INDONESIAN JOURNAL OF APPLIED LINGUISTICS
Vol. 13 No. 3, January 2024, pp. 477-489

Available online at:
https://ejournal.upi.edu/index.php/IJAL/article/view/66933

https://doi.org/10.17509/ijal.v13i3.66933

STEAM pedagogy in foreign language education: An endeavour to broaden CLIL pedagogy through 6E's framework

David Imamyartha[1], Utami Widiati[2*], Aan Erlyana Fardhani[3], Alifiyah A'yunin[4], Mitasari[5], Galuh Candraning Hapsari[6]

[1,2]*Doctorate Program in ELT, Faculty of Letters, Universitas Negeri Malang, Jl. Semarang No. 5, Malang 65145, Indonesia*

[1,3,4,5,6] *Undergraduate Program in ELT, Faculty of Education, Universitas Jember, Jl. Kalimantan No.37, Jember 68121, Indonesia*

ABSTRACT

This study addressed the dilemma in Content and Language Integrated Learning (CLIL) teaching. It argued that a STEAM pedagogy (Science, Technology, Engineering, Arts, and Mathematics) can inform and broaden CLIL pedagogy through 6E's framework (*engage, explore, explain, engineer, enrich,* and *evaluate)*. The authors first theoretically highlighted how STEAM pedagogy addressed some of the issues concerning CLIL instruction and showed that 6E's framework cohered with the 4C's (*culture, content, cognition,* and *communication)* of pluriliteracies approach to CLIL. We then actuated this conceptualization through a case study exploring Indonesian EFL learners' engagement in 16-meeting CLIL lessons by examining their multidimensional learning experiences, affectivity, and emotionality. Data were oriented to the contextual variables of effective learning from learners' standpoint and collected through Academic Emotion Questionnaire (AEQ), language learning attitude battery, and reflection sheet distributed to 204 college learners in six CLIL classes with 6E's framework. The findings demonstrated the potency of 6E's framework to provide vital scaffolding for discipline-specific literacies through scientific inquiry in language learning. The framework stimulated intensive multidimensional learning, positive academic emotions, and positive attitudes toward CLIL lessons. Students' reflections underscored how the framework paved engaging authentic language tasks and science projects as essential drives for intrinsic motivation to learn content and language despite limited linguistic repertoires.

Keywords: CLIL; foreign language education; pluriliteracies approach; STEAM pedagogy

First Received:	Revised:	Accepted:
5 April 2022	26 May 2023	3 December 2023
Final Proof Received:		**Published:**
19 January 2024		31 January 2024

How to cite (in APA style):

Imamyartha, D., Widiati, U., Fardhani, A. E., A'yunin, A., Mitasari, M., & Hapsari, G. C. (2024). STEAM pedagogy in foreign language education: An endeavour to broaden CLIL pedagogy through 6E's framework. *Indonesian Journal of Applied Linguistics*, *13*(3), 477-489. https://doi.org/10.17509/ijal.v13i2.66933

INTRODUCTION

This study amplifies the discussion on the conundrum of Content and Language Integrated Learning (CLIL) instruction through research and pedagogy perspectives. In terms of research, widely found problematic is the primary emphasis on CLIL's instrumental goal of attaining assessment threshold, while treating the educational orientation to meaningful content-language mastery as a peripheral concern (Meyer et al., 2015). Furthermore, CLIL studies have yet to pay sufficient attention to the tertiary context (Porto, 2018) since the majority of studies delve into primary and secondary education. In terms of pedagogy, CLIL instruction is also perplexing since artificially timed tasks generally hold a predominant role when

* Corresponding Author
Email: utami.widiati.fs@um.ac.id

productive skills become a primary concern (Roquet & Pérez-Vidal, 2017). The conundrum is also exacerbated by the prevalence of the input-transfer approach with very little space for learners' autonomy, which signifies the lack of deep learning (Meyer et al., 2015). Even in Europe, the majority of CLIL instructions have been driven by language pedagogy and the resultant literacy skills have been irrelevant to subject learning due to the scarce emphasis on subject learning pedagogy (Mahan, 2020; Meyer et al., 2015; Porto, 2018; van Kampen et al., 2018).

Framing the Study

While the discussions on *ideal* CLIL in Europe and America persist, even after three decades of its first inception, CLIL teachings in the Indonesian context are hardly reported, with its praxis and learning gains therefrom generally characterized by lay theories and teacher beliefs. Extending this research significance is the fact that the Indonesian Directorate of Higher Education (2020) underscores the link beyond the correlation between tertiary education and the professional arena, challenging learners to stay on par with the rapidly changing future at the world level. This agendum mirrors the rationale behind CLIL proliferation across Europe driven by school internationalization. This aims to educate multiliterate, multilingual, and multicultural graduates to better express their expertise within multicultural international settings (Aguilar, 2017). In this scenario, we argue that CLIL instruction remains in dire need of aligning with Coyle's (2007, p. 550) notion of ideal CLIL which can be obtained "through progression in knowledge, skills, and understanding of the content, engagement in associated cognitive processing, interaction in the communicative context, and the development of appropriate language knowledge and skills as well as experiencing a deepening intercultural awareness". Given the contextual dynamics of CLIL instruction driven by social, cultural, political, and academic bearings (Zhu & Wang, 2020), the call for a relevant instructional strategy to reach an ideal balance between content and language learning then appears fundamentally necessary in any teaching context (Mahan, 2020; Meyer et al., 2015; van Kampen et al., 2020). However, the current discourse on such a pedagogical quest seems to offer only little to inform CLIL's future praxis.

