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Effects of Using World Indicators for Online ESD Learning

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Abstract: As a pedagogical method to improve student recognition of Education for Sustainable Development (ESD) through scientific data reading, this study looked at the effects of learning in online academic discussions using data from global indicators. Students' scholarly messages were coded and introduced into qualitative content analysis, sequential analysis, and social network analysis, which are emphasized, respectively, to investigate code co-occurrence, code sequence, and code distribution. In all, 307 messages appeared from 119 university students in the online community. The ESD competencies and collective intelligence (CI) are used as indicators for analyses. Qualitative content analysis, particularly addressing those sentences, proved that CI enhanced communication among students where they shared individual norms and values. Sequential analysis elucidated characteristics of discussion thread characteristics with CI, which induced further discussion with foresight views and questions. Social network analyses indicated students connected and showed the connection structure was meshed. Key student bridging messages were extracted. Whereas ESD competencies appeared effectively, the expansion of the current online environment must be regarded as including competency in participatory learning. After summarizing the effects of the online learning method in the Moodle forum environment, the method was proved to empower students to represent core competencies of ESD and to lead data-driven concept transformation.

Keywords: disorienting dilemma; distributed learning environments; education for sustainable development; learning communities; online higher education; post-secondary education; sustainable online learning; transformative learning; United Nations Sustainable Development Goals

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1. Introduction

Education for Sustainable Development (ESD) and Education for Sustainability are concepts developed to elucidate and transform education systems systematically to promote and galvanize sustainability within the minds, hearts, and actions of future generations [1]. The UN sustainable development summit at the UN headquarters this term, at which 17 sustainable development goals (SDGs) for 2030 were announced, was aimed at establishing quality education systems worldwide, and was aimed at developing knowledge and skills and promoting the exchange of experiences to lead a more sustainable society [2]. Universities have undertaken efforts to implement ESD curriculum points into their frameworks to achieve the SDGs [3].

However, when designing the curriculum contents, difficulties have been reported in understanding the ESD concept and the sustainability concept, including the integral perspective recommended in the preamble to the 2030 Agenda [4,5]. Consequently, the ESD-related research that has taken place mainly examines policy and regulatory measures related to ESD implementation [6]. Furthermore, the promotion of economic growth has highlighted the limitations of sustainable development [7]. Sustainability concepts are not always understood because they are novel concepts in the university environment [8]. Although 231 unique indicators are listed as SDGs [9] to assess the progress of sustainability, these global indicators slated as action domains of ESD remain in the discussion stage [10]. In the diverse areas involved, ESD is expected to play a role that encompasses

the developing competencies for both a country's economic development and strategic political decisions. It should be emphasized to explore a country's case to assess the increase over time of stocks of all types of capital: anthropogenic capital, social capital, and environmental or natural capital [11].

Another challenge that arose during the COVID-19 pandemic is that institutions have suspended their in-person activities. The COVID-19 pandemic has increased the need for universities to provide online instruction [12]. Hands-on learning conducted online can be an effective method of developing new skills and knowledge that can be adapted to remote delivery [13]. Unlike practices of the 20th century, students' study and work in a globalized world. More than ever before, the COVID-19 pandemic has highlighted this global connectedness [14]. Furthermore, COVID-19 has influenced the provision of equitable, accessible, and high-quality education in the post-COVID-19 era [15]. The developed lesson experiences with technology ensured the introduction of the blended learning method that was proposed for higher education in the post-COVID-19 era [16].

Regarding the systematic online implementation of ESD and its evidence-based lessons, the use of data in global indicators is crucially important. This study examined and evaluated effects at a university to achieve this data-driven learning of ESD in an online learning environment. Communication is crucially important for students to assess and acquire their unfamiliar ESD competencies [17]. As an outcome of student learning, we specifically examine the collective intelligence that is expected in an online learning environment.

Collective Intelligence

Collective intelligence (CI) is a group of individuals doing things collectively that appear to be intelligent [18]. Earlier CI studies have examined how people and their communications are connected, allowing them to act more intelligently than individuals, groups, or computers [19,20]. This aggregation engenders decisions and actions that are often better than those an individual could make. In fact, CI, which is visualized at the end of the process when various collaborators are evaluated in the composition of the response [21], is a mode of creating new forms and ways of delivering public goods and services through forms of co-creation and co-production or peer production [22]. Regarding the aggregation of academic knowledge, because the development of the internet and digital media has become a commodity, academic connections in the online community have attracted immense communication to build CI [22].

Although some ESD cases in which CI is demonstrated by students have been reported [23–25], no earlier report has described a study examining the communication and examining the characteristics of the resulting knowledge. In this respect, the online discussions of students working collaboratively on a task can be understood by monitoring the emergent messages for analysis [26]. Students' understanding of world issues is influenced by the opinions of their classmates. The online discussion forum stimulates the awareness and understanding of one's own values, those of others, and social values [27].

2. Online Learning Method

Not only does ESD require the integration of content from global indicators into the curriculum; it also creates interactive, learner-centered teaching and learning settings [28]. In the current study, an online learning method in which students use data from world indicators was introduced. Two basic emphases of transformative learning theory have influenced this method: instrumental learning, which involves controlling or manipulating the environment to improve performance or prediction; and communicative learning, which involves understanding what someone means when communicating with a student in a conversation [29].

This online learning method, along with access to World Bank indicator data (https://data.worldbank.org/indicator, accessed on 14 September 2022), was designed as a student assignment for studying world issues. Students choose countries and collect

successive data about two global indicators. When some perceived disorder or discordance arises from comparing two indicators, they are triggered to conduct an investigation and write a report. This moment is designated in transformative learning theory as the situation of a disorienting dilemma, in which a student realizes that what they thought or believed in the past might not be accurate. Instrumental learning is enacted [30]. Because learning about world issues was the first experience for students, assignments were opportunities to confront counterintuitive world facts and to impose unfamiliar or alien aspects of the world or their interpretation, which is recognized as an occasion for their concept transformation.

