authentic problem-solving contexts rather than standalone technology instruction. When students use digital tools purposefully to address genuine needs, they develop both technological skills and broader innovation competencies simultaneously.

4.4 Assessment Approaches: Traditional standardized testing inadequately captures digital innovator competencies. Assessment systems should incorporate performance-based evaluation, portfolio documentation, and authentic demonstration of competencies in real-world contexts.

4.5 Community Partnerships: Successful implementation requires sustained partnerships with community organizations, providing structures for ongoing collaboration rather than one-time service projects. Schools should invest in relationship-building and partnership infrastructure.

5. Implications for Educational Policy

At the policy level, these findings suggest:

5.1 Standards and Accountability: Educational standards should explicitly recognize and value 21st century competencies alongside traditional academic content. Accountability systems emphasizing only standardized test scores may inadvertently discourage pedagogical innovations like place-based learning that develop broader competencies.

5.2 Resource Allocation: Evidence of large intervention effects justifies resource investment in teacher professional development, community partnership coordination, and technological infrastructure supporting place-based learning implementation.

5.3 Curriculum Flexibility: Rigid curricular requirements and pacing guides may constrain the extended project timelines and responsiveness to community needs essential for effective place-based learning. Policy should provide flexibility for schools to adapt curriculum to local contexts.

5.4 Equity Considerations: While this study demonstrated effectiveness in urban schools with adequate technology access, implementation in under-resourced settings requires attention to digital divides and community resource availability. Policy should ensure equitable access to necessary infrastructure and support.

6. Limitations and Threats to Validity

Several limitations warrant consideration:

6.1 Internal Validity: The non-random assignment creates potential selection bias despite statistical controls. Although groups showed baseline equivalence on measured characteristics, unmeasured confounds may exist. The use of ANCOVA partially addresses this concern but cannot completely eliminate selection threats.

6.2 External Validity: The sample's restriction to urban northern Thai schools limits generalizability to other contexts, particularly rural settings, different cultural contexts, or educational systems with different structures and resources. Replication across diverse settings is needed.

6.3 Instrumentation: While the assessment instruments demonstrated strong psychometric properties, competency measurement remains challenging. Self-report measures may be subject to social desirability bias or limited self-awareness. Performance-based assessments, while more authentic, introduce scoring subjectivity despite rubric use.

6.4 Implementation Fidelity: Variation in how teachers implemented the intervention may have affected outcomes. Although implementation protocols provided guidance, teachers' prior experience, beliefs, and skills likely influenced execution quality.

6.5 Maturation and History: The 16-week intervention period coincides with normal developmental changes and exposure to various experiences outside the study. While the control group design addresses these threats, complete control is impossible.

6.6 Testing Effects: Pretest exposure may have sensitized students to competency dimensions, potentially influencing posttest responses. However, testing effects should affect both groups similarly, limiting impact on between-group comparisons.

7. Directions for Future Research

Future investigations should:

7.1 Examine Long-Term Effects: This study assessed immediate posttest outcomes. Longitudinal research examining competency retention and application in subsequent academic and professional contexts would illuminate lasting impacts.

7.2 Investigate Mediating Mechanisms: While theoretical frameworks suggest mechanisms, empirical examination of specific mediators (e.g., intrinsic motivation, identity development, metacognitive awareness) would clarify causal pathways through which place-based learning affects competencies.

7.3 Explore Moderating Factors: Research investigating which students benefit most from place-based learning (considering prior achievement, socioeconomic background, learning preferences) would inform targeted implementation and differentiation strategies.

7.4 Compare Implementation Variations: Systematic comparison of different place-based learning approaches (varying in community partner types, project duration, digital tool integration levels, assessment methods) would identify optimal design features.

7.5 Conduct Economic Analyses: Cost-effectiveness studies comparing investment requirements and outcomes of place-based versus traditional approaches would inform resource allocation decisions.

7.6 Expand Geographic and Cultural Contexts: Replication across diverse settings—rural communities, different countries, varied educational systems—would establish generalizability and identify culturally-specific adaptation needs.

7.7 Examine Teacher Development: Research investigating how teachers develop competencies for facilitating place-based learning and what professional development approaches prove most effective would support scaled implementation.

7.8 Investigate Community Partner Perspectives: Most research examines student outcomes; investigating community partners' experiences, perceived benefits, and sustainability factors would provide holistic understanding of place-based learning ecosystems.

Conclusion

This quasi-experimental study provides robust empirical evidence that place-based community learning causally enhances digital innovator competencies among upper secondary students. Converging evidence from within-group comparisons, between-group comparisons, and covariance analyses—yielding consistently large effect sizes across six competency dimensions—supports confident causal interpretation despite the non-random assignment inherent in quasi-experimental designs.

The findings demonstrate that when students engage authentically with community problems through structured project-based learning integrating digital tools and meaningful community partnerships, they develop creativity, design thinking, technological skills, innovative problem-solving, collaboration, and adaptive learning dispositions significantly more than through traditional instruction. These competencies represent precisely the capabilities contemporary societies require for navigating complexity, driving innovation, and contributing to community wellbeing.

