An Innovative Approach for Lesson Improvement through Collaboration

Tomomi Kubota and Masami Yoshida

***Abstract*—This study proposes a method for improving lesson revision using the analytical hierarchy process (AHP), which is a structured technique for organized group decision-making. As a fundamental pedagogical principle of the proposed lesson improvement approach, we utilized collaborative action research theory, which involves applied action research, and focused on group-based lesson improvement. Furthermore, this study demonstrates a practical method that enables the incorporation of diverse assessment opinions from itinerant supervisors of educational boards to flow into a common conclusion to improve the lesson. We simulated a discussion case that involves informational avoidance actions. The consistency index of AHP could promote group decisions by presenting scores of consistency value across decision scenes. Furthermore, we present the effect of this method, in which a group produced a written document to transfer the record of the discussion process. This study is the first to illustrate the improvement of lesson design through collaboration among individuals with varied areas of expertise.**

***Index Terms*—Action research, analytical hierarchy process, collaborative decision making, lesson improvement.**

I. Introduction

Although lesson improvements have been conducted in schools, typical scenarios depict a teacher in charge as demonstrating teaching and conducting a subsequent evaluation session. This method typically forms a cycle (plan–do–see) [1]. In other words, session members have found difficulty in managing the results of the evaluation in a procedural manner in the next phase of lesson planning. As a form of measurement, session activities should be integrated into the next phase of lesson planning, whereas the experiences and knowledge of session participants should be incorporated into a developed plan. Such collaborative activities can be a catalyst for improving lessons [2].

A. Collaborative Action Research

Collaborative action research (CAR), which is typically conducted by teams of practitioners, is a process that enables teachers to 1) improve student learning, 2) improve teaching practice, (3) contribute to the development of the profession, and 4) overcome the isolation commonly experienced by classroom teachers [3]. CAR is a place-based approach, where various participants can be organized, such as a group consisting of a teacher, a researcher, and a parent. Various experts in a group possess diverse and varying levels of understanding and knowledge about several aspects of a topic [4]. Previous reported cases are scarce due to difficulty in gathering individuals of diverse talents [5], [6]. Thus, the management of discussions and the integration of various opinions remain unclear. In addition, within a CAR group, a problem emerges when an authoritative researcher provides insight about lesson improvement, whereas a teacher becomes passive and feels unable to contribute ideas [7]. In other words, the lesson improvement process continues without consideration of communication issues between members. Therefore, this study proposes a concrete method for communication during discussions that intends to provide equal priority to the decisions of members involved.

B. Difficulties in Discussion

CAR is frequently conducted by a team of practitioners and experts and denotes cooperation between individuals working toward a common goal, that is, lesson improvement. For this reason, the action research approach is used to analyze the existing practices and identify elements for change [8].

When the topic of discussion involves a complex and ill-structured problem that lacks a solution, group members will likely provide different opinions at the initial phase of a collaborative discussion. As it progresses, these initial opinions will be modified, synthesized, or rejected with the sharing of different perspectives and with the negotiation of the meanings of opinions and evidence [9]. In addition, several members may lack the competencies required to consider the perspectives of others, support their opinions with evidence, make counterarguments, and integrate various perspectives, which may interfere with the discussion from the perspective of argumentation [10]. According to Golman et al. [11], in worst-case scenarios, an individual may be aware of the existence of information but opt to refrain from accessing it despite its availability without cost or the high cost of avoiding it. Many forms of motivation are possible for the active avoidance of information, and individuals may use different methods to avoid accessing readily available information. Edenbrandt et al. [12] defined two broad categories of motivation for active information avoidance as follows:

1) *Dissonance avoidance* occurs as a result of cognitive dissonance (discomfort) from exposure to information that is in conflict with one's prior beliefs or that causes unpleasant emotions or diminishes pleasant ones. The field of psychology also refers to this category as *emotion regulation*.
2) *Strategically motivated avoidance* is an intrapersonal strategic device for eschewing responsibility that emerges when information is expected to instigate an unwelcome responsibility to change one's behavior. An

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example is individuals who tend to consider themselves altruistic and, therefore, avoid information to generate a *moral wiggle room*, where they can allow themselves to act in a selfish manner.

