Journal of Curriculum and Teaching; Vol. 15, No. 4; 2026
ISSN 1927-2677 E-ISSN 1927-2685
Published by Sciedu Press

The Impact of a Career-Connected Convergent Inquiry Project on High School Students' Knowledge and Information Processing Competency in English Education

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Received: March 21, 2026 Accepted: September 29, 2026 Online Published: October 16, 2026

doi:10.5430/jct.v15n4p100 URL: https://doi.org/10.5430/jct.v15n4p100

Abstract

This study explored the impact of a career-connected convergent inquiry project on high school students' knowledge and information processing competency in English education. An explanatory sequential mixed-methods design was employed with 148 students over 17 weeks, encompassing topic selection through final presentation. Quantitatively, pre- and post-surveys using a validated competency instrument were analyzed using paired-samples t-tests and effect size calculations. Qualitatively, semi-structured interviews with nine students were thematically analyzed to explore learning experiences. Quantitative results showed statistically significant improvements across all competency domains and sub-elements, with relatively large effect sizes in "scope setting" and "production." Qualitative findings revealed that students perceived English as a "tool for career exploration" rather than an "assessment object," developing confidence in authentic contexts. Career contexts functioned as "critical filters" for prioritizing information. Students transitioned into knowledge producers through reconstructing information into outputs, while generative AI and digital tools served as "cognitive and affective scaffolding" that reduced linguistic barriers and enabled focus on information processing activities. This study provides empirical evidence that career-connected convergent inquiry projects constitute an effective pedagogical model for cultivating knowledge and information processing competency in English education, offering concrete foundations for process-tracking assessment systems, stage-specific AI integration, and teacher professional development.

Keywords: knowledge and information processing competency, project-based learning (PBL), career-connected inquiry, English as a foreign language (EFL), generative AI and digital tools

1. Introduction

In contemporary society characterized by rapid technological advancement and explosive knowledge growth, the ability to simply memorize and acquire information is gradually losing its effectiveness (OECD, 2018). Amid these changes, education must extend beyond mere knowledge transmission to focus on cultivating learners' capacity to navigate, analyze, and critically evaluate necessary materials from vast information sources to construct new knowledge (Tan et al., 2021; Vincent-Lancrin et al., 2019). Reflecting these societal demands, the 2022 Revised National Curriculum in South Korea emphasizes "knowledge and information processing competency"—the ability to collect, analyze, and utilize information in the process of solving complex problems—as one of its core competencies (Ministry of Education, 2022a). In particular, digital transformation and the popularization of artificial intelligence (AI) have fundamentally changed not only the volume of information but also its forms and modes of access (Coleman, 2024). Consequently, the ability to select and reconstruct meaningful knowledge from diverse information sources based on critical thinking has emerged as a core competency that must be practically implemented across all subject areas (UNESCO, 2023).

In this context, high school English education is also required to shift beyond the development of discrete language

skills toward strengthening information utilization competency mediated through English (Dashtestani & Hojatpanah, 2022). Given that a substantial portion of global knowledge and information is generated and distributed in English, English is no longer merely a "language skill" or an "object of learning" but serves as an essential tool for accessing, understanding, and utilizing the global knowledge system (Syrbe & Rose, 2021). However, current high school English instruction in Korea remains heavily focused on exam-oriented vocabulary, reading comprehension, and grammar education (Choi et al., 2022; Kim & Lee, 2025), failing to provide students with sufficient experiences to explore information, critically evaluate it, and process and produce it according to their purposes within authentic and meaningful contexts using English.

To address these limitations in educational settings and enhance students' knowledge and information processing competency within authentic learning contexts, project-based learning (PBL) has gained attention as a teaching and learning method (Almulla, 2020; Mutanga, 2024). PBL is a method in which learners actively engage in inquiry tasks centered on authentic and meaningful problems, producing outcomes by collecting, analyzing, and synthesizing information, making it effective for competency development as students directly experience the full cycle of knowledge and information processing (Boss & Krauss, 2018; Condliffe et al., 2017; Kokotsaki et al., 2016). Moreover, projects that are connected to students' individual career interests enhance the authenticity and personal relevance of learning, thereby increasing motivation and cognitive engagement (Beier et al., 2019). For high school students, who are at a critical stage of clarifying their career trajectories, such projects provide concrete opportunities to search for and utilize information relevant to their areas of interest (Zhang, 2022). In this context, career-connected convergent inquiry activities implemented within the English curriculum can provide experiences that simultaneously cultivate both language ability and practical knowledge and information processing competency by enabling students to use English not merely as an object of learning but as a tool for information inquiry and knowledge construction (Jelodari et al., 2025; Sun & Zhu, 2023).

Despite this pedagogical potential, previous research has primarily focused on the general effects of PBL or on improvements in language skills within English education. Empirical studies that systematically examine changes in knowledge and information processing competency through career-connected convergent inquiry projects in English remain limited. In particular, research that integrates quantitative and qualitative analysis of the patterns and processes of change in knowledge and information processing competency based on long-term projects implemented in actual instructional contexts with high school students has not been sufficiently accumulated. Therefore, this study aims to explore how a career-connected convergent inquiry project implemented in high school English classes influences students' knowledge and information processing competency in English, using a mixed-methods research design.