Only a few studies attempted to introduce systematic CLIL instruction (see Porto, 2017, 2018; van Kampen et al., 2020 for example). These studies build on Humanities pedagogy to actuate the ideal CLIL model and have demonstrated the potential of subject-learning pedagogy to gainfully integrate content and language learning. Porto (2018) conducted a case study involving two groups of college students from Argentina and England to study the history of the Malvinas War. The findings demonstrate how intercultural citizenship enables the teacher to integrate all language resources and skills throughout the negotiation of content. This is evident not only in students' learning products but also in the process and micro-dimensions of the class, as in the naturally occurring conversations. Most importantly, Porto's study has shown that through intercultural citizenship, CLIL can guide students to develop their democratic competencies and values through civic action. Investigating teachers' practices in teaching *Global Perspectives* in upper secondary education, van Kampen et al. (2020) reported on several combinations of teaching domain-specific academic skills and general skills within the framework of *Global Perspectives* instruction. Despite different teaching contexts and teachers' beliefs, their study demonstrates that focusing on discipline-specific culture and employing cognitive discourse function (CDF) help to reach impactful integration of content and language.

Given the emergent empirics on the encouraging potentials of Humanities pedagogy to reach effective CLIL (e.g., Porto, 2017, 2018; van Kampen et al., 2017, 2018, 2020), embarking on a different line of CLIL inquiry informed by Science pedagogy would lend itself to gaining a broader understanding of how effective CLIL can take place. We believe this gap merits equal research attention since the nature of a subject matter determines how an ideal CLIL takes place, which would otherwise enrich the discussion on CLIL pedagogy in a transdisciplinary setting. This premise is grounded in the idea that an individual subject or discipline has a distinctive set of CDFs as formulated in the knowledge and competencies to be acquired (Dalton-Puffer et al., 2018; Meyer et al., 2015; van Kampen et al., 2020). The present study aims to further bridge the gap between CLIL theory and practice by employing 6E's instructional framework developed for a STEAM pedagogy (Science, Technology, Engineering, and Mathematics). In the following section, we elaborate on how the 6E's framework corresponds to the CLIL approach.

Theoretical Frameworks

We attend to Coyle's (2007) 4Cs framework to reach ideal integration, which requires careful attention to learning content (content), cognitive processes (cognition), language (communication), and academic and societal cultural dimensions of learning (culture). Meyer et al. (2015) argue that how such integration takes shape and what it implies to classroom teaching are interpreted in diverse and limited ways, commonly restricted to curriculum development. In response, they propose a pluriliteracies approach to CLIL by drawing on the 4Cs framework. In the approach, learners should conceptualize disciplinary content in ways relevant to the discipline's C-*Culture* to construct knowledge

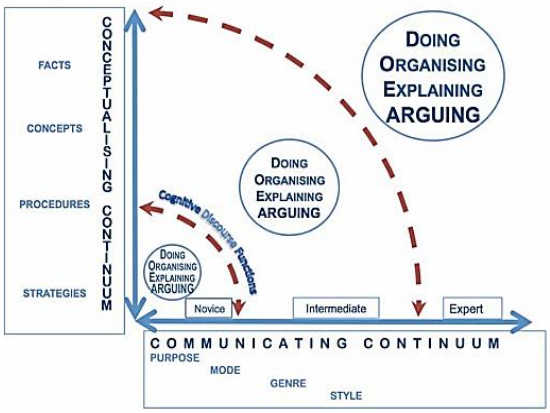
and develop discipline-related literacies. It is the discipline's C-*Culture* that determines how C-*Cognition* is operative in conceptualizing C-*Content* and how C-*Communication* is engaged to (co)construct knowledge. The approach requires active knowledge construction where learners need to engage with subject-specific texts to *language* their understanding for particular audiences through a wide array of modes. In Table 1, we highlight how STEAM tackles some of the issues documented in recent CLIL research and how it fits the pluriliteracies approach.

Table 1
Theoretical Connection among the Challenges to CLIL Instruction, STEAM Pedagogy, and Pluriliteracies Approach

Challenges reported in CLIL research	How STEAM pedagogy meets the challenges	Relation to CLIL's pluriliteracies approach
Input-based transmission approach dominated by teacher talk (Porto, 2018)	STEAM involves higher-order thinking, product-process-based learning, and collaborative inquiry-oriented toward authentic problem-solving (Bautista, 2021; Costantino, 2017; Struyf et al., 2019)	Pedagogy projected to the development of skills, ideas, and knowledge
Scarce emphasis on learning autonomy (Meyer et al., 2015; Porto, 2018)	STEAM creates a student-centered learning community through peers-led projects (Burns et al., 2020; Queiruga-Dios et al., 2021; Struyf et al., 2019)	The role of co-constructors of knowledge shared among learners
Extensive focus on receptive language skills (van Kampen et al., 2017)	Students engage in project-based learning which exposes them to multimodal input and output (Costantino, 2017; Graham, 2021; Zhu & Wang, 2020)	Authentic problem-solving tasks integrating content and knowledge
Inauthentic tasks and excessive orientation to examination (Lo & Jeong, 2018)	STEAM attends to a student-driven project which emphasizes creativity, authenticity, criticality, and aesthetics (Burns et al., 2020; Ortiz-Revilla et al., 2021)	Challenging tasks that demand the co-construction of knowledge in authentic problem-solving tasks
Incongruence between students' cognitive development and language proficiency (Porto, 2018)	STEAM focuses on authentic problem-solving tasks, which aids in developing pluriliteracies and subject-specific communicative competence (González-becerra, 2017)	Dual foci on the gradual increment of concept and communication mastery