Within such an environment, obtaining clear instructions on performing discussion tasks effectively and efficiently is uncommon. As such, the absence of coordination and the presence of potential conflicts between group members impede performance [13].

The current study aims to address these lateral issues, which are embedded in discussions among individuals with different skill sets, by introducing scientific guidelines.

C. A Supportive Tool for Discussion

The analytical hierarchy process (AHP) is a criteria-based decision-making method established by Saaty [14]. It is an effective tool for integrating opinions within groups during discussions [15]. Thus, the present study applied the AHP during the CAR process.

The AHP is characterized by executing paired comparisons that can convert categorical and continual variables into numerical values. Moreover, it can provide concrete focal points for members to discuss. These comparisons are obtained from actual measurements or from a fundamental scale that reflects the relative strength of preferences and opinions. Therefore, this method considers the fuzziness of people's judgments about complex topics and calculates the degree of the effect of each factor [16]. Furthermore, it integrates the structure of various carefully reviewed decisions to create a dictionary that can serve as a source of reference for others to consult. In this manner, members can benefit from the knowledge utilized during the formulation of decisions [15]. Simply put, the process of the discussion can be converted into a shareable document.

II. Methodological Frameworks

A. The Kawakita Jiro Method

Brainstorming is typically used to conceive ideas during the AHP process. However, we propose the Kawakita Jiro (KJ) method instead of brainstorming, because it can aggregate many ideas into a few. In addition, the KJ method promotes the anonymity of individual opinions, such that the method is independent of the social authority of members. To introduce CAR into an AHP session, many criteria and alternatives may be proposed because multiple experts are likely to intervene. However, Takahagi and Nakajima [17] argue that sessions through the AHP process should follow a limited number of criteria and alternatives, which may range from two to seven. Otherwise, the three steps of the KJ method are recommended to reduce the number [18]. First, ideas put forth by members are written on a card, which are then classified according to issues. Once a conceptually similar card group is formed, a label is created with a sentence that represents the entire group. Finally, the grouped cards are placed on a large piece of paper to create a diagram.

B. The Consistency Index

The consistency index (CI) is calculated during the AHP process [17]. When a paired comparison is performed, the results may show significant inconsistency. Suppose the following contradiction: A is better than B; B is better than C; and C is better than A. Despite calculating the weight on the basis of the inconsistent answers, reliability remains low. As such, a risk of contradiction occurs, because paired comparisons are performed using the human senses. If the consistency is more significant than 0.1–0.15, then the paired comparison should be reconsidered.

$$CI = \frac{Eigenvalue - Number\ of\ items}{Number\ of\ Items - 1}. \quad (1)$$

For a perfectly paired comparison, eigenvalues should be equal to the number of items. Therefore, the numerator is set to the eigenvalue minus the number of items, such that it becomes 0 when consistent. The denominator is set to the number of items minus one, because the eigenvalue tends to increase with the increase in the number of items. The more consistent the paired comparison, the smaller the CI. However, the eigenvalue cannot be obtained using the geometric mean method. The fore, the eigenvalue should be estimated if the goal is to determine consistency. The calculation procedure takes the total evaluation value and divides it by the weight to obtain the estimated eigenvalue.

$$total/weight = estimated\ eigenvalue. \quad (2)$$

III. Research Objectives

We propose the applied methods for CAR using AHP, where the opinions of participants can be integrated into a unified conclusion.

For this reason, we set the following objectives of this study:

1) to present a concrete method for integrating the opinions of diverse experts for lesson improvement; and
2) to propose an approach for promoting effective discussions and for developing shareable records of opinions.

