THE EFFECTS OF INDEXING PROMPTS ON PROBLEM-SOLVING IN CASE LIBRARY LEARNING

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Abstract

Researchers have suggested that case library learning is an effective instructional method that promotes argumentation skills for ill-structured problem-solving. However, little research has examined scaffolding strategies to implement effective case library learning. The aim of this research was to examine the effects of indexing prompts as scaffolds on argumentation skills during problem-solving in case library learning. A quasi-experimental design was employed for the research. A total of 111 first-year students in a university across three sections in a career development course participated in the experiment. Participants were provided with three different indexing prompts: explanation-based indexing prompts (focused on self-explaining anomalies of individual cases), difference-based indexing prompts (focused on self-explaining similarities and differences between cases), and no prompts (allowing spontaneous self-explanations when studying cases). Learners' argumentation essays comprising initial arguments, counterarguments, and rebuttals were collected. The results found that learners who were prompted to generate mental indices outperformed the learners in the control group when constructing argumentation. More specifically, explanation-based indices were beneficial in making counterarguments and rebuttals, and difference-based indices were helpful when making rebuttals. These findings suggest that indexing cases based on both exploration of the anomalies of each case and comparisons between cases improves argumentation by facilitating case retention, retrieval, and reuse.
Keywords: *argumentation skills, case library learning, case-based reasoning, indexing prompts.*

Introduction

Scaffolding Strategies for Problem-Solving Learning

One of the fundamental pedagogical approaches used in constructivism is that learning should be situated in solving authentic problems, not in direct instruction from teachers (Hmelo-Silver et al., 2007; Jonassen, 2011). In student-centered problem-solving learning, learners learn how to solve problems on their own and take the lead in their learning. Hence, learners construct their knowledge themselves while solving problems. Learners are no longer simply receiving information from teachers in a passive manner. This transfer of the learning initiative from teacher to learner has proved advantageous in various studies on problem-based learning (Dochy et al., 2003; Hmelo-Silver, 2004; Wijnen et al., 2017).

In this student-centered learning environment, learners still need guidance in order to not lose their way on their learning journey. If not guided well or sufficiently, learners often become overloaded or distracted cognitively, causing them to handle irrelevant aspects of tasks only and resulting in poor overall knowledge construction (Kirschner et al., 2006; Mayer, 2009). An adequate level and amount of scaffolding is necessary to fulfill the cognitive and metacognitive

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requirements of truly effective student-centered problem-solving learning (Ge & Land, 2004; Hmelo-Silver et al., 2007).

Scaffolding strategies for learning to solve problems vary depending on problem structuredness (Jonassen, 2011). For example, for learning to solve well-structured problems, researchers have explored the use of different types of worked or modeling examples (van Gog & Rummel, 2010), accompanied by self-explanation prompts (Hilbert et al., 2004) and scaffold fading (Atkinson et al., 2003). Meanwhile, task sequencing strategies from simple to complex (Van Merriënboer & Kirschner, 2018), an educational approach utilizing case-based reasoning (Jonassen & Hernandez-Serrano, 2002), and question prompts (Chen, 2010; Ge & Land, 2003) have been suggested as scaffolds for ill-structured problem-solving.

In particular, for learning to solve ill-structured problems, Ge and Land (2003) have examined the benefits of question prompts and peer interactions. According to their research, question prompts to facilitate any ill-structured problem-solving process and peer interactions for collaborative problem-solving processes are useful scaffolding strategies, as they induce learners to process key information and build ideas interactively. Likewise, Chen (2010) found that question prompts used to promote conceptual knowledge or facilitate the process of problem-solving had a positive impact on problem-solving and knowledge acquisition.

However, those question prompts (Ge & Land, 2003) seem not to best support analogical reasoning, which is also essential for some ill-structured problem-solving that involves case-based reasoning. Given this gap, case library learning has been introduced to facilitate analogical and case-based reasoning (Tawfik & Jonassen, 2013; Tawfik, 2017). Case libraries provide learners with different cases that deliver practitioners' experiences with success or failure in the form of narratives. As expert practitioners use case-based strategies when solving real-life problems, these cases provide new learners with examples of these strategies (Kolodner, 1993).