Based on the conceptual links in Table 1, we extrapolate how STEAM pedagogy potentially aids in reaching effective CLIL teaching on both product and process dimensions. Concerning product, STEAM shares with CLIL the educational goal of acquiring meaningful disciplinary knowledge, understanding, and skills through meaningful learning experiences. The multimodality in the creative inquiry process engages deep cognitions to learn and communicate content to an authentic audience. Regarding the process, STEAM is congruent with CLIL's 4Cs approach as it appreciates a stimulating environment that exposes learners to multimodal resources in collaborative peer-led projects. In addition, STEAM coheres with Meyer's et al., (2015) pluriliteracies approach in that both value active involvement in authentic meaning-making within a resource-rich transdisciplinary setting. Figure 1 illustrates how both the product and process of STEAM pedagogy correspond to the simultaneous development of content mastery throughout the conceptualizing continuum and of language mastery along the communication pathway.

Figure 1
Mapping pluriliteracies development (Meyer et al., 2015, p. 49)



Since STEAM pedagogy embraces deep learning by harnessing real-life issues and the creative inquiry process (Queiruga-Dios et al., 2021), this allows the increment of meaningful discourse functioning specific to a content subject. As learners excel along the conceptual continuum, they explore four science activity domains: doing, organizing, explaining, and arguing science, with a gradual increment of complexity and depth. By implication, learners should be able to position themselves effectively along the communication

continuum by addressing three key determinants: what is the discourse context? who is the target audience, and what is the aim of discourse production? Meyer et al. (2015) highlight that the requisite for effective learning resides in learners' discourse mastery that positions themselves along the continuum. This emphasis on discourse mastery fits the teaching context in our study that emphasizes high linguistic demand while maintaining low cognitive demands as the instructional design in our study treats language learning as the precursor to support subsequent content learning (Coyle, 2007).

Equally crucial to our conceptualization is the fact that STEAM involves diverse modalities as learning input and output due to the inclusion of technology (Zhu & Wang, 2020). The 6E's framework coheres with Costantino's (2018) notion of the creative inquiry process as the former aids in creating more positive attitudes, content learning, and growing metacognitive and social development through multimodal discourse and cognitive processing. We believe that underpinning CLIL class with a pedagogy that values multimodal resources and peer-led inquiry helps expand classroom praxis, at least, to *approximate* effective CLIL. Not only does this multimodality align with multimodal semiotics in the pluriliteracies approach, but both also emphasize learning autonomy as students are encouraged to navigate diverse learning resources, particularly with the increasing roles of technology to support CLIL learning (Meyer et al., 2015). STEAM emphasizes the extent to which students can showcase their knowledge, understanding, and skills through a wide array of literacy activities within science discourse (English et al., 2017). This orientation to authentic assessment is aligned with how students actively make meanings and how they *language* their subject-specific domain knowledge. We attempt to make our conceptualization operational through STEAM 6E's instructional framework (see Lin & Chiang, 2019 for an example of the 6E learning model). Hereunder, we highlight how 4C's are engaged throughout 6E's framework.

(1) ***Engage***: This aims to pique students' interest and create a connection to prior knowledge and experience. It is concerned with *Content*, discipline-specific knowledge, in the CLIL framework, which students draw upon to scaffold the subsequent learning content.

(2) ***Explore***: Knowledge is constructed based on an individual's experiences and assumptions of the environment. This phase helps students to understand learning contents and identify the links between the contents under exploration. Essentially, this phase taps into *Content* and *Cognition* dimensions as students make meaning of disciplinary and linguistic information and draw increasingly complex relationships between units of information.

(3) ***Explain***: This phase intends to define what students know and consider valuable from the knowledge being learned. This stage involves *Communication* and *Culture* and draws on the communication extreme of pluriliteracies, with emphasis on content, audience, purpose, style, and mode. In the pluriliteracies approach, this stage marks the outset of deep learning throughout the last three phases as students reconceptualize, critically reflect, and communicate more complex concepts (Meyer et al., 2015).

(4) ***Engineer***: Students co-construct knowledge, understanding, and skills associated with Science, Technology, Engineering, and Mathematics from practical experiences. This phase allows *learning by doing*. This is achieved through examining complex problems, employing any means available, and designing strategies to solve problems (Struyf et al., 2019). Although not designed for language learning *per se*, these tasks expose students to discipline-specific genres and content knowledge. All C's are operative in the last three phases as students deploy their experience and expertise (*Content*) to construct ideas and products (*Cognition*) by interacting through multimodal texts (*Communication*) geared to a specific objective, audience, style, and mode (*Culture*).