2. Literature Review

2.1 Project-Based Learning (PBL)

Project-based learning (PBL) is a learner-centered instructional model in which learners engage in extended inquiry processes to produce final outcomes by confronting authentic and complex questions or problems (Kokotsaki et al., 2016). The essence of PBL lies not in a simple sequence of activities but in "in-depth inquiry" where knowledge acquisition and application occur simultaneously (Guo et al., 2021). In this process, students move beyond being passive recipients of knowledge to assume the role of active inquirers who structure knowledge themselves by repeatedly setting research questions, exploring necessary resources, and collecting, judging, and interpreting information (Arochman et al., 2024). Particularly in the high school education context, PBL provides opportunities for students to connect abstract knowledge within textbooks to real-world contexts and plays a critical role in cultivating self-directed learning abilities and higher-order thinking skills (Loyens et al., 2023; Shekh-Abed, 2025).

In English education, PBL serves as a powerful pedagogical approach for shifting form-focused instruction toward authentic meaning and task-based learning (Beckett, 2025). Particularly when students explore convergence topics connected to their interests or careers through English, English acquires a practical function not as the "purpose" of learning but as a "tool" for accessing knowledge and processing information (Gibbes & Carson, 2014). This aligns with the contexts of content-based instruction and content and language integrated learning, resulting in learners simultaneously developing linguistic proficiency and subject-matter knowledge through directly reading and analyzing English materials related to their academic or career aptitudes (Beckett, 2025; Ferry, 2021).

Furthermore, modern PBL environments that incorporate information exploration using AI and digital tools provide a practical foundation for cultivating knowledge and information processing competency by enabling students to select

and reconstruct meaningful content from vast amounts of English-language resources (Azamatova et al., 2023). In particular, AI-supported PBL can facilitate information processing by supporting information search, providing personalized feedback and inquiry scaffolding, and assisting learners in organizing and producing content, thereby promoting more active engagement in higher-order inquiry and knowledge construction (Luan et al., 2026; Yiling et al., 2025).

2.2 Knowledge and Information Processing Competency in English Education

In the 2022 Revised National Curriculum of Korea, knowledge and information processing competency is defined as the ability to deeply understand knowledge and information across various domains and to critically explore and utilize them to rationally solve problems learners encounter (Ministry of Education, 2022a). The English curriculum does not establish this general competency as a separate sub-competency but rather organically integrates it within the concept of "English communication competency," which encompasses acquiring and understanding diverse information presented in English, thinking critically about it to creatively express one's thoughts, and cooperatively interacting with English-using communities (Ministry of Education, 2022b). This approach positions English not merely as a "means of linguistic communication" but as a core "inquiry tool" for exploring, processing, and constructing meaning from information. The "opportunities for English use connected to real-life contexts," emphasized in the character section, require students to acquire and communicate various forms of information through English while designing their lives and career pathways (Ministry of Education, 2022b). Furthermore, the objective section explicitly states "search, collect, understand, analyze, evaluate, and utilize digital knowledge and information from various media expressed in English according to one's purposes," clearly establishing that the entire process of information processing is positioned as a central objective of English subject learning (Ministry of Education, 2022b). Synthesizing these points, knowledge and information processing competency in English education can be understood as the ability to actively perform a series of cognitive processes including information exploration, evaluation, analysis, reconstruction, and expression mediated through English.

Empirical research on knowledge and information processing competency has been conducted across various subject areas and academic contexts. In non-English subject contexts, Jang (2018) demonstrated that statistics project instruction for high school students significantly improved knowledge and information processing competency as well as communication competency through authentic data collection, analysis, and outcome production processes. Similarly, Ju et al. (2024) confirmed the positive effects of convergent problem-solving processes on information processing and collaboration competencies through middle school students' earth science data utilization projects, highlighting the importance of data-based inquiry activities. Within English education, knowledge and information processing competency has been discussed in alignment with digital transformation and artificial intelligence environments. Kwack and Uhm (2025) analyzed the effects of digital literacy on educational technology acceptance intentions among specialized vocational high school students in AI-based English classrooms, identifying that self-directed learning competency plays a key mediating role between information technology utilization and competency development. Furthermore, Bae and Choi (2024) suggested that information searching, utilization, and evaluation skills significantly affect learners' affective attitudes in the process of identifying sub-factors of high school students' digital English literacy. These prior studies indicate that information searching and utilization within project-based inquiry activities and digital learning environments function as core mechanisms for fostering learners' knowledge and information processing competency. At the same time, they empirically support the necessity of integrating convergent inquiry processes in English education, in which learners critically process and reconstruct knowledge through English rather than merely acquiring discrete language skills.