Beyond statistical significance, the practical significance reflected in large effect sizes suggests substantial real-world impact. Students in the experimental group demonstrated competency gains approximately one standard deviation above control group students—differences likely to manifest in enhanced capability for future academic work, career success, and civic engagement.

As educational systems worldwide grapple with preparing students for rapidly evolving futures, this research offers evidence-based guidance. Place-based community learning emerges not as peripheral enrichment but as a core pedagogical approach meriting central position in curriculum design, resource allocation, and teacher preparation. By connecting learning to authentic community contexts, leveraging digital technologies purposefully, and positioning students as capable contributors to genuine challenges, education can fulfill its promise of developing competent, engaged citizens prepared to innovate and lead in the 21st century.

References

Beghetto, R. A., & Kaufman, J. C. (2014). Classroom contexts for creativity. *High Ability Studies, 25*(1), 53-69. https://doi.org/10.1080/13598139.2014.905247

Brown, T. (2008). Design thinking. *Harvard Business Review, 86*(6), 84-92.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268. https://doi.org/10.1207/S15327965PLI1104_01

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.

Eshet-Alkalai, Y. (2004). Digital literacy: A conceptual framework for survival skills in the digital era. *Journal of Educational Multimedia and Hypermedia, 13*(1), 93-106.

Fosnot, C. T. (Ed.). (2013). *Constructivism: Theory, perspectives, and practice* (2nd ed.). Teachers College Press.

Howley, A., Howley, M., Camper, C., & Perko, H. (2011). Place-based education at Island Community School. *Journal of Environmental Education, 42*(4), 216-236. https://doi.org/10.1080/00958964.2011.556682

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher, 38*(5), 365-379. https://doi.org/10.3102/0013189X09339057

Jonassen, D. H. (2011). *Learning to solve problems: A handbook for designing problem-solving learning environments*. Routledge.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Prentice Hall.

Koo, T. K., & Li, M. Y. (2016). A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *Journal of Chiropractic Medicine, 15*(2), 155-163.

Lai, E. R. (2011). *Collaboration: A literature review*. Pearson. http://www.pearsonassessments.com/research

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Meichtry, Y. J., & Smith, J. E. (2007). The impact of a place-based professional development program on teachers' confidence, attitudes, and classroom practices. *Journal of Environmental Education, 38*(2), 15-32. https://doi.org/10.3200/JOEE.38.2.15-34

OECD. (2018). *The future of education and skills: Education 2030*. OECD Publishing. https://www.oecd.org/education/2030/

Partnership for 21st Century Learning. (2019). *Framework for 21st century learning definitions*. Battelle for Kids. http://www.battelleforkids.org/networks/p21

Penuel, W. R., Harris, C. J., & DeBarger, A. H. (2016). Implementing the Next Generation Science Standards: The dimensions of using tools and engaging students in scientific arguments. *Science Education, 100*(3), 478-501. https://doi.org/10.1002/sce.21216

Powers, A. L. (2004). An evaluation of four place-based education programs. *Journal of Environmental Education, 35*(4), 17-32. https://doi.org/10.3200/JOEE.35.4.17-32

Razzouk, R., & Shute, V. (2012). What is design thinking and why is it important? *Review of Educational Research, 82*(3), 330-348. https://doi.org/10.3102/0034654312457429

Reichardt, C. S. (2019). *Quasi-experimentation: A guide to design and analysis*. Guilford Press.

Runco, M. A. (2014). *Creativity: Theories and themes: Research, development, and practice* (2nd ed.). Academic Press.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi- experimental designs for generalized causal inference*. Houghton Mifflin.

Slavin, R. E. (2008). What works? Issues in synthesizing educational program evaluations. *Educational Researcher, 37*(1), 5-14. https://doi.org/10.3102/0013189X08314117

Smith, G. A., & Sobel, D. (2010). *Place- and community-based education in schools*. Routledge.

Sobel, D. (2004). *Place-based education: Connecting classrooms and communities*. Orion Society.

Stevenson, R. B., Brody, M., Dillon, J., & Wals, A. E. J. (Eds.). (2013). *International handbook of research on environmental education*. Routledge.

Treffinger, D. J., Young, G. C., Selby, E. C., & Shepardson, C. (2008). *Assessing creativity: A guide for educators*. National Research Center on the Gifted and Talented.

UNESCO. (2015). *Rethinking education: Towards a global common good?* UNESCO Publishing.

Van Laar, E., van Deursen, A. J., van Dijk, J. A., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior, 72*, 577-588. https://doi.org/10.1016/j.chb.2017.03.010

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies, 44*(3), 299-321. https://doi.org/10.1080/00220272.2012.668938

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice, 41*(2), 64-70. https://doi.org/10.1207/s15430421tip4102_2

Name: Meka Deesongkram
Highest Education: Master's Degree in Educational Administration
Affiliation: Science and Technology Learning Area, Sakolrajwittayanukul School