(5) ***Enrich***: Students create deeper meaning upon encountering more complex and complicated problems, and this phase fosters their exploration to apply the understanding to more complex problems.

(6) ***Evaluate***: Teachers and students construct knowledge and meaning from evaluation according to the constructivism theory. The goal is to enable teachers and students to diagnose students' progress through the inception of project-based tasks oriented to respective CDFs which underpin the whole lesson.

We believe that this operational framework helps to develop discipline-related literacies by stimulating students' inquiry, higher-order thinking, product-process-based learning, and authentic problem-solving within transdisciplinary contexts. STEAM makes the links with the pluriliteracies approach explicit since transdisciplinary content serves as learning content and aids the shift from *learning to use the language* to *using the language to learn it*. In response to the growing need for fine-grained evidence of *successful* CLIL learning experiences from learners' standpoints, we examine the magnitude of learners' cognitive, affective, and

emotional outcomes that have been documented to drive engagement in CLIL lessons (Coyle, 2013). This is deemed essential to garnering balanced and complete evidence, rather than aiming at test scores that only partially describe successful learning beyond the actual learning context. To that end, the present study is guided by the following research questions (RQs):

a. (**RQ1**) To what extent does CLIL class with 6E's framework activate college English students' deep learning as embedded in their learning processes, thinking processes, and knowledge-creation efficacy?
b. (**RQ2**) What are the profiles of the students' academic emotions subsequent to their engagement in CLIL class with 6E's framework?
c. (**RQ3**) How does the students' engagement in CLIL class with 6E's framework influence their attitudes to CLIL learning?

METHOD

Context and Participants

The study was conducted at an Indonesian state university where English was taught as General English and content-based instruction. Initially, the research goal and procedure were introduced, and written consent was collected from the research participants. The first author was responsible for designing and teaching the lessons with the aid of one subject teacher qualified in Science education. The latter was only involved in developing the course materials and class observation. All six classes ran for 16 meetings, with each focused on different majors: Science Education, Mathematics Education, Nutrition Science, Public Health, Agriculture, and Civil Engineering. The participants were 204 freshmen with ages ranging from 17 to 19 years old enrolled in six different majors. Their language proficiency level was at A2 and B1 on the CEFR scale. These included 43 males and 161 females. Code-switching was operative to help the teacher sensitize himself to students' language difficulties and better adjust the lesson load accordingly (Coyle, 2007). In addition, all language skills were kept simple for a seamless introduction to new content.

We used the last unit, entitled '*Human and Climate Change*', to exemplify how 6E's were operative in our study. It was deemed the most complex compared to the previous ones as it involved more extended language input and output. As the names suggest, the last unit was also more conceptually complex due to the integration of a wider range of disciplines as indicated by the students' roles in Table 2. The unit was geared toward the following objectives:

a. Language learning objectives:
   - Identifying stated and implied details on climate change presented in explanatory texts and video
   - Composing short explanatory texts to clarify the solutions to climate change
b. Content learning objectives:
   - Defining and proposing solutions to climate change
   - Using the Internet to research and collate authentic resources to inform the solutions to climate change
   - Designing a model of *Climate-smart Living* as a solution to climate change.

Table 2
The sample lesson developed for all six classes

Meeting (100 minutes each)	Phase	Teacher Activities
One	Engaging	Guiding students to identify environmental hazards through pictures
	Exploring	Showing a video of climate change and guiding students' discussion on the causes, effects, and solutions of the environmental issue.
	Explaining	Assigning students to work in literature circles on texts related to climate-change issues in Indonesia
Two	Engineering	Guiding group project '*Climate-Smart Living'* with specific roles shared among students, i.e., project manager, environmental scientist, architect, and health expert, to create a house model to tackle climate change
		Facilitating students to explain a specific part of the model house in a brief explanatory paragraph (50 to 100 words) based on content-driven prompts, e.g., *why is this component important for your design?*
Three	Enriching	Giving feedback to students writing, focusing on content, organization, vocabulary, and language.
		Guiding peer assessment on each other's house model and giving constructive feedback using a project checklist, e.g., *the house structure withstands the effects of climate change.*
	Evaluating	Assigning the students to revise their writings based on peer and teacher feedback, with one student focusing on one specific part of their model house.

Measures

This study delved into students' cognitive, affective, and emotional outcomes after their engagement in CLIL lessons. This multi-facet investigation was deemed necessary as CLIL triggers sophisticated cognitions through problem-solving, co-restructuring knowledge, and translating novel insights into familiar concepts (Coyle, 2007). CLIL lessons may therefore lead to negative affectivity, rather than being a stimulus for learners' motivation to engage in CLIL lessons (Otwinowska & Foryś, 2017). In the same vein, positive and negative emotions influence students' cognition, motivation, behavior, and achievement (Pekrun et al., 2011).

Multidimensional Perceptions of Learning

Chai's et al. (2015) battery of multidimensional perceptions on learning was at play to fathom a wide range of pertinent learning and thinking processes, both extrapolated to be an essential drive for knowledge-creation efficacy. The emphasis on knowledge-creation efficacy finely fits the orientation toward deep learning as the core of the pluriliteracies approach. The survey items were distributed across seven areas comprising authentic problem solving (APS), self-directed learning (SDL), meaningful learning with technology (MLT), collaboration (CoL), critical thinking skills (CriT), creative thinking skills (CreT), and knowledge creation self-efficacy (KCE). Only 23 out of 32 items were included to ensure the brevity and sufficient completion rate of the overall research questionnaire. This was done by omitting one out of two or three items that shared common constructs.