2.3 Distinctiveness and Significance of This Study

Prior research addressing PBL and knowledge and information processing competency has accumulated across various contexts, including AI-integrated project design in university general English courses (Kim, M. K., 2023, 2025), analysis of competency-based project instruction effects in elementary English (Choi, 2025; Kim, J. Y., 2023) and other subject areas (Jang, 2018; Ju et al., 2024; Kim, E. J., 2024), and the development of measurement tools for knowledge and information processing competency (Baek et al., 2017; Jang et al., 2020; Son, 2023) or subject-specific core competencies (Ku, 2020). While these studies have contributed to understanding the effectiveness of PBL as an instructional framework for competency-based learning, research within the context of English education has tended to focus on isolated elements such as information searching or material utilization. Consequently, empirical studies that conceptualize knowledge and information processing competency as an integrated, process-oriented competency spanning the entire inquiry cycle remain limited.

More specifically, research examining semester-long career-integrated convergence topic inquiry projects in high

school English classes and explores how the processes of information exploration, judgment, analysis, reconstruction, and expression mediated through English manifest as changes in students' knowledge and information processing competency by combining quantitative change verification and qualitative experience analysis has not been sufficiently conducted. Therefore, this study aims to fill existing research gaps and provide empirical evidence for cultivating knowledge and information processing competency in English education by exploring the impact of career-integrated convergence topic inquiry projects implemented in high school English classes on students' knowledge and information processing competency in English through an explanatory sequential mixed-methods design. The research questions of this study are as follows:

1) Do high school students' knowledge and information processing competency in English (overall domains and sub-elements) show statistically significant changes before and after participation in career-integrated convergence topic inquiry projects?

2) How do learners' specific experiences and perceptions during the project explain and complement changes across the sub-domains of knowledge and information processing competency?

3. Methodology

3.1 Research Design

This study employed an explanatory sequential mixed methods design based on a one-group quasi-experimental design to comprehensively explore the impact of career-integrated convergence topic inquiry projects on high school students' knowledge and information processing competency in English education (Creswell & Plano Clark, 2017). The explanatory sequential design first collects and analyzes quantitative data to identify overall patterns of change, then complements and interprets these results through qualitative data. In this study, pre- and post-project changes were analyzed through a survey on knowledge and information processing competency in English, followed by in-depth exploration through student interviews of how these changes were formed within specific learning experiences and contexts. This research design aims to capture the direction and level of competency change through quantitative analysis while multidimensionally understanding the process and meaning of such changes through qualitative analysis (Fetters et al., 2013).

3.2 Participants

Participants in this study were students enrolled in a high school located in Chungcheongnam-do, South Korea, which had been designated as an AI Convergence Curriculum Leading School. The school implements project-based learning in English classes using digital tools, including generative AI, and the present study was conducted within this educational context. For the quantitative phase, a total of 148 students were selected through stratified sampling to ensure balanced representation across grade levels: 50 first-year students, 49 second-year students, and 49 third-year students. For the qualitative phase, in-depth interview participants were selected through convenience sampling, focusing on students who could relatively richly explain learning processes and changes in perception based on their project implementation experience, resulting in nine students total—three from each grade level. Participants' English proficiency levels were identified as CEFR B1–B2 based on the school-level English achievement data and teachers' professional judgment. Prior to participation, all students and their legal guardians were fully informed of the study's purpose and procedures, and written consent for voluntary participation was obtained. All collected data were anonymized and used solely for research purposes, and participants were explicitly informed that their participation and responses would have no impact on academic evaluation.

3.3 Research Procedure

This study was conducted over 17 weeks during the first semester, beginning in the second week of March 2025. The project was primarily operated during regular English class periods of three sessions per week, with students' voluntary individual or team activities after school conducted as needed. The career-integrated convergence topic inquiry project was designed and operated as a major performance assessment task in the English curriculum for each grade level, with students performing the entire topic inquiry process using English as the medium of instruction. In terms of research procedures, a project orientation and pre-survey on knowledge and information processing competency in English were conducted in Week 1, followed by phased project activities from Week 2 to Week 16. After project completion, a post-survey was conducted in Week 17, and semi-structured interviews were conducted with selected students to explore in-depth the changes in knowledge and information processing competency and learning experiences that emerged during the project implementation process.

The career-integrated convergence topic inquiry project was designed to enable students to conduct English-based information inquiry reflecting their career interests and was structured in six stages to allow stepwise experience of the entire process of knowledge and information processing competency. In Stage 1 (Topic Selection), students selected a specific topic connected to their career interests under a shared overarching theme, such as sustainable futures. During this stage, students identified problems or tasks and defined the scope of their inquiry. For example, students aspiring to be environmental engineers chose renewable energy technology, those aspiring to be fashion designers chose sustainable fashion, those aspiring to be teachers chose environmental education programs, and those aspiring to be business managers chose topics such as corporate ESG management. In Stage 2 (Information Search Planning), students established search scopes for collecting English-language materials and identified key search terms in English. In Stage 3 (Data Collection), students collected materials using various media centered on English-language sources and evaluated the reliability and appropriateness of materials. In Stage 4 (Data Analysis), students systematically analyzed and interpreted collected materials to organize core content. In Stage 5 (Outcome Production), students produced English-language outcomes based on analysis results. Finally, in Stage 6 (Presentation and Sharing), students presented and shared their completed outcomes in English and extended their learning content through Q&A and feedback with their peers.