When provided with cases, learners will better argue for their own solutions (Jonassen & Hernandez-Serrano, 2002; Tawfik & Jonassen, 2013). In case libraries, learners may retrieve their prior knowledge and activate problem-related schema to study cases. Then, having assessed the situations, they can explain any deviations, generate indices, and prioritize the indices for later use. Once learners have retained the cases, they can retrieve relevant cases when solving a given problem. As such, this learning environment helps learners employ case-based reasoning (CBR) and encourages them to solve problems based on lessons learned from the cases and build argumentation (Jonassen, 2011). As the quality of argumentation for a solution often determines how well learners will solve ill-structured problems, providing such cases is an effective way of scaffolding problem-solving more successfully (Jonassen, 2011).

This beneficial effect of case libraries on argumentation depends on how appropriately and sufficiently internal indices for these cases are created and how much learners reuse the lessons found in the cases (Park et al., 2020; Tawfik et al., 2019). As narratives of cases offer helpful lessons or perspectives, learners can be exposed to multiple perspectives from individual cases (Tawfik & Jonassen, 2013). Learners can also expand the problem space when they retain lessons from multiple cases (Choi & Lee, 2008) using easily retrievable indices. When cases are properly indexed, learners can find and consider multiple perspectives when solving a given problem. That is, learners can consider the pros and cons of all possible options and weigh them to generate the most viable option.

Necessity for Additional Scaffolds in Case Libraries

Offering cases only, however, does not ensure successful case indexing and construction of knowledge in a learning domain. When learning in case libraries, learners are expected to draw lessons from individual cases, generate internal indices, and construct a problem schema with which to solve a given problem well (Kolodner et al., 2004). However, this process of learning from cases can sometimes be challenging for novices. For example, learners often struggle with prioritizing indices when they are provided with just cases (Tawfik et al., 2019).

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Unlike experts, novices lack the ability to extract important and relevant information with which to construct appropriate solutions (Shanteau, 1992). These findings suggest that learners may still have difficulty in engaging in successful index prioritization when they are offered with cases alone. Other forms of scaffolding for promoting index construction are necessary to maximize the positive effects of case libraries on argumentation skills.

Offering indexing prompts, which is the main interest in this research, can be an effective form of additional instructional support. Although over-scaffolded examples of ill-structured problems may hinder learners' self-directed, constructive learning and result in simply reproducing the teacher's thinking (i.e., instructional explanation; Jonassen, 2011), it is believed that prompts for indexing cases can maximize generative thinking (i.e., self-explanation), including inferring information that is not stated explicitly, comparing and contrasting cases, and repairing existing knowledge. If prompts given to learners only encourage learners to replicate the given information verbatim, then learning activities will be passive, resulting in poor learning. On the other hand, if these prompts induce learners to infer, compare, or contrast the information or repair knowledge, then these learners will have undertaken a constructive cognitive process (Chi & Wylie, 2014). Information obtained from constructive activities not only enhances the further understanding of the examples provided but also remains more retrievable than passively presented information (Hausmann & VanLehn, 2010).

It should be noted that studies addressing the effects of prompting self-explanation when learning from examples have mostly been done in procedural domains, such as science and mathematics (Chi & Wylie, 2014; see Renkl (2014) for an overview). However, prompting self-explanation can still be fundamental instructional support in ill-defined domains. For example, Schworm and Renkl (2007) have argued that prompting self-explanations has its positive effects when learners try to understand underlying principles and how these principles are reflected in constructing argumentation, which is a non-algorithmic learning domain. Regarding learning clinical reasoning, Chamberland et al. (2015) reported that when students were prompted to give self-explanations for underlying principles present in examples or revise their mental model while studying examples, they performed better in subsequent problem-solving tasks in comparison to subjects in a control group who did not receive such prompts.