Academic Emotion

The previous reports on the emotional outcome during and after the engagement in CLIL lessons substantiated the relevance of Pekrun's et al., (2011) Academic Emotion Questionnaire (AEQ). The questionnaire was helpful to gauge both positive and negative emotions at the class level and within individual learners as members of a learning community. AEQ was considered relevant to the research objective in that multiple events are pondered, including classroom-related emotion (CRE) and learning-related emotion (LRE). All sixteen items were involved.

Students' Attitudes to Language Learning

Due to the impact of the language learning approach on students' attitudes to English learning (Meyer et al., 2015; Otwinowska & Foryś, 2017), this study adapted Gardner's (2005) attitude/motivation battery to measure students' language learning attitudes. Only nine items on English learning were involved, each of which addressed students' attitudes to English learning. For a more holistic picture of students' learning experiences, the present study also deployed a retrospective reflection with the prompts below. Both prompts and responses were written in *Bahasa Indonesia.*

a. What is your opinion on the learning activities?
b. Are you motivated to learn English in the class?
c. What English language skills or components do you learn from the class?
d. What parts of the class do you think are difficult?
e. Do the learning activities help you learn content subjects (Health, Science, Agriculture, Engineering, Technology, and Mathematics)?

Data Collection and Analysis

Data were collected using a Likert scale with five options (1-*strongly disagree* and 5-*strongly agree*) and a guided reflection sheet. The quantitative instruments were translated into *Bahasa Indonesia*, with a trial of the former involving 35 freshmen in the non-English department. Reliability analysis documented α 0.901. At the end of the course, the researchers distributed the questionnaire to the participants in six classes, while the reflection was administered only to four classes, due to time constraints. Anonymity was ensured throughout data collection. The data from the 5-scale questionnaire were analysed through descriptive statistics using SPSS 26.

Attending to Braun and Clarke's (2006) thematic analysis, the authors collectively read the retrospective reflections closely to identify dominant codes and search themes from existing codes. Repeated reading on the reflections was done for careful identification and categorization of the codes by first highlighting the words that portrayed key concepts. The authors reviewed and redefined the codes into several categories. These categories were developed based on how particular codes were linked. The emerging categories aided in redefining the themes guided by the reflection prompts. These collective multiple reviews helped to ensure the accuracy of data interpretation and the research conclusion. The authors relied on lexical resources during data interpretation. For example, "*I realized that English is badly needed in the future. Also, as future health practitioner I need to be able to speak English well when later on engaging with real-life community"* was classified into the theme "*Intrinsic Motivation for Learning Content and Language".* This was because the participant had no informed understanding of intrinsic motivation, yet he relied on his common sense.

FINDINGS AND DISCUSSION

This section displays the research findings in correspondence with each of the research inquiries. Each of the following three sub-sections on the

research findings is directly discussed to address the corresponding inquiry, while also justifying its implications to the respective theoretical underpinnings.

The 6E's-based CLIL and Students' Deep Learning

The statistics revealed that the students reported substantial rates of multidimensional learning experiences.

Table 3
Students' Multidimensional Perceptions of Learning

Domains	Mean (M)	Standard of Error (SE)	Standard Deviation (SD)
Self-directed learning	4.1826	0.03674	0.52469
Meaningful learning with technology	4.2475	0.04443	0.63459
Collaboration	4.4167	0.03568	0.50956
Critical thinking	4.2917	0.04447	0.63516
Creative thinking	4.3448	0.04670	0.66698
Authentic problem solving	4.3676	0.03914	0.55897
Knowledge-creation efficacy	4.1152	0.04465	0.63766

As documented in Table 3, the students reported a strong willingness to monitor their learning, assumedly attributable to the discipline-related content as the drive to self-directed learning (M=4.1826). The statistics also affirmed robust meaningful learning with technology (M=4.2475). This experience exceeded the mere acquisition of language knowledge or skills, as technology-enhanced collaboration and research fostered creative and critical thinking, which form parts of deep learning in Meyer's et al., (2015) proposal. Another essential dimension with a promising trend was collaborative learning (M=4.4167). We believed that collaborative learning fuelled higher-order thinking as the students encountered different ideas in group discussions, and it gainfully reshaped the group's ideas. Porto (2018) contends that collaboration propels the co-creation of valuable artifacts in knowledge-creating communities as the students create and criticize ideas as well as products upon solving authentic problems. This argument was well acknowledged in the intensity of students' thinking processes associated with the authentic projects in the present study.

The data also discovered the high extent of criticality (M=4.2917), creativity (M=4.3448), and authentic problem-solving (M=4.3676). These three outcomes were believed to stem from the engineering activities that amplified collaborative inquiry, the activation of relevant knowledge, and discipline-related multimodal discourses (Greenier & Greenier, 2018). The transdisciplinary culture created motivating challenges through which content knowledge and cognition were expanded throughout discipline-related literacies. This premise resonated with the value of authentic problem-solving to foster students' reconstruction of knowledge and understanding as they drew on their familiarity with discipline-related information. Meyer et al., (2015) posit that access to discipline-related language through such an authentic learning experience allows students to explore the possibility to acquire knowledge, skills, and understanding of their subject. In congruence, Coyle (2007) deems such a genuine learning context as an essential component to reconstructing discipline-related knowledge along with relevant cognition, mediated by authentic language input and output.