Then, their reports are submitted on the Moodle discussion forum, where students' online communication was introduced. Regarding online discussion, earlier studies introduced the notion of a transient ad hoc community to denote small groups of students, one of whom posts a message to which the others reply or answer in a collective, dedicated, and online discussion space [31–33]. The effects of a transient community were proved not only to capture the CI of its peers, but also to provide an opportunity to build on CI and make it work for the common good [31].

Referring to existing global indicators or composite indicators such as gross domestic product (GDP) or a human development index (HDI), the limitation of using these indicators to understand world issues was discussed [34]. Conclusions indicate the necessity of examining the relationship between SDG global indicators and the situation of the country concerned to gain a deeper understanding of the ESD rather than a superficial understanding of the indicators. Not only should the policy and philosophy of the SDGs be targeted for learning, but the indicators used in the SDGs dashboard should also be targeted. Our online learning method emphasizes examination of the indicators listed in the SDGs dashboards specifically. Therefore, students can achieve a rational understanding based on concrete data. Moreover, students have an opportunity to familiarize themselves with a country that they have never known before.

As a difference between this online learning method and other pedagogical methods, this method offers no pre-prepared problems. Because the method assigns only two indicators for investigation, the conceived problems are rooted in self-initiated learning or collaboration. Although the method involves web searching, the objective of searching is not to find a fact, but to find resources that are available to explain it. Moreover, the method of communication was not managed by a teacher. Students must prepare a message that can attract peers.

The following statements summarize the online learning method process:

1. Students are instructed on how to access the world database

   Introduce students to a comprehensive worldview across time and space;
2. Collect longitudinal data

   Trends in indicators over the years reveal the situation of a country;
3. Comparing two indicators

   Students choose a country for which two indicators engender a discrepancy beyond the intuitive notion, common sense, or innate opinion of students, leading them to the conceptual gateway for transforming their concept;
4. Look for potential factors to explain a gap

   Students engage in searching for diagnostic information and constructing a consistent opinion to explain the gap separating indicators;
5. Transformation

   Students are tasked with understanding target areas and the relationships between indicators by deciphering resources and opinions among themselves. They unravel promising or deadlocked notions in conjunction with peers. They can naturally accommodate their conceptualization to the resulting CI.

3. Analytical Frameworks

For this study, the following three analytical methods are used to examine the online community. Each analysis specifically examines a different layer of the community.

3.1. Qualitative Content Analysis

Qualitative content analysis is used to examine a specific statement in a message. This analysis is that of qualitative data analysis methods using a content-coding method that encodes the underlying meaning of a dataset according to criteria [35]. For coding, CI and ESD competencies (Table 1) are used as codes in this study. The ESD competencies comprise the eight key competencies which were synthesized for ESD [28].

Table 1. ESD competencies (abbreviations for key competencies are used for this report.).

Key Competencies	Explanation
Systems thinking competency (ST)	Ability to recognize and understand relationships, analyze complex systems, consider about how systems are embedded in different domains and scales, and deal with uncertainty.
Anticipatory competency (AC)	Ability to understand and evaluate multiple futures (possible, probable, and desirable), create one's own vision for the future, apply the precautionary principle, assess the consequences of actions, and cope with risks and changes.
Normative competency (NC)	Ability to understand and reflect on the norms and values that underlie one's actions and negotiate sustainability values, principles, goals, and targets in a context of conflicts of interests and tradeoffs, uncertain knowledge, and contradictions.
Strategic competency (SC)	Ability for collective development and implementation of innovative actions that foster sustainability at the local level and further afield.
Collaboration competency (CC)	Ability to learn from others, understand and respect the needs, perspectives, and actions of others (empathy), understand, relate to, and be sensitive to others (empathic leadership), deal with conflicts in a group, and facilitate collaborative and participatory problem solving.
Critical thinking competency CT)	Ability to question norms, practices, and opinions; reflect on one's values, perceptions, and actions; and take a position related to the sustainability discourse.
Self-awareness competency (SA)	Ability to reflect on one's role in the local community and (global) society, continually evaluate and further motivate one's actions, and cope with one's feelings and desires.
Integrated problem-solving competency (IP)	Overarching ability to integrate the above-mentioned competencies and apply different problem-solving frameworks to complex sustainability problems and develop viable, inclusive, and equitable solution options that promote sustainable development.

The coding activity is processed to extract the manifest and latent meaning of a message's contents. Whereas manifest coding annotates the visible and superficial content of a message, latent coding reveals the underlying meaning of the message [35]. Subsequently, qualitative content analysis initiates the classification of datasets into identified groups of similar meaning [36], thereby allowing analysis of the content to establish similar results across group codes [37]. In other words, it is a method for systematically describing the meaning of qualitative material [38]. In this study, a systematic process of coding, finding, categorizing, and defining the meaning of opinions [39–41] is used for grouping codes to relate to latent codes of ESD competencies and CI.

To perform rigorous analysis of the manifest and latent coding, ATLAS.ti computer software (ver. 9; Scientific Software Development GmbH) was used.

3.2. Sequential Analysis

Based on codes obtained through the qualitative content analysis, a sequential categorical data analysis can be introduced to detect code patterns in the online discussion threads. Sequential analysis defines datasets of four types in which the data file is either an Event, State, Timed, or Interval. The data type is identified by the included data attribute as event sequential data (Event), state sequential data (State), timed event sequential data (Timed), or interval sequential data (Interval) [42]. Because the current study does not provide onset and offset times for the codes, the multi-event sequential data type of applied event sequential data type is used, which is a series of multi-events using one or

more concurrent codes [43]. Codes are not mutually exclusive: more than one code can characterize each event.