Within the context of case library learning, Tawfik (2017) examined the effects of prompts in the business domain. The prompts used for Tawfik's research functioned as facilitators of the problem-solving process when learners represented the problem, identified the problem space, selected a solution, justified and evaluated their solution using the given questions (retain prompt), or compare individual cases based on specific points stated in the questions (retrieval/reuse prompt). Their research results showed that the retain prompt was beneficial in counterclaiming and overall tasks, while the retrieval/reuse prompt was not effective in improving argumentation skills. However, neither type of prompt was designed to help generate indices for those individual cases even though the quality of index generation would positively influence CBR. They only influence internal indexing indirectly when learners select and justify a solution based on the cases or a comparison of the cases. Since learners are expected to learn the content as well as a causal reasoning process when they solve ill-structured problems (Tawfik et al., 2019), prompts that facilitate the understanding of the cases directly (i.e., indexing prompts) as well as prompts for the problem-solving process (Ge & Land, 2003; Tawfik, 2017) need to be explored. In the same vein, Chen (2010) suggested that combining procedural prompts for the problem-solving process and integration prompts for relevant knowledge acquisition could better improve schema construction as well as problem-solving skills compared to offering only a single type of prompt.

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Research Aim and Questions

It remains unclear, however, how advantageous the constructive activities induced by prompts when learners study these vicarious experiences (i.e., cases in the form of narratives) are for learning to solve problems and which prompts for indexing are the most effective in terms of facilitating constructive activities.

The aim of this current research, therefore, was to examine the effects of different types of indexing prompts on ill-structured problem-solving skills (i.e., argumentation skills in this context). To achieve this aim, this research compared three different condition groups--cases without prompts and cases with embedded prompts for explanation-based indexing and difference-based indexing. These latter two indexing methods are the typical indexing strategies that CBR introduces. To examine the effects of indexing prompts on argumentation skills, the following research question and sub-questions were posited:

RQ: To what extent does learner performance on a decision-making argumentation task differ if learners are provided with prompts for explanation-based indices, difference-based indices, or no prompts in case library learning?

(a) To what extent do initial argument scores for a learning task differ among the groups?

(b) To what extent do counterargument scores for a learning task differ among the groups?

(c) To what extent do rebuttal scores for a learning task differ among the groups?

(d) To what extent do overall argumentation scores for a learning task differ among the groups?

Research Methodology

Research Design

In this research, a quasi-experimental design was used to examine how ill-structured problem-solving skills, i.e., argumentation skills, are affected by different types of indexing prompt in case library learning. One hundred and eleven college students who enrolled in a career planning course during the Spring 2018 semester at the Dankook University in South Korea participated in the experiment for two weeks. During the case library learning, learners in the control group received cases without prompts whereas the treatment groups were given either explanation-based indexing (EBI) prompts or difference-based indexing (DBI) prompts. The theoretical background that underlay the development of each prompt type was CBR. Detailed explanations are given in the following subsections.

Context and Participants

The career planning course is a compulsory subject that all first-year student are required to take during their first semester to fulfill their general education requirements. The course requires students to explore their characteristics, interests, and occupational views; research different careers; learn strategies for rational decision-making; and develop a career plan. A total of 111 first-year students (average age = 20.2) from a wide variety of majors were enrolled in this course across three sections. The 38 students in one section were assigned to the control group, 37 students in another section were offered EBI prompts, and 36 students in the last section experienced DBI prompts. Note that it was not possible to draw more samples from other sections of this course since the experiment had to ensure that the participants had the same learning progress from the same lecturer. Among the participants, there were 62 female students (55.9%) and 49 male students (44.1%). The lecturer informed the students a week before the problem-solving phase that an experiment would be conducted as part of their learning and that all the text-based data from these problem-solving activities would be collected for that experiment. All the students agreed to participate.

The Indexing Prompts

The method by which individual cases were scaffolded (i.e., different types of indexing prompts across the groups) was the independent variable in this research. The researchers developed two different indexing prompts: explanation-based and difference-based prompts. These prompts were designed based on the implications of CBR. i.e., the CBR process was reflected in prompt design.

According to CBR research (Aamodt & Plaza, 1994; Jonassen & Hernandez-Serrano, 2002; Kolodner et al., 2004), when exploring practitioners' experiences, learners can acquire lessons that can then be retrieved later to predict viable decisions for a new problem. These lessons might include deviations and causality to be identified and indexed as either: a) anomalies, i.e., failures, in the individual cases; or b) differences or similarities between cases (Kolodner, 1993; Schank, 1999). In this regard, CBR researchers have introduced two different methods for indexing individual cases, namely, EBI and DBI. Each indexing method was, respectively, reflected in each indexing prompt type. Examples of both prompts are shown in Table 1.