IV. Applied CAR Method

The process chart in Fig. 1 illustrates the process of lesson improvement through CAR using AHP. It is designed to establish effective communication among group members with different areas of expertise. This study reveals a practical method that could integrate diverse evaluation opinions from various experts, such as lesson practitioners, university researchers, teacher mentors, and supervisors, to generate a decision. A regional educational board dispatches itinerant supervisors to conduct general training in lesson improvement for in-service teachers. Although inspection occurs weekly during the training period, the lesson improvement session should be planned at this point. Although many arrangements are possible for selecting experts, the most common examples are the involvement of experts in lesson planning and information technology. The discussion is frequently led by three members who can easily apply the triangulation technique, because it is processed with the creation of the AHP [19].

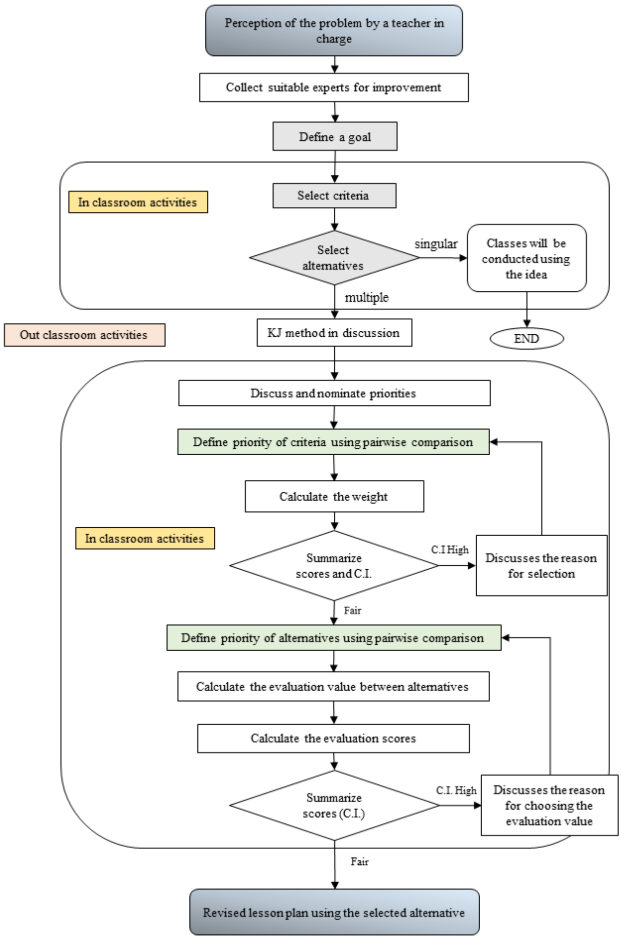

Fig. 1. Discussion process in CAR.

A. Organization of the Structure of the Problem

At the initial stage of the lesson improvement process, the hierarchical structure of the AHP should be configured. Moreover, this stage should be implemented entirely via discussion among group members with the nomination of possible criteria and alternatives.

The present study created a sample case to simulate the proposed approach by introducing active information avoidance (I-B-1) and identified indispensable measures for collaborative activities.

V. Discussion

Two typical cases were designed to simulate the proposed approach to enhance the understanding of the effects of the AHP.

A teacher in charge was tasked with improving a lesson on Goal 4 of the Sustainable Development Goals (SDG-G4) [20]. However, the teacher, who was unable to determine the best pedagogical principle, called on experts to hold a discussion. The teacher invited a university researcher, a teacher mentor, an information and communication technology (ICT) teacher, and an English teacher to form a group. They observed a class and provided suggestions on the criteria that they deemed should be met to improve the lesson on SDG-G4. In addition, they discussed which competencies students should develop through the improved lesson plan. Through the discussion, they listed four competencies as criteria (Fig. 2), namely, education for sustainable development (ESD) competencies, communication skills, ICT competencies, and English proficiency.

Given that each expert had different areas of expertise, such as self-regulated learning, computer-mediated communication, and problem-based learning, they used the AHP to process the discussion and evaluate the importance of the selected criteria and alternatives.