Code patterns refer to sequential relations between individual coded message contents. The patterns can be ascertained by calculating the significance level of a code sequence with one particular code immediately followed by another. For this calculation, the collected numbers of code sequences are arranged in a cross-tabulation style (given-target) to ascertain whether these sequential code relations reach the significance level ($p < 0.05$). The numbers in the crosstab represent the total number of times a column code occurs immediately after a row code [44]. The adjusted residual results (z-scores) are calculated using Formula 1, shown below. For a sequence, a calculated z-score greater than 1.96 indicates that the sequence of a row and column is significant ($p < 0.05$) [42].

R: Number of rows (given)
C: Number of columns (target)
x_{rc}: Observed joint frequency for cell in r-th row and c-th column of a $R \times C$ table
p_c: Probability for the c-th column = $x_{+c} + N$
p_r: Probability for the r-th row = x_r / N
e_{rc}: Expected frequency, by chance = $p_{+c} \times x_{r+}$

$$z_{rc}: \ Adjusted \text{ residual} = \frac{x_{rc} - e_{rc}}{\sqrt{e_{rc}(1 - p_c)(1 - p_r)}} \quad (1)$$

For calculation, a generalized sequential querier (GSEQ) (ver. 5.1.23; Mangold), a computer software program, was used to analyze interaction sequences [43]. The GSEQ provides statistical results indicating which patterns are most likely to occur in the sequences [45] (p. 318). Similarly, to the investigations undertaken in this study, GSEQ was used for a group discussion to extract patterns from the discussion community [44], to extract patterns of knowledge construction [46], learning analytics [47], and to examine pedagogical method effects [48]. The GSEQ can be a mediator of message analysis in the current study.

3.3. Social Network Analysis

Social network analysis (SNA) is suitable for examining and monitoring online interactions because it can analyze interaction data and provide an overview of the structure and interaction patterns of social groups. It also facilitates the mapping of all communications in the relational space [49]. All connections in the scholarly community are converted into nodes (students) and edges (messages). NodeXL Pro software (ver. 1.0.1.504; Social Media Research Foundation) was used to analyze and draw a social graph and calculate the graph's metrics. A vector operation of the directed graph method was used for this analysis. During the analysis process, measures are taken to describe the overall network structure and extend it to capture important nodes among students.

Quantitative network metrics enable systematic analysis of the network. The degree of a node is a count of the number of unique edges connected to it [50] (p. 72). Betweenness centrality measures the number of times a node falls on the shortest path between two other nodes [51]. For example, a node with low betweenness centrality has fewer information collection paths. Other nodes with a higher betweenness centrality score can collect the same information by passing through different paths. High betweenness centrality represents more opportunities to broker the flow of information; it also has higher social capital [52] (pp. 202–247). Eigenvector centrality is a measure used to identify the existence of a particular influential node within a given network [53]. A node with few connections has a higher eigenvector centrality if the node is connected to a very well-connected node.

3.4. Research Questions

This study explores how the online learning method can be implemented effectively to transform students' conceptualization to fit the global perspective. This study also offers

reflections on collaborating in a constrained environment under COVID-19 to contribute to ESD curriculum development and implementation at universities.

To this end, this study examined how the emergence of their ESD competencies in the online community was structured through analysis of their posted messages. The following research questions were addressed:

RQ1: *Characteristics of student communication to achieve collective intelligence in the online learning method*.

RQ2: *Identify the advantages and limitations of the method for ESD in online collaboration*.

4. Materials and Methods

For this study, a dataset was selected from an online course in which students at a Japanese university had learned about world issues. The course was managed entirely as emergency remote teaching during the COVID-19 pandemic. For this study, one assignment session was selected for investigation. In all, 119 first-year undergraduate students in literature, engineering, and nursing were led in a week-long online discussion (18–25 May 2021) related to their submitted reports (Figure 1).

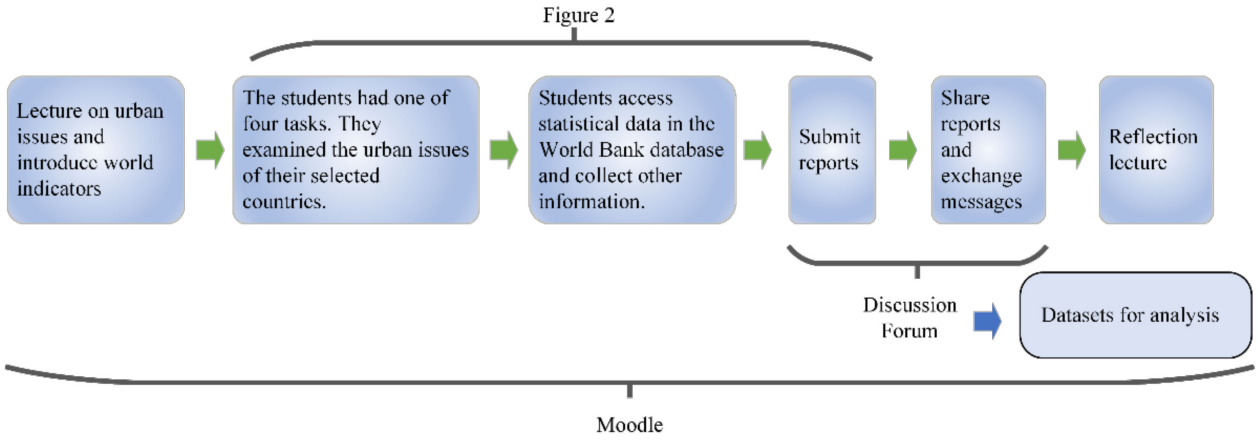

Figure 1. The lesson process.

Online Learning Process

After an introductory lecture, the online learning method was used for the assignment. Figure 2 shows the online learning flow. Each student was allotted one of four sets of assignments, in which they compared an indicator on the urban issue from SDG Goal 11 with an indicator from Goal 5, Goal 16, or Goal 11 (Indicators 1 and 2 in Figure 2). They accessed the World Bank database and collected data for two indicators. After finding an unexpected trend in the indicator data ("gap" in Figure 2), they engaged in the collection of additional information related to a country for explanation. Then they were required to submit a report on a Moodle discussion forum. The reports were shared. Finally, after the online discussion, students participated in a reflection session with a teacher in charge to enhance their deep and proper recognition (Figure 1).