Table 1
Examples of Indexing Prompts

Question Prompts for Explanation-Based Indexing	Question Prompts for Difference-Based Indexing
1. What do you think are mentor Lee's interests and values? What is her personality like? Why do you offer these answers?	1. What do you think are the mentor Lee's interests and values? What is her personality like? Why do you offer these answers?
2. Why do you think mentor Lee had difficulties in adapting to her first job? What do you think mentor Lee overlooked when choosing her first job?	2. Are there differences in mentor Lee's circumstances, career changes, personality, interests, and values compared to those of other mentors? If there are, what are they?
3. Do you think mentor Lee's career change will bring about desirable results or not? Why do you say so?	3. Are there similarities among the mentors in terms of their personal circumstances, career changes, personalities, interests, and values? If so, what are they?

EBI allows a reasoner to explain why a solution does not work or why a particular perspective is especially crucial in a given context (Kolodner, 1993). This method encourages learners to assign indices to the anomalies in individual cases. Learners are required to explain why the solution for each narrative worked or did not work. They are then expected to attempt to generalize their explanations and the indices that are constructed during this process. Kolodner further argued that EBI will focus on the most relevant facts of a case and thus also determine the facts that can be ignored.

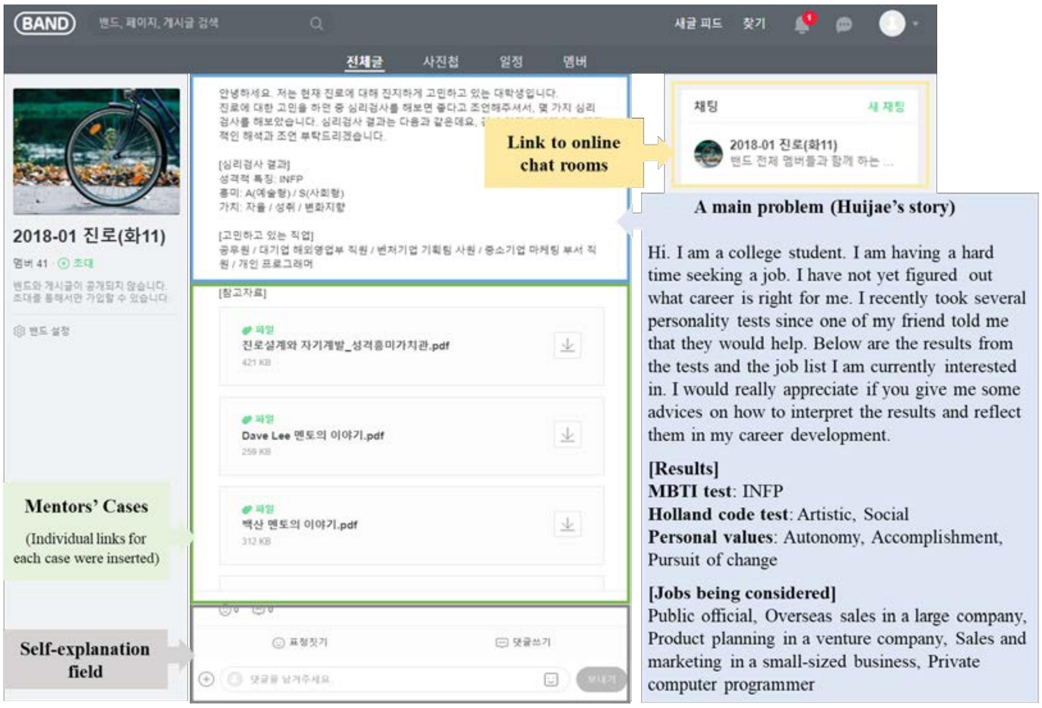
On the other hand, DBI allows learners to distinguish cases from one another, resulting in higher predictability in the retrieve and reuse phases (Kolodner, 1993). This method encourages learners to assign indices based on the common or different aspects that specialize the norms. If the difference-based indices are generated, learners can choose the "best-matching cases from the case library" (Kolodner, 1993, p.266).