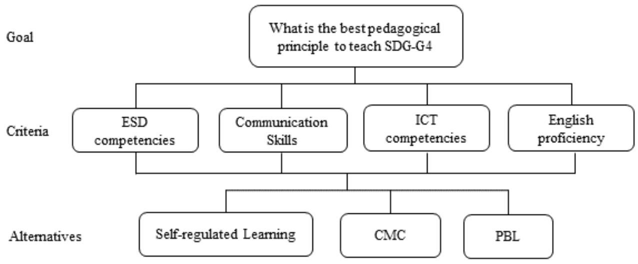

Fig. 2. Hierarchical structure of case simulation.

A. A Case with Ideal Discussion: A Near-Perfect Paired Comparison Gives a Low CI

1) Defining priorities among variables

Pairwise comparison begins with the selection of two variables, which are compared and evaluated to determine which one is considered more important or preferable. According to the structure of the case simulation (Fig. 2), if three alternatives are considered variables, then three comparisons should be made; if four items are possible at the criterion level, then six comparisons should be made. The number of comparisons required for a particular matrix of order n, whereas the number of elements being compared is $n(n-1)/2$ [17].

A spreadsheet is used to calculate the result of a paired comparison between criteria during a discussion and automatically displays the result of the CI, which is available to group members (Fig. 3).

In the method that employs computer calculation and the discussion process, "1" should first be placed in the diagonal column of the paired comparison tables (A)–(E), because a paired comparison of the same items should be of the same importance.

TABLE I. Intensity of Paired Comparison

Intensity	Definition
9	Absolutely A
7	Very much A
5	Much more A
3	Somewhat A
1	Neutral
1/3	Somewhat B
1/5	Much more B
1/7	Very much B
1/9	Absolutely B

The results of the pairwise comparison are then entered. For example, in the comparison between ESD and Communication skills in Fig. 3(A), the group decided that ESD is *extremely* important, such that the value of the paired comparison under the ESD column is 7 (Table I). Correspondingly, a value of 7 is entered in the ESD row and Communication column in Fig. 3(A). The paired comparison value for Communication is the reciprocal of this, 1/7, which is also the counter-score of 7, it is entered in the Communication row and under the ESD column.

Subsequently, other values for paired comparison are entered in each table.

Finally, we will describe a method for calculating the weight from the paired comparison table. Two methods are used to calculate AHP, namely, the eigenvalue method and the geometric mean method, which is a simplification of the first method.

What is the best pedagogical principle to teach SDG-G4

(A) Evaluation between criteria (weight)

	ESD	Communication	ICT	English	Geometric mean	Normalization
ESD	1	7	5	3	3.2011	0.5638
Communication	1/7	1	1/3	1/5	0.3124	0.0550
ICT	1/5	3	1	1/3	0.6687	0.1178
English	1/3	5	3	1	1.4953	0.2634
				total	5.6776	1.0000
					CI	0.0390

Evaluation between alternatives

(B) ESD (weight)

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	1/3	3	1.0000	0.2583
CMC	3	1	5	2.4662	0.6370
PBL	1/3	1/5	1	0.4055	0.1047
			total	3.8717	1.0000
				CI	0.0193

(C) Communication

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	1/3	1/5	0.4055	0.1047
CMC	3	1	1/3	1.0000	0.2583
PBL	5	3	1	2.4662	0.6370
			total	3.8717	1.0000
				CI	0.0193

(D) ICT

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	5	1	1.7100	0.4353
CMC	1/5	1	1/7	0.3057	0.0778
PBL	1	7	1	1.9129	0.4869
			total	3.9286	1.0000
				CI	0.0063

(E) English

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	1/7	1	0.5228	0.1194
CMC	7	1	5	3.2711	0.7471
PBL	1	1/5	1	0.5848	0.1336
			total	4.3786	1.0000
				CI	0.0063

(F)

	ESD	Communication	ICT	English
Self-regulated	0.2583	0.1047	0.4353	0.1194
CMC	0.6370	0.2583	0.0778	0.7471
PBL	0.1047	0.6370	0.4869	0.1336