Eventually, the fact that students reported high means of knowledge-creation efficacy (M=4.1152) evinced that 6E's empowered students to co-construct knowledge representation. 6E's offered a stimulating learning environment to channel students' collaborative inquiry toward deep learning within a transdisciplinary setting while affording them more learning ownership (Costantino, 2017; Meyer et al., 2015). The knowledge co-construction activities framed in 6E's stimulated intense learning processes and thinking processes as they had to draw on their full conceptual and linguistic repertoires. Referring to Coyle's (2007) notion of effective CLIL learning, the intensity of learning processes (i.e., collaboration, self-directed learning, and meaningful learning with ICT) manifest students' noteworthy involvement in interactive communication as the outset to sustainably explore the subject-discipline cultures through technology, both as an individual learner and as a member of learning community. In the same vein, the magnitude of thinking processes (i.e., creativity, criticality, and authentic problem-solving) attested to the encouraging potential of 6E's framework to help students develop their knowledge, understanding, and skills of content as they gain deeper engagement in subject-specific projects where the abovementioned three elements were influential to the project accomplishment.

Students' Academic Emotions after Experiencing the 6E's-based CLIL

Table 4 documents the magnitude of positive academic emotions germane to the class atmosphere and learning experience, and contingently scanty negative emotions.

Table 4
Students' Academic Emotions

Domains		*M*	*SE*	*SD*
Positive class-related emotions	Enjoyment	4.6078	.04357	.62236
	Hope	4.1127	.05864	.83756
	Pride	4.1863	.05222	.74583
Negative class-related emotions	Anger	1.5049	.06463	.92314
	Anxiety	1.8431	.06719	.95973
	Shame	1.6716	.06967	.99505
	Hopelessness	1.6667	.07042	1.00573
	Boredom	1.4608	.05992	.85583
Positive learning-related emotions	Enjoyment	4.5343	.04015	.57347
	Hope	4.1225	.06017	.85942
	Pride	3.7696	.06180	.88271
Negative learning-related emotions	Anger	1.3922	.05702	.81436
	Anxiety	2.0049	.07999	1.14254
	Shame	2.5637	.09037	1.29069
	Hopelessness	1.5735	.06016	.85931
	Boredom	1.3627	.04844	.69181

Table 5
Students' Attitudes toward English Learning

Aspects	*M*	*SE*	*SD*
I really enjoy learning English.	3.7892	0.85367	0.05977
English is an important part of the school program.	4.4951	0.69124	0.04840
I plan to learn as much English as possible.	4.4363	0.71635	0.05015
I would really like to learn English	4.3775	0.79387	0.05558
Studying English is an enjoyable experience.	4.4755	0.71189	0.04984
English is one of my favorite courses.	3.8186	1.00317	0.07024
I really work hard to learn English.	4.2353	0.75823	0.05309
I enjoy the activities of our English class much more than those of my other classes.	3.9657	0.92251	0.06459
My English teacher has a dynamic and interesting teaching style.	4.8039	0.45571	0.03191

Table 5 portrays positive attitudes to the learning experiences in CLIL lessons. The students acknowledge substantial enjoyment (*M*=3.7892), and values of the lessons (*M*=4.4951), particularly attributed to the learning activities (*M*=3.9657) and instructional structures the teacher put at play (*M*=4.8039). As a corollary, these attitudinal outcomes gave rise to long-term self-regulated learning (*M*=4.4363), a finding analogous to the self-directed learning reported earlier. In the same wavelength, the following sub-sections report on students' reflections with three emerging themes: 1) holistic and authentic language learning, 2) increased motivation for content and language learning, and 3), enhanced knowledge, understanding, and skills related to a content subject through peer-led projects. All names presented are pseudonyms.

Holistic and Authentic Language Learning

STEAM pedagogy embraced multimodal language learning and enabled students to resort to their entire language repertoires upon engaging with authentic language learning. Instead of merely learning language theories, they actively used the language for meaningful purposes within an academic context.

Juli *I learnt different language skills through different projects. The digital portrait helped me to structure proper paragraphs; the water filter project helped me improve my writing and speaking performance; and the Book of Earth helped me to learn listening and writing; and in the climate-smart living I learnt all language skills.*

Juli's voices demonstrated how diverse projects catered to different language modalities, thus allowing the lesson to meet students' needs and wants better. Peer-led engineering activities opened diverse paths to various cognitive discourse functionings structured by the tasks and helped them navigate across conceptual-communication continua. Meyer et al., (2015) espouse that discipline-specific literacies encompass written text, visual/audio resources, non-verbal communication, graphic representation, and action. This engagement of multimodal texts helped to compensate for limited linguistic repertoires and thus fostered language performance as well as content learning within the reach of students' proficiency.