Prompts were developed for each case. Validation for the four pairs of indexing prompts was confirmed by two professors with Ph.D.'s in Educational Technology. They reviewed the prompts while focusing on whether the prompts were developed appropriately for the two indexing methods.

Materials

Case library learning environment For the experiment, the lecturer used a mobile and web-based social media platform, BAND, which provides private, invitation-only online bulletin and discussion boards. A case library, which contained the main problem, individual cases, indexing prompts, and self-explanation field, was developed in this platform. Figure 1 depicts the case library learning environment used in the current research.

Figure 1
Case library learning environment



Main problem and related cases The main problem to be solved was developed by the lecturer who had taught the course for the past four years, based on her previous experience as a career counselor for college students. This problem required learners to think of the most viable decision that the character, Huijae, could make about his future career and then develop an argument for that decision in the role of the character's advisor. The researchers modified the problem to make it more ill-structured. For example, a civil servant and a computer programmer were added to the list of jobs being considered. In addition, to make the circumstances still more complicated, the protagonist was given conflicting information on career changes, which widened his possible options from a long-term point of view and confused him further.

Related cases were designed to be failure-based since Tawfik and Jonassen (2013) reported that learners benefit more from failure-based cases when making counterarguments than they do from success-based cases. Tawfik and Jonassen argued that these learners might

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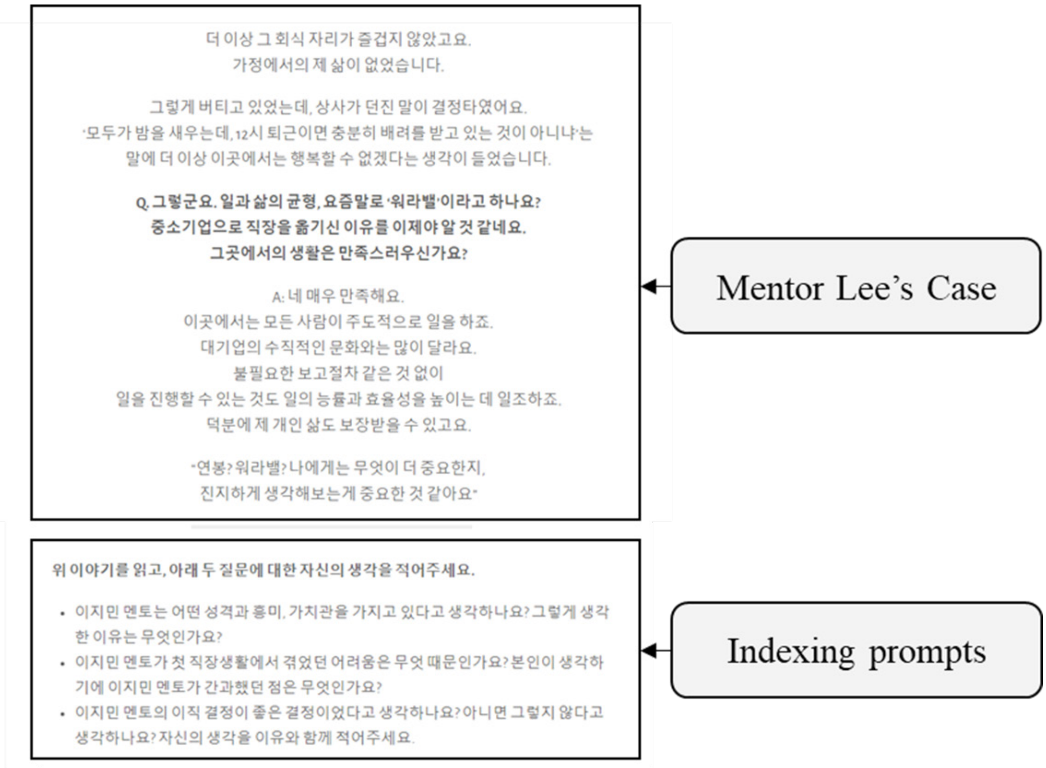
have a greater chance of generating indices from failures because they are exposed to the mental discomfort of the characters in the narratives and the explanations offered for the unexpected result, which usually allows them to identify alternative perspectives.