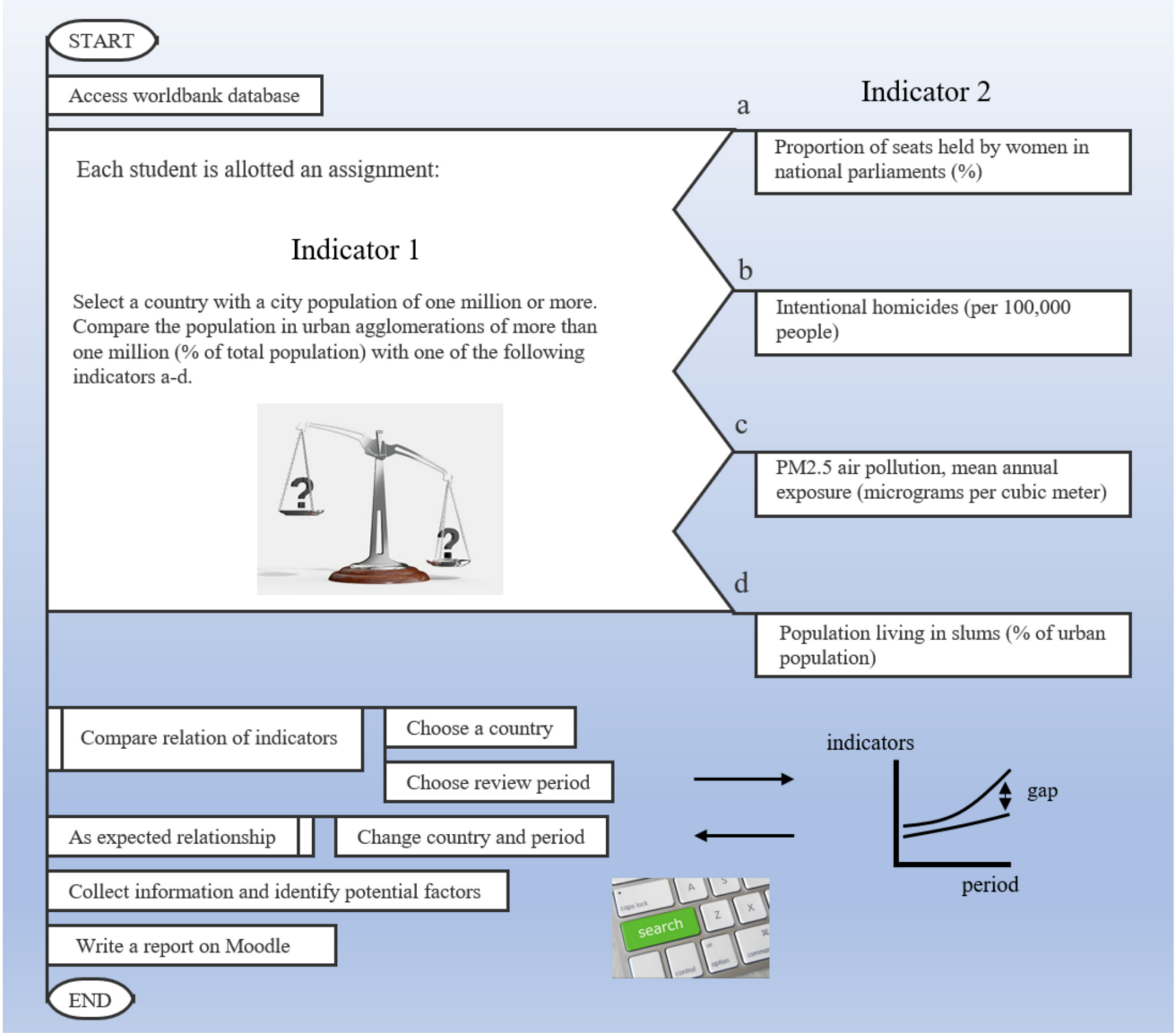

Figure 2. Problem analysis diagram showing the online learning flow.

All student messages in the Moodle forum were collected, tagged with a relational attribute, and used as a dataset for analyses. During continuous analysis, three distinctive analytical methods presented in the preceding section were applied.

5. Results

A total of 307 messages from 119 students appeared in the online community. In all, 56,644 words appeared in messages (word count of English translation, excluding words in tables, diagrams, and figures that students posted as graphics).

5.1. Qualitative Content Analysis

Through our coding process, the presented information, comparisons, interpretations, inferences, opinions, questions, views, positions, values, norms, involvements, communications, applications, and strategies that arose were coded into manifest codes. These codes were then incorporated into the latent codes of ESD competencies and CI. The CI appeared as a short sentence in contextual discussion sentences, in a summative form, as presented below.

> *. . . I was able to draw conclusions about the link between infrastructure development and air pollution based on my collected information. Additionally, I was relieved that the link was explicitly explained in your document. The perspective of aging facilities from S92 also led to further understanding . . . .*
>
> *(From a message about Bangladesh, by S34, translated by the author)*

Figure 3 presents the results of the qualitative content analysis. Systems thinking competency (ST) was found to have the highest number (294) in the community; co-occurrence was determined to be 46%. Additionally, 38% of collaboration competency (CC) co-occurs with other competencies. There is a proven effect of these two competencies when students learn in an online community. The highest co-occurrence coefficient score was found between CC and normative competency (NC). Therefore, CC was directed to find a shareable norm to explain the data.