3.4 Data Collection and Analysis

Data collection and analysis followed an explanatory sequential mixed-methods design, proceeding from quantitative data collection and analysis to qualitative data collection and analysis. First, in the quantitative phase, a survey instrument was developed based on the knowledge and information processing competency measures proposed by Jang et al. (2020) and Baek et al. (2017). The items were reconstructed to fit the context of English education, and content validity was established through expert review by two doctoral researchers specializing in English education (see Appendix A). The survey consisted of 30 self-report items across four upper domains and eight sub-domains: problem and task recognition (problem and task identification), knowledge and information planning (scope setting, media selection, and material evaluation), knowledge and information processing (analysis and interpretation), and knowledge and information utilization (production and presentation). Responses were recorded on a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). Reliability verification of the survey indicated high internal consistency, with Cronbach's α values for the pre- and post-surveys total items and each sub-domain ranging from .788 to .922 (Hair et al., 2019). The survey was conducted before and after the project implementation, and the collected data were analyzed using SPSS (Statistical Package for the Social Sciences) version 27.0. Paired-samples t-tests were conducted to examine differences between pre- and post-test scores, and Cohen's d was calculated as the mean difference divided by the standard deviation of the paired difference scores to estimate effect sizes.

In the qualitative phase, semi-structured individual interviews were conducted to gain deeper insights into the statistically significant changes and salient patterns identified in the quantitative results. The interviews focused on exploring students' perceptions and experiences related to English-mediated information inquiry processes, strategies for utilizing information, and experiences with product creation and presentation (see Appendix B). Collected interview data were transcribed after recording and inductively analyzed through thematic analysis (Braun & Clarke, 2019). Through the identification of recurring meaning units, categories and themes were derived to explain and complement the quantitative findings and to provide a broader interpretation of the contexts and processes underlying changes in knowledge and information processing competency. Through this, the study aimed to enhance the interpretive validity of research findings by providing an in-depth explanation of change patterns confirmed through quantitative analysis with qualitative data (Morgan, 2014).

4. Findings

4.1 Quantitative Findings

To examine the effects of the career-integrated convergence topic inquiry project on knowledge and information processing competency in the context of English education, paired-samples t-tests and Cohen's *d* effect sizes were calculated (see Table 1). First, the overall mean of knowledge and information processing competency improved by .203 points from a pre-test mean of 3.624 (*SD* = .614) to a post-test mean of 3.827 (*SD* = .639), showing a statistically significant difference ($t = 2.870$, $p = .005$), with an effect size of Cohen's $d = .236$, indicating an effect between small and moderate in magnitude. At the upper domain level, statistically significant improvements were observed across all four upper domains: problem and task recognition (increase of .189 points, $t = 2.219$, $p = .028$, $d = .182$), knowledge and information planning (increase of .219 points, $t = 3.023$, $p = .003$, $d = .249$), knowledge and information processing (increase of .185 points, $t = 2.377$, $p = .019$, $d = .195$), and knowledge and information

utilization (increase of .206 points, t = 2.711, p = .008, d = .223). Among the eight sub-domains, the greatest improvements were observed in scope setting (increase of .288 points, t = 3.515, p = .001, d = .289) and production (increase of .241 points, t = 2.892, p = .004, d = .238). Statistically significant improvements were also found in media selection (increase of .172 points, t = 2.326, p = .021, d = .191), material evaluation (increase of .198 points, t = 2.415, p = .017, d = .199), analysis (increase of .189 points, t = 2.138, p = .034, d = .176), interpretation (increase of .181 points, t = 2.406, p = .017, d = .198), and presentation (increase of .170 points, t = 2.093, p = .038, d = .172), indicating significant gains across all sub-domains.

These quantitative results demonstrate that the career-integrated convergence topic inquiry project had a positive impact on students' overall knowledge and information processing competency in English, with relatively large effects in scope setting for information exploration and outcome production abilities. However, numerical results alone cannot fully explain how these statistical changes emerged during the actual project process, what experiences students had while exploring and utilizing English-language sources, or how career-connected inquiry shaped the meaning of information processing. Therefore, the following qualitative analysis aims to explore the concrete learning experiences and underlying dynamics that led to changes in knowledge and information processing competency based on learners' in-depth interviews.

Table 1. Pre- and Post-Test Comparison of Knowledge and Information Processing Competency in English

Domain	Pre-test *M* (*SD*)	Post-test *M* (*SD*)	Mean Difference	*t*	*p*	Cohen's *d*	95% CI for *d*
Overall	3.624 (.614)	3.827 (.639)	.203	2.870	.005**	.236	[.072, .399]
1. Problem/Task Recognition	3.615 (.776)	3.804 (.721)	.189	2.219	.028*	.182	[.020, .345]
1.1. Problem and Task Identification	3.615 (.776)	3.804 (.721)	.189	2.219	.028*	.182	[.020, .345]
2. Knowledge and Information Planning	3.644 (.617)	3.863 (.631)	.219	3.023	.003**	.249	[.085, .412]
2.1. Scope Setting	3.604 (.693)	3.892 (.721)	.288	3.515	.001***	.289	[.124, .453]
2.2. Media Selection	3.672 (.630)	3.843 (.642)	.172	2.326	.021*	.191	[.028, .353]
2.3. Material Evaluation	3.657 (.715)	3.855 (.708)	.198	2.415	.017*	.199	[.036, .361]
3. Knowledge and Information Processing	3.629 (.693)	3.814 (.696)	.185	2.377	.019*	.195	[.032, .358]
3.1. Analysis	3.613 (.738)	3.802 (.786)	.189	2.138	.034*	.176	[.013, .338]
3.2. Interpretation	3.645 (.734)	3.826 (.680)	.181	2.406	.017*	.198	[.035, .360]
4. Knowledge and Information Utilization	3.595 (.673)	3.801 (.699)	.206	2.711	.008**	.223	[.059, .386]
4.1. Production	3.543 (.770)	3.784 (.732)	.241	2.892	.004**	.238	[.074, .401]
4.2. Presentation	3.647 (.700)	3.818 (.733)	.170	2.093	.038*	.172	[.009, .334]