The researchers constructed each case narrative using low-density text to reduce reading time, due to the limited time (an hour and a half) assigned to the case-based learning phase under all conditions. It was not enough time for learners to read a very long, text-only narrative. In order to construct low-density texts, a question-and-answer format was adopted. Using low-density text can reduce learning time, but it does not compromise the learning outcome (Ross & Morrison, 1989).

Figure 2
Mentor Lee's case with the following indexing prompts



Instrument validation for the problem and its cases was achieved in two ways. First, two subject matter experts, who participated in developing the textbook for this course, helped check the content validity of the problem and the cases. Second, two researchers with Ph.D.'s in Educational Technology examined the problem and the four cases to see if they were ill-structured, which meant that they had multiple alternative solutions, unclear goals, constraints that made them too complex, and multiple criteria for evaluating the solutions (Jonassen, 2011, p.7).

Procedure

The case library learning had two learning phases, namely, a case study phase and a problem-solving phase. During the case study phase, the lecturer posted the main problem to solve on BAND. Four related cases, which students could then access through hyperlinks embedded in the main problem, were provided. Students were encouraged to read and review the main problem and the related cases for 30 minutes.

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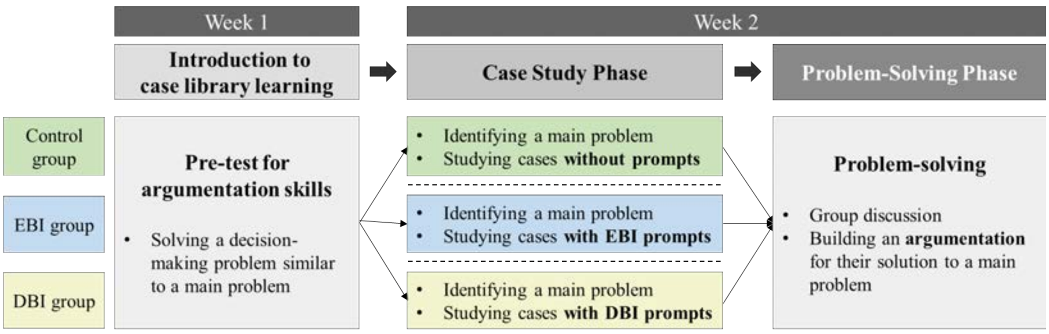
Meanwhile, the three different groups across the three class sections were provided with different types of prompts that were attached to each individual case. Students in the two treatment groups were required to answer the given prompts, while the students in the control group received no prompts. Students who were not provided with prompts were instead allowed to write down the ideas that occurred to them spontaneously. The learning time for all the case studies was kept constant among the groups.

After reading the main problem and four cases individually, students were encouraged to hold a group discussion in a text-based online chatting environment to resolve the main problem. After 30 minutes of group discussion, students were to develop their argumentation for the solution individually and post it on BAND over the course of another 30 minutes.

Figure 3
Procedures used in the case library learning of the control and treatment groups



Measurements

Pre-test A pre-test covering argumentation skills was taken one week ahead of the main learning session for the case library learning. Students were asked to solve a decision-making problem which was designed to be as identical as possible to the learning task in terms of its structure (e.g., certain multiple perspectives to be considered). The surface features of the problem, such as characters and contextual details, were different.

When solving the problem presented on the pre-test, learners were required to construct argumentation. Their argumentations on the pre-test were scored using the holistic argumentation scoring rubric adapted from Jonassen and Cho (2011). These scores ranged from 0 (no clear claim stated) to 6 (a clear claim, counterclaim, and rebuttal offered with substantial evidence).

Argumentation essay As a dependent variable, argumentation can represent how well learners solve a decision-making problem in case libraries, as they develop their argumentation by using the lessons learned from cases to justify their claims. When solving the main problem, learners were required to build argumentation essays that comprised three different components (initial argument, counter-argument, and rebuttal) (Tawfik & Jonassen, 2013; Tawfik, 2017). According to Kuhn and Udell (2003), including a counterargument and rebuttal is a powerful strategy for constructing a good argument.