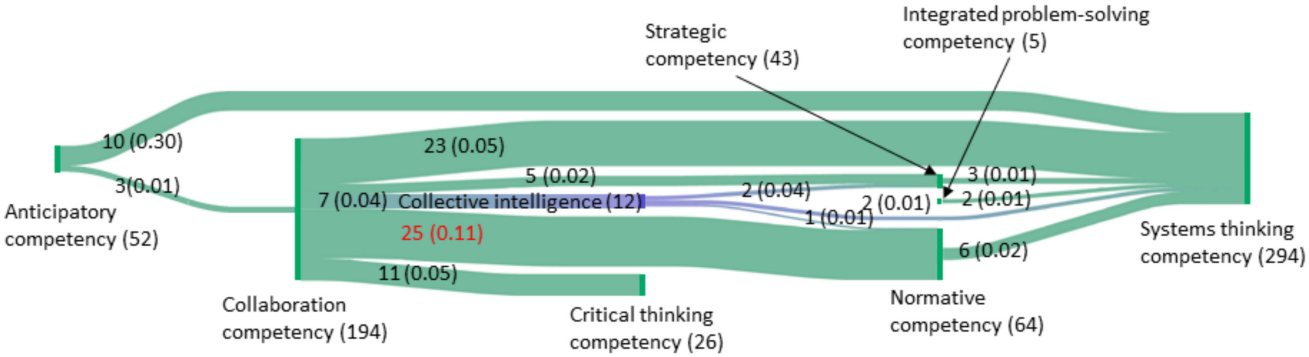

Figure 3. Sankey diagram showing ESD competencies and collective intelligence. Grand totals of codes or co-occurrence coefficients are in parentheses.

To understand the collaboration effects, a simulation was conducted from which CC was excluded (Figure 4). Co-occurrence among ESD competencies is only proven with ST. Four codes (IP, SC, AC, and NC) appeared in Figure 4 as non-aggression. All co-occurrence cases with ST showed lower co-occurrence coefficients. The result indicates higher relations of these competencies with CC. However, the 100% of CI co-occurring with ESD competencies in Figure 3 and 58% of CI co-occurring with CC show how CI was developed through a close relationship with ESD competencies.

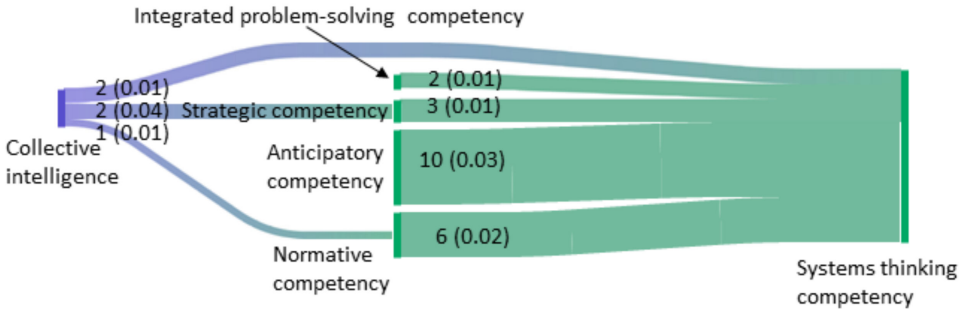

Figure 4. Sankey diagram excluding collaborative competency. Co-occurrence coefficients are in parentheses.

5.2. Sequential Analysis

A total of 109 discussion threads appeared. They were classified into three learning types: an isolate type that does not include connected messages from others, a communication type that includes connected messages and discussions on the subject areas, and a completion type that includes CI and presents a conclusion (Figure 5). Typically, the thread content is filled with contextual sentences and information because students have

limited pre-acquired knowledge of the target countries and need explanations for their understanding (Appendix A). In the competency-related dimension, we confirmed the presence of seven ESD competencies. The diagram in Figure 5 presents significant ESD competency sequences ($p < 0.05$) by learning type.

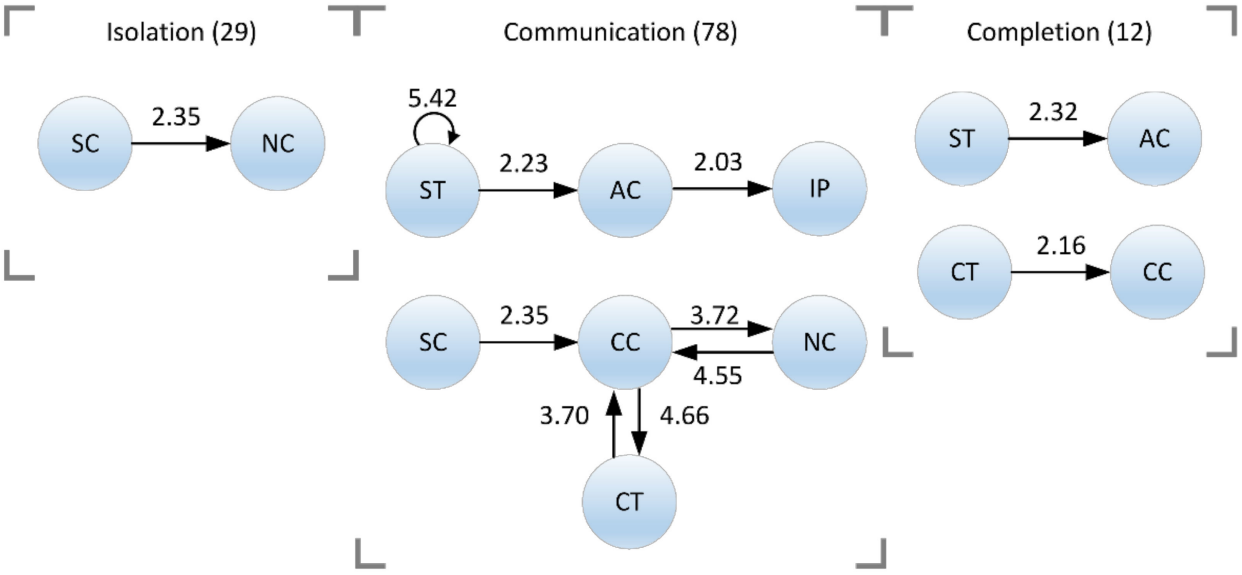

Figure 5. Diagram of important competency sequences ($p < 0.05$) by learning type in the community: isolation, communication, and completion. Abbreviated code names are presented in Table 1. Grand totals of threads are in parentheses.