Note. N = 148; CI = confidence interval; *p < .05; **p < .01; ***p < .001.

4.2 Qualitative Findings

4.2.1 Experience of a Comprehensive Inquiry Process Beyond Fragmented Language Activities

Students perceived that the project provided a qualitatively different English learning experience compared to conventional English performance assessments. Whereas previous assessments often focused on fragmented measurement of discrete language skills—such as listening tests, vocabulary quizzes, or short speaking tasks—the present project enabled students to engage in the entire inquiry process, from topic selection and information searching to data analysis, product creation, and presentation, using English as an active tool for inquiry. In this process, students perceived that they naturally accumulated experience not only in merely improving linguistic proficiency but also in systematically organizing and managing English-language information.

Unlike previous English performance assessments that usually focused on a single skill, this project required

me to connect reading, writing, and speaking. I had to use English throughout the entire process, from choosing a topic to organizing information and creating a final product, which felt completely different. [Participant A, July 7, 2025; similar views were expressed by Participants C, F, and G]

Additionally, students responded that they came to use English not as "a language to be evaluated" but as "a tool for exploring their own career interests." This shift in perception helped build students' confidence in using English in authentic contexts. These qualitative findings support the quantitative result of significant improvement in the overall mean score of knowledge and information processing competency, suggesting that the convergent project experience combining language learning and information processing activities had a positive impact not only on learners' cognitive growth but also on affective attitudes toward English learning.

Instead of constantly worrying about whether my English was correct, I focused more on exploring topics related to my career interests. English wasn't just for tests anymore. It became my tool for exploring topics. [Participant F, July 9, 2025; similar views: A, D, E, G]

4.2.2 Developing the Ability of "Scope Setting" Through Career-Contextualized Inquiry Amid Information Overload

Regarding the "scope setting" that showed the greatest improvement in quantitative analysis, students perceived the process of demarcating boundaries of valid information—rather than simply collecting large volumes of information from vast online data—as the most critical yet challenging task of the project. Students stated that while they could easily access vast amounts of English-language resources through the internet and generative AI, this made it important to select information at a scope and level that aligned with their inquiry topics and career interests rather than collecting all information.

As the project progressed, I realized that setting an appropriate level and scope of information was more important than gathering everything. [Participant B, July 7, 2025; similar views: C, H, I]

Particularly while addressing topics directly connected to their careers, students explained that they began asking themselves "Why is this information necessary?" beyond mere curiosity, consequently developing strategies to gradually narrow and specify the search scope. This experience supports the quantitative finding that the scope setting domain showed the greatest improvement, suggesting that contextualized project design linking learners' real lives and career interest provided a critical framework for prioritizing and evaluating information.

I began selecting information based not on whether it was interesting, but on how it contributed to my career exploration. That question played a key role in specifying and refining the search scope. [Participant I, July 9, 2025; similar views: B, E]

4.2.3 Beyond Knowledge Consumers to Knowledge Producers: Strengthening Product Creation Ability

Improvement in the "production" area within the knowledge and information utilization domain emerged not simply as increased tool utilization ability but as a result of repeatedly performing experiences of structuring information and reconstructing meaning. Students responded that during the project process, rather than simply listing collected English-language materials, they had to select core content and reorganize it from their own perspectives to create it as various forms of outcomes such as visual materials, written reports, and presentation slides. In this process, students came to consider both "what should be communicated" and "how to present it" simultaneously, and this experience led to the development of information hierarchization and logical structuring abilities.

While creating the outcomes, I realized how important it was to prioritize information and build a clear structure. It was completely different from just collecting materials. [Participant D, July 8, 2025; similar views: A, G, H]

Additionally, students reported that through revising and supplementing outcomes via peer feedback and presentation processes, they came to perceive the production process as a cyclical thinking process rather than one-time output. This 'producer-oriented experience' provides important evidence explaining the quantitative finding of a relatively large effect size observed in the production sub-domain.

Through presentations and feedback, I kept refining my work. I realized that production is not a one-time task. [Participant F, July 7, 2025; similar views: G, I]

4.2.4 Generative AI and Digital Infrastructure as Cognitive and Affective Scaffolding

Students reported that generative AI and various digital tools played decisive supporting roles throughout the project process. Students perceived that generative AI such as ChatGPT played supportive roles across all stages of the project, including specifying inquiry directions, facilitating understanding of English-language materials, clarifying

complex concepts, and refining final English expressions. Through this support, students stated that they could reduce cognitive overload caused by linguistic barriers and allocate more cognitive resources to the core activity of "information processing."