Learners first provided their initial claim as to which career path best suited the character. They were then encouraged to offer as much evidence as possible. Next, they presented an alternative solution and were to supply convincing evidence that argued against the initial solution. The counterargument could be derived from other perspectives and positions. Lastly, learners gave rebuttals to challenge the counterclaim in terms of its validity or weaker influences or synthesized the initial and counter-arguments (Tawfik & Jonassen, 2013) to form a new solution.

The current research employed the scoring rubric used in Tawfik and Jonassen (2013) to assess the students' argumentation skills. Its components consist of an initial argument, counterargument, rebuttal, and holistic scores calculated by aggregating the three scores (see Table 2).

Table 2
Argumentation scoring rubric for a learning task

Score	Initial Argument	Counterargument	Rebuttal
0	No initial argument or claims are inconsistent	No clear counterargument stated, or claims are inconsistent	No clear rebuttal stated, or claims are inconsistent
1	Argument is clear and supported by a single reason	Counterargument is clear and supported by a single reason	Rebuttal is clear and supported by a single reason
2	Argument is clear and supported by multiple reasons that are not specifically explained and elaborated	Counterargument is clear and supported by multiple reasons that are not specifically explained and elaborated	Rebuttal is clear and supported by multiple reasons that are not specifically explained and elaborated
3	Argument is clear and supported by multiple reasons that are partially explained and elaborated	Counterargument is clear and supported by multiple reasons that are partially explained and elaborated	Rebuttal is clear and supported by multiple reasons that are partially explained and elaborated
4	Argument is clear and supported by multiple reasons that are specifically explained and elaborated	Counterargument is clear and supported by multiple reasons that are specifically explained and elaborated	Rebuttal is clear and supported by multiple reasons that are specifically explained and elaborated

Note. Adapted from "The Effects of Successful versus Failure-Based Cases on Argumentation while Solving Decision-Making Problems" by A. Tawfik, D. Jonassen, 2013, *Educational Technology Research and Development, 61*(3), pp.394-395. Copyright 2013 by the Association for Educational Communications and Technology

Two coders, the main researcher and a graduate student, respectively, coded 20 essays that were randomly chosen according to this rubric. Inter-rater reliability was moderate (Cohen's kappa = .74) after coding 20 essays. Having discussed the differences between the assigned scores, the coders individually coded the remaining essays (Cohen's kappa = .87). Afterwards, all discrepancies were resolved through discussion.

Research Results

Pre-test

An ANOVA revealed no significant differences among the groups in terms of the argumentation scores received on the pre-test ($F\,(2, 108) = .644, p = .527$). This finding indicates that the students in the three groups were showed no differences in their argumentation skills.

Initial Argument

An ordered logistic regression was conducted for the initial scores because the dependent variable was based on ordinal data. The parallel regression assumption was tested before the main analyses were conducted. The results of the test yielded $\chi^2\,(6) = .698$ ($p = .995$), upholding the assumption. The main analysis then followed. For the initial scores, ordinal logistic regression did not find significant differences (χ^2 (2) = .649, *p* = .723) among the control group (*M* = 3.34, *SD* = .85), EBI group (*M* = 3.16, *SD* = 1.17), and DBI group (*M* = 3.19, *SD* = .86).

Counterargument

For the counterargument scores, an ordered logistic regression was again employed. The assumption of parallel lines was met (χ^2 (6) = 10.297, *p* = .113). The main analysis found a statistically significant difference (χ^2 (2) = 8.852, *p* = .012) between the control group (*M* = 1.42, *SD* = 1.08) and EBI group (*M* = 2.00, *SD* = .97, Log Odds = 1.325, *p* = .003). No significant differences were found between the DBI group and the control and EBI groups.