In harmony with Burns et al. (2020), the mathematical, scientific, and technological practices in this study were congruent with the pluriliteracies model in that both attended to multimodal communication and various cognitive discourse

functionings. Language learning grounded within subject-specific discourse enables teachers to assess students' conceptual understanding as they reach a wider spectrum of proficiency to *language* discipline-related literacies (Meyer et al., 2015). Attending to Coyle's (2007) notion of effective CLIL learning, Juli's reflection abovementioned portrayed how the integration of relevant cognitive processing through different projects encouraged authentic language tasks within an interdisciplinary setting. Again, these projects were proven valuable vehicles by which students were enabled to encounter and familiarize themselves with meaningful subject-specific literacies, which fundamentally sparked the inkling of love for learning the target language (Grandinetti et al., 2013).

Some language challenges were reported in the study, yet these did not lead to declined motivation or engagement. The following responses affirmed the motivating factor of high-demand CLIL learning wherein the language barrier served as an added challenge (Lasagabaster & Doiz, 2016).

Abigail	*Parts of the English that were challenging for me were listening and vocabulary. Listening made me struggle since I was not familiar with the way native speakers talked. Also, the vocabulary was unfamiliar to me since they were related to science. Learning vocabulary was quite a challenge, yet that motivated me to read more.*
Citra	*The main difficulty for me was speaking because I was not used to speaking in English. However, the more I engaged with the lesson, the more proficient I became in pronouncing words.*
Wildan	*Despite the challenge of structuring sentences and words as well as learning vocabulary, I liked the speaking practices through project-based learning.*

The above excerpts indeed acknowledged the demands on familiarity with subject-specific discourse, as in the case of subject-specific lexical items and spoken tasks. While language challenges from subject-specific discourse were evident, the students demonstrated persistent motivation and more intense engagement with the lesson. In essence, these empirics corroborated the values of engaging students in subject-specific discourse and task, i.e., project-based learning, in the language class which gave them a more authentic and meaningful learning experience (Coyle, 2007; Meyer et al., 2015). Although subject-specific discourse initially obstructed their comprehension and performance, it appeared that the positive academic emotion and motivation stemming from deep learning outweighed the struggle due to language barriers.

These findings also portrayed how STEAM pedagogy can be interwoven into CLIL learning, in moderation, to draw on students' initial familiarity with the subject-specific content or discourse and help them excel in their productive and receptive language skills, as reported by Wildan and Abigail. This resonated with Grandinetti et al., (2013) who propose the values of subject-specific discourse to scaffold students' language development, as premised on *using known content to learn an unknown language*. This postulation also echoes the proposition of ensuring the equilibrium between content cognitive demand and language cognitive demand as a pivotal foundation for ensuring students' engagement while ensuring progress toward the increment of content-language learning (Coyle, 2007). The following section further points out how students' engagement in an authentic learning experience can serve as the springboard to their motivation, the growth of disciplinary knowledge and understanding, and learning satisfaction.

Intrinsic Motivation for Learning Content and Language

As the students discovered a robust linkage between English and their discipline, they acknowledged the value of their experiences in relation to their current studies and future careers. An ideal balance between content and language, as voiced through an attitudinal stance, was achieved.

Doni	*I realized that English is badly needed in the future. Also, as a future health practitioner, I need to be able to speak English well when later engaging with the real-life community.*
Windi	*The class was exciting not only because it involved both English and science but also because we were engaged in discussions on different disciplines, such as engineering, health, and others. This made us more aware of the challenges of environmental problems.*
Jovita	*The class really helped me to learn Public Health more deeply. This benefited me when I was in other classes wherein the lecturer used English in their presentation*

Jovita's voice demonstrated how the lesson held a robust linkage to her study. Language learning oriented to subject-specific literacies allowed the students the freedom to partake in meaningful multimodal communication. In addition, as Doni and Windi expressed, being engaged in the class shifted their motivation from mere instrumental goals of academic achievement to authentic deep learning wherein students encountered real-life problems.

The findings were in harmony with Struyf's et al., (2019) work which underscores amplified engagement in STEAM lessons when students

discover the indirect relevance of the lesson to their lives. To that end, STEAM pedagogy assuages the paucity of student engagement stemming from the dominance of teacher's talk. Albeit language challenges, most students voiced interest and motivation for further study. The findings highlighted the importance of authentic learning and personal relevance to pique students' interest and propel their motivation to study and future careers. These findings cohered with Sahin's et al., (2017) study on STEAM employing social cognitive career theory (SCCT) which points out that the value and interest associated with STEAM learning drive students' self-efficacy and learning performance. Equally important is that these voices supported the statistics documenting positive attitudes to English and English learning in our study.

Enhanced Content Knowledge, Understanding, and Skills through Peer-led Projects

With discipline-specific tasks, students discovered novel ideas and concepts pertinent to their major and transdisciplinary content. Authentic problem-solving projects challenged the students' creativity, criticality, and curiosity, leading to escalated knowledge, understanding, and skills. This is the case of Ragil's response below.