> *When English materials were difficult, ChatGPT helped clarify the content and direction, so my thinking was not interrupted by language barriers. I could allocate more energy to the content. [Participant C, July 9, 2025; similar views: A, D]*

Additionally, students mentioned that various digital tools such as DBpia for academic material search and Canva for visual material production greatly enhanced the efficiency of information exploration and outcome production. This collaborative experience with digital tools became an opportunity for students to cultivate active digital literacy that goes beyond passively using technology to understanding the strengths and weaknesses of each tool and selectively utilizing them for specific purposes. Consequently, these experiences contributed to building students' confidence that they can actively respond to the information environment of future society.

> *By using multiple digital tools together, I was able to enhance the efficiency of both information search and creating outcomes. And, I could develop the ability to select appropriate tools according to specific purposes. [Participant F, July 8, 2025; similar views: D, E, H]*

5. Discussion

The findings of this study demonstrate that the career-connected convergent inquiry project implemented in high school English classes brought meaningful changes in students' knowledge and information processing competency, extending prior discussions of project-based and inquiry-oriented learning to the context of English education. Quantitative analysis revealed statistically significant improvements in overall competency as well as all upper domains and sub-elements. These results align with previous studies indicating that project-based and inquiry-centered instruction enhances learners' information processing and problem-solving competencies (Almulla, 2020; Jang, 2018; Ju et al., 2024; Mutanga, 2024), with significance lying in empirical confirmation of such effects within English classroom contexts. However, although the improvements observed in this study were statistically significant, the effect sizes remained small, which may reflect differences in subject domain, project duration, learner characteristics, or the self-report nature of the competency measure used in this study.

Qualitative findings provide multidimensional explanations of the specific contexts in which these quantitative changes emerged. Considering the limitations of Korean English education's focus on exam-oriented, fragmented language instruction (Choi et al., 2022; Kim & Lee, 2025), this study demonstrated that process-oriented, integrated competency development is achievable when students directly experience the complete inquiry cycle from information search to outcome production. Unlike conventional performance assessments measuring discrete language functions, students perceived English as a "tool for career exploration" rather than an "assessment object" through this project, and this perceptual shift led to more positive perceptions of English use in authentic contexts. This finding empirically supports that English can function as a practical mediating tool for knowledge construction beyond merely as a learning target (Syrbe & Rose, 2021).

Notably, the "scope setting" domain, which showed the greatest improvement in quantitative analysis, reveals that career interests functioned as critical filters for determining valid boundaries within vast English-language resources. This empirically supports previous research indicating that cognitive engagement and critical judgment are strengthened when learners' personal interests combine with real-life contexts (Beier et al., 2019; Zhang, 2022). Furthermore, improvements in "production" domain demonstrate that students transitioned beyond mere consumption of English materials to knowledge producers who reconstruct meaning and organize content from their own perspectives. This confirms that the organic integration of English communicative competency and knowledge and information processing competency, as emphasized in the 2022 Revised National Curriculum, is implementable in actual classrooms (Ministry of Education, 2022b), extending competency research from other subject areas (Jang, 2018; Ju et al., 2024) to English education and presenting a practical model for competency-based instructional design in English education.

Finally, the role of generative AI and digital tools offers new implications for digital transformation in English education. In this study, AI was not merely as a convenience tool but as "cognitive and affective scaffolding" that reduced cognitive overload from linguistic barriers and enabled learners to concentrate on higher-order information processing activities. This extends Kwack and Uhm's (2025) discussion of digital literacy as a mediating factor in competency development, confirming that technology can serve as essential infrastructure supporting learners'

autonomous knowledge structuring processes. However, the reduction in cognitive load was not directly measured but inferred from students' self-reported experiences; thus, it is more appropriate to interpret this finding as indicating that students perceived AI as a form of scaffolding, rather than as evidence of its causal effect.

6. Implications

The findings of this study provide several concrete implications for high school English education and competency-based curriculum design. First, English performance assessment systems need to shift from evaluating final products focused on discrete language skills toward process-trace centered approach that captures the entire inquiry cycle. The overall improvement in students' knowledge and information processing competency observed in this study was closely associated with their experience of conducting the full inquiry cycle—topic selection, information search, analysis, production, and sharing—in English. Accordingly, English assessment should transition toward process-tracking assessment that evaluates not only the quality of final products but also the criteria students used for information exploration and the rationale for selecting and reconstructing materials. For example, by collecting and assessing search-term evolution, material selection rationales, and decision records about AI use through reflective journals or digital portfolios, English assessment systems can expand beyond linguistic accuracy to encompass thinking processes and information processing competency.