Isolation type

Only SC→NC achieved a significant z-score. A strategic perspective or opinion developed by a student was incorporated into the updating of one's own norms.

Communication type

The following six identical sequences were extracted: The self-loop of ST (the highest z-score showed their reflections on different areas dealing with uncertainty); ST→AC (they presented their future views or predictions); AC→IP (their integrated activities by application of different frameworks to discuss options for the complex sustainability problem); SC→CC (a perspective on development to bridge the gap separating local and broader levels was explained and discussed); CC↔NC mutual sequence (the discussion often included updating their norms); and CC↔CT mutual sequence (discussion that was often introduced to criticize a norm for elaboration).

Completion type

Two sequences were valid. ST→AC (similar to the communication type but more predictive) and CT→CC (their question was properly positioned in the sustainability discussion). This outcome expanded the result of qualitative content analysis with regard to the context of discussion with CI.

As a noteworthy point in the result of sequential analysis, no significant path from ESD competencies to collective intelligence was observed. However, both "communication" and "completion" showed positive collaborative activities in which CC was included.

Significant code sequences differed between learning types. "Isolation" included only one sequence. Surprisingly, "communication" had the greatest number of sequences and comprehensively covered ESD competencies. This finding proved the effectiveness of the method in online discussion and the involvement of ESD competencies. In fact, this effect was found even for threads in which students were unable to reach their conclusion. Moreover, although the threads with CI were only 12 (11%), there was an important sequence to expand their conclusion into their collaborative scholarly activity, CC. Because

this case was the first approach of students to a new academic arena, we can recognize that the emergence of competencies appeared naturally in the discussion.

5.3. Social Network Analysis

Figure 6 portrays the social graph of the resulting community, providing a holistic view. The maximum number of edges in a connected component is 294, indicating comprehensive message connections in the community.

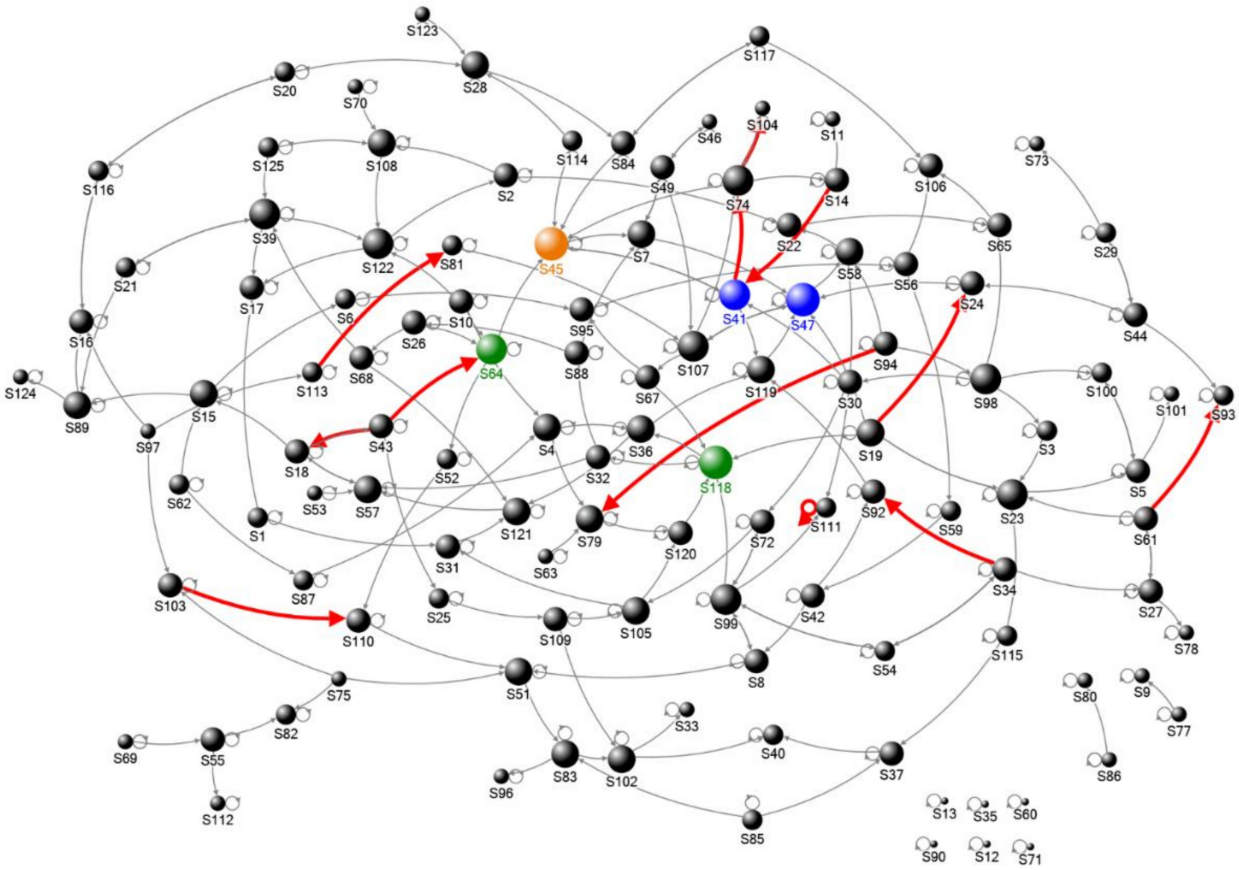

Figure 6. Social graph of the emergent community. *Note:* Node size is proportional to the degree. S45 (orange), S118 (green), and S64 (green) are ranked as the highest in betweenness centrality. S47 (blue), S45 (orange), and S41 (blue) are ranked as the highest in eigenvector centrality. The social graph is arranged by Harel–Koren Fast Multiscale [54]. The highlighted red edges represent messages that involve CI.