> *Ragil* *I felt that the learning activities were engaging and active. Also, the positive teacher support and teacher-student interaction created a stimulating learning environment. Collaborative project-based learning increased students' engagement, criticality, creativity, and language learning.*

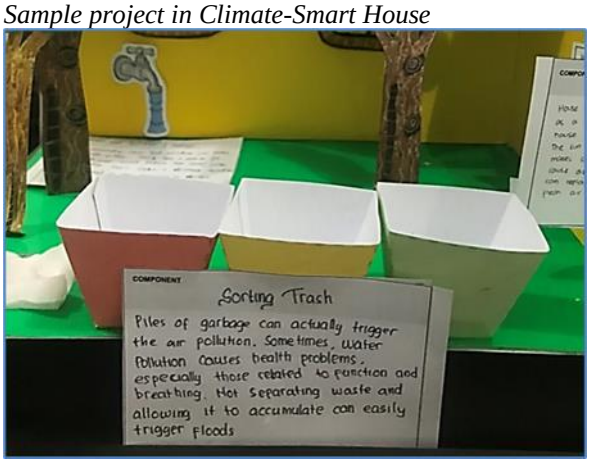
Ragil's opinion was one of many similar responses appreciating the shift toward student-centered learning. Collaborative projects were preferred by CLIL learners as they fostered learning engagement and thus performance (Burns et al., 2020). STEAM pedagogy offered stimulating activities, which granted students full ownership over their learning. This helped to mitigate the dearth of collaboration among learners. STEAM pedagogy again showcased its linkage to the pluriliteracies approach in that the former offered a clear structure of peer-driven projects, therefore opening the path for engagement, reflection, and awareness-raising through feedback and scaffolding (Meyer et al., 2015)

> *Edi* *The class was really fun since we could express our ideas and understand nature even better. The problem-solving projects challenged us to find the right solutions to the environmental problems*
>
> *Evan* *Science is both a product and a process, which are inseparable. In the class, I learned explanations related to natural phenomena, causal relations about nature, various hypotheses about nature, and also scientific experiments. With the English lesson integrated with science, I felt more motivated to probe further into my major.*

The abovementioned voices exemplified how deep learning occurred by means of scaffolding and collaboration among students through the co-construction of knowledge and ideas. As Edi mentioned, the lesson created a space for awareness-raising on environmental issues and helped refine students' understanding of the issues. In addition to the intrinsic motivation stemming from transdisciplinary content, as in the case of Evan, the projects were essential to students' engagement and performance. Reminiscent of how CLIL affords pragmatic means to foster discipline discourse functionings among sub-optimal language learners (Meyer et al., 2015), Figure 2 exemplifies how the '*Climate-smart House'* project helped the students to create a learning artifact that was conceptually authentic and linguistically effective to explain the function and benefits of a Trash Sorting in addressing the environmental issue. It was obvious that the writing lacked cohesion and coherence, yet these hardly interfered with the overall meaning.

Figure 2

Sample project in Climate-Smart House



To sum up, student-centered learning gave the impetus to deep learning where they collaborated to make meaning, construct a hypothesis, propose an explanation, and substantiate solutions to real-life problems. Pondering Meyer's et al., (2015) idea of knowledge creation as meaning-making in subject-specific discourse, the present study corroborates that STEAM pedagogy has not only afforded stimulating learning structures and environment laden with myriads multimodal resources, but also created spaces for reflection and awareness-raising, and opportunity to 'semiotize' students' newly acquired knowledge, understanding, and skills. This tackles the issues of superficial language learning and content-language imbalance by allowing students to engage in diverse cognitive discourse functions across different projects. Such learning

satisfies CLIL students' preference for deep-learning activities reported in previous work (Pérez Cañado, 2018). In our study, these learning experiences were enabled by the following:

1) Technology-enhanced research for information and theories
2) Learning autonomy through peer-driven projects
3) Authentic language learning and problem-solving tasks
4) New learning partnership between teacher and students
5) Transdisciplinary learning laden with personal relevance
6) Multimodal resources for both content and language learning

CONCLUSION

The research findings corroborate the potency of 6E's as one alternative of an effective CLIL model on the grounds of robust learning engagement in multiple dimensions, positive academic emotion, and a strong attitude to language learning. Aligned with the pluriliteracies approach, the collaborative project gives rise to deep learning in that students are emboldened to use newly acquired knowledge, understanding, and skills to create meaningful learning artifacts for addressing real-life issues. In addition, 6E's framework enables the creation of an authentic context through which students re-conceptualize content knowledge and multiperspective thinking through multimodal discourses with specific genres, styles, and purposes.

Endeavoring to reiterate the ideal CLIL model, this study has documented the value of student-centered learning where students can learn and use content-language knowledge, understanding, and skills. Entrenched to students' performance and reflection in peer-led projects, research implication underscores the essence of balancing *known-language-to-unknown-content* or *known-content-to-unknown-language*. This allows the teacher to potentiate students' hidden capacity to *language* newly learned content for genuine purposes to the genuine audience. Framing CLIL class in scientific inquiry through 6E's helps ordinary teachers depart from instrumental orientation to the educational goal of CLIL teaching, better helping students develop their competence as language learners and scientists. While this study demonstrates positive emotion and strong motivation, more extensive studies are needed to scrutinize students' actual gains in content and language learning through authentic assessment. The transfer to experimental study will better inform how STEAM pedagogy operates to enhance CLIL learning, compared to conventional praxis driven by linguistic approach.

ACKNOWLEDGEMENT

This work was funded by LP2M of Universitas Jember, with contract reference 3075/UN25.3.1/LT/2019.

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