Second, this study suggests that generative AI and digital tools can function as cognitive and affective scaffolding that enables competency-based learning rather than merely as efficiency-enhancing tools. This indicates that AI integration in English classrooms should be reconceptualized not as a matter of "preventing academic dishonesty" or "whether to permit," but rather as "at which stages and for what purposes" to utilize it. For instance, teachers can design AI integration models that maintain learners' cognitive agency by clearly defining stage-specific AI roles: guiding students to use AI for scope setting and concept refinement in early exploration stages, while limiting its role to expression revision and structural review in the production stages. Additionally, critical AI literacy education is essential, teaching students to verify the accuracy of AI-generated information, cross-check multiple sources, and ultimately reconstruct content in their own language.

Third, the direction of teacher professional development needs to be reconsidered. Successful implementation of career-connected convergent inquiry projects demands that teachers possess not only English subject expertise but also multifaceted competencies including "career-connected curriculum design capacity" to identify students' career interests and connect them to curriculum, "technology integration competency" to incorporate digital tools and AI into instruction, and "assessment expertise" to design and implement process-oriented evaluation. Therefore, pre-service teacher education programs and in-service professional development should incorporate PBL design practice, AI-integrated pedagogy, and digital portfolio-based assessment as core content, while establishing professional learning communities where teachers can collaboratively design projects and share implementation practices.

7. Conclusion

This study examined the impact of a career-connected convergent inquiry project implemented in high school English classes on students' knowledge and information processing competency through a mixed-methods approach. Quantitative results showed significant improvements not only in overall competency levels but also across all upper domains and sub-elements, while qualitative findings specifically explained how these changes emerged through learning experiences in which students engaged in the entire inquiry process in English. Notably, students experienced English as a tool for career exploration rather than an assessment object, developing confidence in authentic contexts. Career interests functioned as critical filters for determining appropriate scope within information-rich environments, and students transitioned into knowledge producers through reconstructing information into outputs. Additionally, generative AI and digital tools functioned as cognitive and affective scaffolding that reduced linguistic barriers and enabled learners to focus on core information processing activities. These findings provide empirical evidence that project-based learning can effectively integrate the development of language proficiency and knowledge and information processing competency in English education, offering significance by presenting a practical model for competency-based English education as envisioned in the 2022 Revised National Curriculum.

Despite these contributions, this study has several limitations. First, generalizability is limited as the research was conducted at a single school designated as an AI Convergence Curriculum Leading School with relatively

well-developed digital infrastructure and project-based learning experience. It may be difficult to expect similar effects in school environments with limited digital tool accessibility or where teachers lack experience in implementing PBL. Second, the one-group pretest-posttest design without a control group makes it difficult to clearly distinguish whether observed competency improvements resulted purely from project effects or from natural maturation over the semester or other educational influences. Third, reliance on self-report surveys for measuring knowledge and information processing competency may have reflected students' perceptions rather than actual performance, with possible social desirability bias.

Future research should address these limitations through multi-level sampling designs across diverse school types (e.g., general, specialized, and vocational high schools) and regional contexts (e.g., urban and rural settings and varying levels of digital infrastructure), along with quasi-experimental or experimental designs including comparison groups to more rigorously verify the effects of career-connected convergent inquiry projects. In particular, longitudinal studies tracking the sustainability and transfer of competency gains are also warranted to compare project-based learning with traditional English classes. In addition, beyond self-report surveys, performance-based assessment that analyze actual artifacts and performance data generated during inquiry processes would enable more precise measurement of how knowledge and information processing competency is manifested in practice. Furthermore, subsequent research should explore the multiple conditions and structural factors necessary for effective implementation of competency-based project learning in English education by examining differential impacts of AI utilization patterns, teacher variables (PBL implementation experience, digital literacy, teaching efficacy), and interdisciplinary integration contexts beyond English. Through such follow-up studies, theoretical and practical understanding of competency-based project learning in English education can be further deepened.

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Appendix A. Survey Items (Knowledge and Information Processing Competency in English Education)

Response: 5-point Likert scale (1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

1. Problem and Task Recognition

1.1 Problem and Task Identification

1.1.1 I can independently identify problems or tasks that I need to address in the English learning process.

1.1.2 I can recognize the importance of problems or tasks that need to be solved in the English learning process

2. Knowledge and Information Planning

2.1 Scope Setting

2.1.1 I can set an appropriate scope for information searching when collecting English materials.

2.1.2 I can generate key search terms (keywords) for exploring English materials and information.

2.1.3 I can selectively search for up-to-date English materials.

2.2 Media Selection

2.2.1 I can select appropriate media (e.g., books, newspapers, internet, social media, videos, AI, etc.) for collecting English materials.

2.2.2 I understand the characteristics, advantages, and disadvantages of various media (e.g., books, newspapers, internet, social media, videos, AI, etc.) for collecting English materials.

2.2.3 I can collect English materials using various offline media (e.g., books, newspapers, textbooks, etc.).

2.2.4 I can collect English materials using various online media (e.g., internet, e-books, videos, social media, AI, etc.).

2.2.5 I can seek advice or assistance from experts in related fields through various methods in English (e.g., email, interviews, etc.).