Findings indicate that CI did not appear in an aggregated form but that it was distributed across the community. However, some nodes accumulated edges in an egalitarian mesh structure of community. To verify these noticeable nodes, brokers' bridging information were extracted based on their highest betweenness centrality (S45, S118, and S64). Influencers featuring nodes were extracted based on their highest eigenvector centrality (S47, S45, and S41). Because messages with CI were distributed uniformly, these nodes became important for communication. Additionally, the findings revealed that these students were extracted based on the metrics of the community, not on their individual covariates. This result indicates the effects of a holistic view using SNA. However, the effects of meshed connections in the network created a student (S111) who was able to submit a report with CI after reviewing information posted by others. Another notable finding was that students who posted messages with CI were not influenced by their node degrees. Through its structural features, the online learning community supported CI emergence.

6. Discussion

RQ1: *Characteristics of student communication to achieve collective intelligence in an online learning method*.

Table 2 presents a comparison of three analyses used for this study, in which different layers of analysis were presented. Because the online learning method comprises tasks of information collection and communication, codes with these inherent tasks tended to appear. Qualitative content analysis revealed features of CI sentences that tend to co-occur with CC and showed that students were highly motivated to achieve CI with their peers. Sequential analysis identified features of CI threads that specifically examined adopting member foresight and continuous communication introduced after critical view. However, other threads put many ESD competencies up for discussion. Even isolated messages express scholarly analysis. Social network analysis revealed a structural function to establish connections between isolation, communication, and completion-learning types. This structural feature explains how students with connecting roles are important to promote CI. In summary, our online learning method governed the distributed CI messages in the community and bridged messages between students.

RQ2: *Identify the advantages and limitations of the online learning method for ESD in an online collaboration*.

Table 2. Comparison of layers related to the emergence of collective intelligence from ESD learning.

Layer	View	Remarks
Code co-occurrence	Focused	58% of CI co-occurred with CC. CC was directed to find a shareable norm.
Code sequence	Relational	Active discussion using various ESD competencies emerged. Threads with CI lead to AC and CT.
Code distribution	Holistic	CI messages were distributed in the community. CI emerged from nodes of various degrees. Brokers and influencers are detected. Opinions were referenced and interconnected.

Self-regulated learning has been identified as important for emergency remote education [55]. The use of the online learning method proved that student experiences of self-regulated learning of new knowledge can afford aggregated cyber information and distributed learning works of peers into an online place and can give opportunities to transform their immature concept into a multifaceted understanding of the subject area through statistical data and communication. The effects of the online learning method achieved the construction or transforming of concepts adaptable to their inexperienced field. Results show that our online learning method introduced a learning environment with highly active communicative learning. The structure allowed a few CI messages to be shared. In addition, online learning enhanced the online activities of most students and was able to position some students in the community structure as brokers and influencers, spreading the existence of notable messages to others. Moreover, our online learning method introduced core ESD competencies into student learning.

Core ESD competencies appeared in threads, but SA did not appear in all threads. This inconsistency is a conspicuous difficulty of our online learning method under the current lesson setting. ESD aims at shifting away from earlier conventions of attitude and behavior towards situated, co-engaged, participatory, and inclusive learning approaches [17] (p. 130). When a university course conducts the development of SA using online learning, it must consider the introduction of the following difficult argument.

The use of online resources enables the gathering of knowledge, experience, and resources from potentially thousands of people in cyberspace; it also introduces an interactive process that represents new forms of knowledge acquisition for CI [56,57]. These benefits imply the expansion of the learning environment to include social users and the use of social media to access students' unfamiliar ideas. Indeed, the social environment, authentic activities, and participatory development are important concepts for SDGs and ESD [17,58]. However, how the university curriculum deals with the social environment remains a sensitive issue. Regarding the start of a student community on social media, the cold-start problem has been reported; it entails initial difficulties in connecting with social users [59]. To socialize the student community, the roles of brokers who create connections between a scholarly community and a social community are expected to be filled. In particular, such brokers include "representatives" who introduce the student community into the social community and "gatekeepers" who introduce information about the social community into the student community [60]. The benevolence of unselfish and kind-hearted behavior that deserves the goodwill of people was noted as a motivation for brokers [61]. However, an earlier study examined the social media messages posted by students after online learning methods. The community of students in the social network was monitored to show how the community of students accomplishes social user participation. As a result, only two students were able to make reciprocal ties with other social users. The study also proved a further need to organize their messages to make an impression on social users [62]. Students must acquire additional skills in prosocial behavior to communicate.

7. Conclusions

Results show that our online learning method enhanced communication among students, with shared individual norms and values, with discussion of CI inducing further discussion with foresight views and questions, and with a connected and meshed community. Whereas ESD competencies appeared effectively, the competencies of participatory learning appeared only with difficulty. This difficulty is related to the different environments for learning outcomes and learning participation. For both learning aspects, collaboration is an indispensable activity for student development.

A limitation of this study is that we were unable to follow the detailed structure of the connections. More research must be conducted to ascertain how individual learning takes place in a community. In our next study, a new analytical method such as network structure analysis will be examined to ascertain complex connections.

In summarizing the effects of the online learning method in the Moodle forum environment, one can infer that the online learning method helped students to represent the core competencies of ESD. It introduced data-driven concept transformation. However, when a curriculum is aimed at developing an advanced ESD competency in students, the discussion must address the use of social media and the provision of additional social competencies.

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Informed Consent Statement: Informed consent was obtained from all students involved in the study.

Data Availability Statement: The data originated during the research project are available from the author upon reasonable request.

Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Example of a thread that includes collective intelligence

Note. Messages were translated by the author. Figures were edited by the author to improve their readability.