X

weight of (A)	0.5638	0.0550	0.1178	0.2634

(G)

Self-regulated	0.1456	0.0058	0.0513	0.0314
CMC	0.3591	0.0142	0.0092	0.1968
PBL	0.0590	0.0350	0.0574	0.0352

(H) Comprehensive evaluation value

	0.2341
total	0.5793
	0.1866

(I)

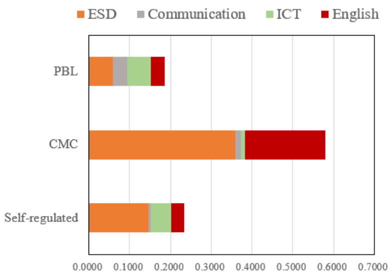

Fig. 3. Summary result (ideal).

According to Fechner [21], the Weber–Fechner law posits that a subjective sensation is proportional to the logarithm of the intensity of the stimulus; thus, the relationship between a stimulus and perception is logarithmic. Moreover, when a stimulus varies in a geometric progression, the corresponding perception is altered in an arithmetic progression. Therefore, we use geometric scores for the intensity of the opinions of the students and teachers. This paper presents the process using the geometric mean method, which is easy to calculate and understand. The geometric means of the results of paired comparison are normalized in a continuous manner. The product of the paired comparison values is then obtained. For example, 1 ×7 ×5 ×3 = 105. Next, the geometric mean value is the 4th root of 105 (a number that becomes 105 when raised to the 4th power), which is calculated as 3.2011. Similarly, the other rows are calculated. Finally, the geometric mean value is divided by the sum to determine the weight, such that the sum is 1. This process is called normalization (0–1).

(A) Evaluation between criteria (weight)

	ESD	Communication	ICT	English	Geometric mean	Normalization
ESD	1	7	1/7	3	1.3161	0.2810
Communication	1/7	1	1/9	3	0.4671	0.0997
ICT	7	9	1	1/3	2.1407	0.4570
English	1/3	1/3	3	1	0.7598	0.1622
				total	4.6837	1.0000
					CI	1.1428

Evaluation between alternatives

(B) ESD (weight)

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	1/3	3	1.0000	0.2583
CMC	3	1	5	2.4662	0.6370
PBL	1/3	1/5	1	0.4055	0.1047
			total	3.8717	1.0000
				CI	0.0193

(C) Communication

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	1/3	1/5	0.4055	0.1047
CMC	3	1	1/3	1.0000	0.2583
PBL	5	3	1	2.4662	0.6370
			total	3.8717	1.0000
				CI	0.0193

(D) ICT

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	5	1	1.7100	0.4353
CMC	1/5	1	1/7	0.3057	0.0778
PBL	1	7	1	1.9129	0.4869
			total	3.9286	1.0000
				CI	0.0063

(E) English

	Self-regurated	CMC	PBL	Geometric mean	Normalization
Self-regulated	1	1/7	1	0.5228	0.1194
CMC	7	1	5	3.2711	0.7471
PBL	1	1/5	1	0.5848	0.1336
			total	4.3786	1.0000
				CI	0.0063

(F)

	ESD	ommunicati	ICT	English
Self-regulated	0.2583	0.1047	0.4353	0.1194
CMC	0.6370	0.2583	0.0778	0.7471
PBL	0.1047	0.6370	0.4869	0.1336

X

weight of (A)	0.2810	0.0997	0.4570	0.1622

(G)

Self-regulated	0.0726	0.0104	0.1989	0.0194
CMC	0.1790	0.0258	0.0356	0.1212
PBL	0.0294	0.0635	0.2225	0.0217

(H) Comprehensive evaluation value

	0.3013
total	0.3615
	0.3372

(I)

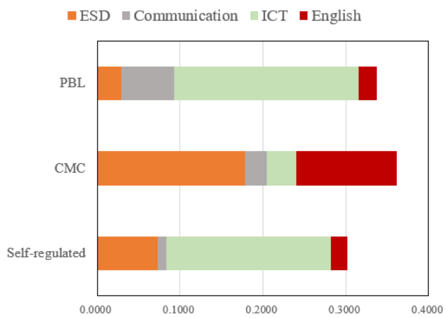

Fig. 4. Summary result (dissonance avoidance).