2.3 Material Evaluation

2.3.1 I can judge whether the collected English materials are appropriate for my purpose.

2.3.2 I can select materials that will be helpful for solving the task from among the collected English materials.

2.3.3 I can judge whether the sources of the collected English materials are reliable.

2.3.4 I can judge whether the collected English materials violate personal information privacy or copyright.

3. Knowledge and Information Processing

3.1 Analysis

3.1.1 I can organize the collected English materials so that they can be easily found.

3.1.2 I can systematically organize the collected English materials.

3.1.3 I can reorganize the collected English materials by transforming them into visual forms graphs, charts, etc.

3.1.4 I can properly organize and cite the sources of the collected English materials.

3.2 Interpretation

3.2.1 I can evaluate the quality of English materials based on criteria such as the reliability, accuracy, and validity.

3.2.2 I can prioritize English materials.

3.2.3 I can make value judgments about English materials.

3.2.4 I can summarize the core content of English materials concisely.

4. Knowledge and Information Utilization

4.1 Production

4.1.1 I can select and edit the content necessary for producing English outcomes (products).

4.1.2 I can select appropriate production tools or software necessary for creating English outcomes (products).

4.1.3 I can create English outcomes (products) using various tools or software.

4.2 Presentation

4.2.1 I can explain my English outcomes (products) to others in English.

4.2.2 I can exchange opinions about my English outcomes (products) with others in English.

4.2.3 I can guide others in English so that they can easily review my English outcomes (products).

4.2.4 I can share my English outcomes (products) using social media or similar platforms.

4.2.5 I can receive feedback and answer questions in English about my shared English outcomes (products).

Appendix B. Semi-structured Interview Questions

1. Can you describe your overall experience with the career-connected convergent inquiry project? What were your initial thoughts when you first heard about this project?

2. How was this project different from previous English performance assessments or learning activities you've experienced?

3. What aspects of the project were most challenging for you? What aspects were most enjoyable or rewarding?

4. How did you choose your inquiry topic? What was the connection between your chosen topic and your career interests?

5. Did connecting the project to your career interests affect your motivation or engagement? If so, how?

6. How did your perception of the relationship between English learning and career exploration change through this project?

7. How did you plan your information search at the beginning of the project? What strategies did you use to set the scope of your research?

8. What criteria did you use to determine whether information was relevant and appropriate for your project?

9. Can you describe a situation where you had to narrow down or refine your search scope? What made you decide to adjust it?

10. How did you select keywords for searching English-language materials? Did your keyword selection strategy change as the project progressed?

11. What types of media or sources did you use to collect information? Why did you choose those particular sources?

12. How did you evaluate the reliability and credibility of the English-language materials you found?

13. Did you encounter any unreliable or inappropriate sources during your research? How did you identify and handle them?

14. How did you analyze and organize the English-language materials you collected? What process did you follow?

15. What strategies did you use to understand complex or difficult English texts? Can you give a specific example?

16. How did you determine which information was most important or relevant to your research question?

17. Did you notice any patterns, connections, or contradictions among different sources? How did you handle them?

18. Can you describe the process of creating your final product? What did you consider most important while producing it?

19. How did you transform the collected information into your own product? What was different from simply summarizing the materials?

20. Did you receive any feedback during the production process? How did you incorporate feedback to revise your work?

21. How did you decide on the structure and organization of your final product? What principles guided your decisions?

22. How did you prepare for your final presentation in English? What aspects were most challenging?

23. What did you learn from presenting your work and receiving questions from peers? How did it affect your understanding of your topic?

24. Did your confidence in using English for authentic communication change through the presentation experience? How?

25. What role did generative AI (such as ChatGPT) play throughout your project? At which stages was it most helpful?

26. How did AI and digital tools help you overcome language barriers or difficulties in understanding English materials?

27. What other digital tools did you use besides generative AI? How did you decide which tool to use for specific purposes?

28. Do you think using AI and digital tools changed the way you processed information? How did it affect your thinking process?

29. Has your perception of English changed through this project? Do you now view English differently as a learning subject versus a practical tool?

30. Looking back at the entire project, what competencies or skills do you think you developed most? How might you apply what you learned to your future studies or career?

Author Statements

Author(s) declared the statement below:

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Writing – original draft, Writing – review and editing, Conceptualization, Data curation, Software, Methodology, Project administration, Resources, Supervision, Validation: Dr. Whyunyoung Choi, 0009-0007-1693-3066

Consent for Publication

All authors have read and approved the published version of the manuscript.

Funding

This research received no external funding.

Declaration of Competing Interest

The author has no conflicts of interest to declare.

Informed Consent

Informed consent was obtained from all participants.

Ethics Approval

This work involved human subjects in its research. All procedures followed the ethical principles and guidelines for research at (Kongju Keumsung Girls' High School, KKGH-2396, 13-03-2025).

Data Availability Statement

The data that support the findings of this study are available from the author upon reasonable request.

Use of Artificial Intelligence

The author used ChatGPT-5.6 & Grammarly for language editing and grammar improvement. The author reviewed and verified all AI-assisted revisions and take full responsibility for the final content of the manuscript.

Supplementary Materials

Appendix A: Survey Items (Knowledge and Information Processing Competency in English Education)

Appendix B: Semi-structured Interview Questions

Journal Information

The Editorial Board declared the below statement on behalf of the journal and publisher.

Ethics Statement

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Preservation Policy

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