<Message from S79, 19 May 2021>

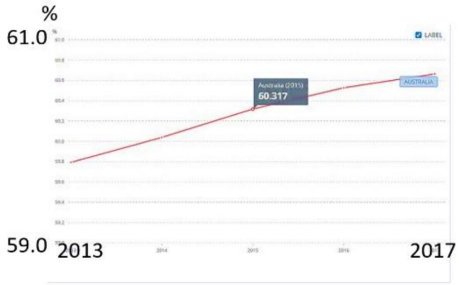

Figure A1. Urban population rate.

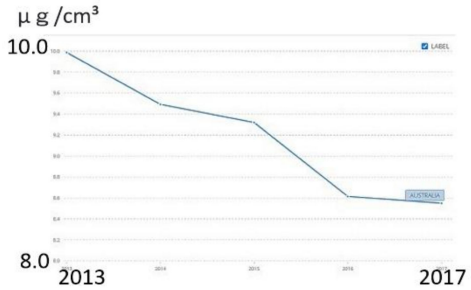

Figure A2. PM2.5.

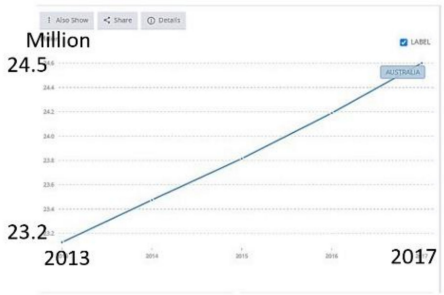

Figure A3. Population.

During the five years since 2013, the urban population rate changed by only about 1%. It is almost constant. However, the absolute number increased by about 1.1 million because of the increase in the population of Australia during the same period. Most of the land in Australia is dry land. Residential areas are concentrated on the eastern coast; population concentration started early. As a result, population migration has slowed.

As for PM2.5, no notable features exist it is decreasing at a roughly constant rate. In addition, the WHO environmental standard of 10 μg/cm^3 has been undercut since 2013. The PM2.5 levels change because of various factors, but the change in the concentrations in Australia since 2013 has not been so dramatic that it is difficult to pinpoint the factors. As a main contributor to PM2.5 emissions, I will specifically examine thermal power generation, which is one contributor. Although thermal power generation has long been popular in Australia and has remained useful by virtue of the abundant coal resources, the introduction of renewable energy has been promoted. Its ratio has been increasing since around 2000. This is probably related to the drop in PM2.5.

In general, the urban population rate increases with economic development. Air pollution also occurs simultaneously. Because Australia has developed with a stable population distribution because of domestic climatic conditions, it is thought that the effects of environmental measures (renewable energy, etc.) are greater than the generation of PM2.5 accompanying economic development. One of Australia's urban issues is the inadequacy of infrastructure in urban areas because of increased immigration. Australia is tolerant of immigrants because of its multiculturalism, but about 80% of immigrants are

concentrated in urban areas, where the population is growing and where infrastructure is persistently inadequate.

The solution is to revitalize rural areas and to decentralize urban functions. Although Australia currently limits immigration flows by 15% and restricts urban residency rights, this does not address the root cause. Australia has officially announced a goal of moving the center of politics from the two major cities of Sydney and Melbourne to Canberra, which is located between them. Creating an environment in which people can find jobs in rural areas is important.

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What are PM2.5 environmental standards?

Effects of PM2.5 air pollution on health and precautions in daily life

https://atomica.jaea.go.jp/data/detail/dat_detail_14-03-01-01.html, accessed on 14 September 2022

Population and population distribution

https://www.jri.co.jp/MediaLibrary/file/report/jrireview/pdf/11440.pdf, accessed on 14 September 2022

Immigration policy

https://www.mlit.go.jp/kokudokeikaku/iten/onlinelecture/lec03.html, accessed on 14 September 2022

<Message from S4, 21 May 2021>

I saw your message. I also agree with the last suggestion. However, the location of renewable energy supply is inevitably affected by land and climate, so I think it is very difficult to proceed with development without increasing the emission of harmful substances. Additionally, when it comes to developing residential areas, domestic water is required, but because there are many dry areas and because the presence or absence of groundwater is very important, the places are quite limited. However, I think that I can expect enough because the past achievements are quite large. It was a good opportunity for me to examine the current situation in Australia. Thank you very much.

<Message from S94, 24 May 2021>

I agree with the S79 opinion. It was novel for me to think about the problem of PM2.5 in connection with power generation and immigration. I also researched PM2.5 in New Zealand, which is located near Australia. In addition to that, I heard that Australia has become cleaner since 2013. I felt that Oceania's countermeasures against PM2.5 were progressing. I realized that promoting renewable energy and infrastructure development are the keys to creating a clean environment. Thank you very much.

<Message from S63, 25 May 2021>

I also believe that thermal power generation is the cause of the air pollution caused by PM2.5. Therefore, when I investigated the thermal power generation in Australia, the percentage of thermal power generation in Australia was declining. However, the amount of electricity produced by thermal power generation is still high, accounting for 86% of the total, or 228 TWh in terms of power generation. Although Egypt and Turkey, which are developing countries, respectively, produce 160 TWh of thermal power and 177 TWh, which are less than that of Australia, the figures for average annual exposure to PM2.5 are, respectively, 44 and 87, which are higher than Australia's value of 9. In other words, the level of PM2.5 is lower than that of either Egypt or Turkey, even though they generate electricity with thermal power. It is said that air pollutants can be removed by purifying the smoke emitted from thermal power plants. I thought that the big reason for Australia's lower PM2.5 levels compared to developed countries is that pollutants with high environmental awareness are managed properly.

I was able to deepen my understanding of thermal power generation, PM2.5 in Australia, and the circumstances of power generation. Thank you very much.

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Filters for thermal power plants in Australia

Amount of power generated by thermal power plants in Turkey

Share of thermal power generation in Turkey, Australia, and Egypt
Total power generation in Australia
Egypt's total power generation

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