Fig. 3(B) illustrates the paired comparison between alternatives. A paired comparison is conducted between alternatives for ESD, which is a paired comparison of the goodness of each alternative based on the ease of fostering ESD competencies.

Fig. 3(C)–(E) depict the paired comparison values for the other criteria.

2) Introduction of summary results

The calculation for obtaining the comprehensive evaluation by integrating the evaluation values and weights of each alternative are then summarized. Fig. 3(F) displays the results of the paired comparison of each alternative. Then, the weights of each criterion are summarized in Fig. 3 weight of (A). In Fig. 3(G), a table that weighs the values in each alternative table is created, where the sum of each row in Fig. 3(G) is calculated and used as the overall evaluation value (Fig. 3(H)). Reaching the comprehensive evaluation value, we can introduce the process of discussion and scoring as well as the selected result. In terms of the formula, the overall evaluation of the Self-regulated variable is $0.5638 \times 0.2583 + 0.0550 \times 0.1047 + 0.1178 \times 0.4353 + 0.2634 \times 0.1194 = 0.2341$.

Fig. 3 (I) shows these comprehensive evaluation values.

B. A Case Involving Dissonance Avoidance Personnel

During the discussion, suppose that one person insists on introducing a computer and believes that using a computer will improve lessons. In such a case, the CI would be high. Contradictions can be revealed by providing ill-structured consistency (Fig. 4).

VI. Conclusion

The AHP is a convenient method that plays a vital role in enhancing CAR. It displays the following effects:

1) Presents the rationale;
2) Explains the decision-making process; and
3) Obtains a consensus.

These effects are explained in detail.

1) The AHP process provides group members with the opportunity to transfer tacit knowledge into explicit knowledge. In particular, many schoolteachers possess tacit but ambiguous knowledge (e.g., “There is no particular reason, but this is somehow good”). AHP renders discussions using paired comparisons possible and, at the same time, provides the rationale necessary to answer questions, such as “Why do you think this is important?” and “Why did you choose this?”
2) AHP renders information extremely easy to communicate. Using AHP, reporting to individuals who were uninvolved in the discussion and presenting how a revised plan was selected are possible.
3) The criteria used in AHP promote qualitative and quantitative data. In addition, AHP emphasizes the involvement of members and their subjective attendance by providing the activities of paired comparisons. In other words, the tacit knowledge of teachers and data from researchers can co-exist when making decisions. Therefore, obtaining results that can be agreed upon by members with different areas of expertise is possible.

However, in discussions among members with different skill sets, transmitting opinions it is typically easy to eliminate the irrelevant social authority of members. For example, in a group of teachers and researchers, opinions from researchers frequently become strong, whereas teachers concede to their opinions. However, using AHP, the criteria are anonymized and shaped, weighted, and compared during the discussion. As such, reaching a consensus becomes possible instead of deciding based on the weight of the opinion of a particular individual.

In addition, we often get lost in choosing between A, B, and C and go in circles. The reason for this notion is that A, B, and C may have inherent merits. Therefore, AHP is used to facilitate decision-making within limited interaction times.

Thus, AHP promotes effective interaction between groups. Moreover, the CAR process promotes the sharing of essential aspects when deciding and evaluating the criteria and alternatives to be used in AHP.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization, T.K. and M.Y.; Methodology, T.K. and M.Y.; Validation, T.K. and M.Y.; Formal Analysis, T.K.; Writing – Original Draft Preparation, T.K.; Writing – Review & Editing, M.Y.; Visualization, T.K. and M.Y.; and Supervision, M.Y. All authors have read and agreed to the published version of the manuscript.

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