Table 3
Parameter estimates of ordered logistic regression for counterarguments

		Estimate	Std. Error	Wald	*df*	*p*
Threshold	[Counterargument=0]	-1.833	.398	21.171	1	<.001
	[Counterargument=1]	.414	.316	1.721	1	.190
	[Counterargument=2]	2.402	.391	37.683	1	<.001
	[Counterargument=3]	3.701	.521	50.370	1	<.001
Location	[Prompts=0]	1.325	.444	8.910	1	.003
	[Prompts=1]	.814	.437	3.466	1	.063
	[Prompts=2]	0[a]			0	

Note. Link function: Logit. a. This parameter is set to zero because it is redundant

Rebuttal

An ordered logistic regression was conducted once more for the rebuttal scores. The parallel regression assumption was not violated (χ^2 (6) = 7.148, *p* = .307). As in the analysis of counterargument scores, the ordinal logistic regression found a significant difference between the control group (*M* = 1.71, *SD* = .98) and the EBI group (*M* = 2.19, *SD* = 1.13, Log Odds = .961, *p* = .029). There was also a significant difference (χ^2 (2) = 8.464, *p* = .015) between the control group (*M* = 1.71, *SD* = .98) and the DBI group (*M* = 2.28, *SD* = .85, Log Odds = 1.208, *p* = .007).

Table 4
Parameter estimates of ordered logistic regression for rebuttals

		Estimate	Std. Error	Wald	*df*	*p*
Threshold	[Rebuttal = 0]	-3.004	.615	23.903	1	<.001
	[Rebuttal = 1]	-.177	.311	.324	1	.569
	[Rebuttal = 2]	1.939	.368	27.776	1	<.001
	[Rebuttal = 3]	2.673	.411	42.330	1	<.001
Location	[Prompts = 0]	.961	.440	4.779	1	.029
	[Prompts = 1]	1.208	.447	7.294	1	.007
	[Prompts = 2]	0[a]	.	.	0	.

Note. Link function: Logit. a. This parameter is set to zero because it is redundant

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Overall Argumentation

An ANOVA was conducted on the overall argumentation scores (0 - 12), which were calculated by adding up the other three scores. However, there were no significant differences (F (2, 108) = 1.979, p = .143) between the control group (M = 6.47, SD = 2.01), the EBI group (M = 7.35, SD = 1.126), and the DBI group (M = 2.28, SD = .849).

Table 5
The descriptive statistics of argumentation scores

	Initial argument		Counterargument		Rebuttal		Overall	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
No prompts	3.34	.85	1.42	1.08	1.71	.98	6.47	2.01
Explanation-based indexing prompts	3.16	1.17	2.00	.97	2.19	1.13	7.35	2.43
Difference-based indexing prompts	3.19	.86	1.75	.73	2.28	.85	7.22	1.68

Discussion

In response to the increasing importance of how to argue well to solve ill-structured and authentic problems (Keinonen & Kärkkäinen, 2010; Quintana & Correnti, 2019), researchers have proven that case libraries are effective learning environments in which to support the ill-structured problem-solving process (Park et al., 2020; Tawfik & Jonassen, 2013; Tawfik, 2017). Scaffolds, such as the question prompts suggested in Tawfik's research (2017), can help learners generate better representations of the problem and its subsequent solutions. However, the question prompts that are given in the problem-solving phases facilitate problem-solving but do not provide help index individual cases effectively. To build on the studies that address the scaffolding of case libraries, the current research examined the effects of prompts for index construction on ill-structured problem-solving skills. The research employed two types of prompts for index construction: (a) prompts for EBI construction, and (b) prompts for DBI construction. The results suggested that providing prompts when learners study individual cases had positive effects on argumentation skills.

Learners in the two treatment groups did not seem to benefit from index construction activities in terms of their initial claims. The initial claim scores for the three different groups were not statistically different. This result resembles Tawfik's (2017) findings, which indicated that problem-solving prompts do not improve initial argument skills. Although it would be inappropriate to compare Tawfik's work and the current research since the types and timing (either when studying cases or solving problems) of prompts were different, it can still be inferred, however, that further instructional support in addition to the provision of cases may not enhance skills in constructing initial arguments. The result can also be explained by the explicitness of the instructions provided, which can refine implicit argumentation skills (Nussbaum & Schraw, 2007). Given that the average scores of all the groups in this research were more than 3 points out of 4, it can be assumed that this set of learners was generally good at presenting a solution that they believe is the best solution.

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On the other hand, the learners who participated in EBI constructions outperformed the control group in making counterarguments and rebuttals. It is assumed that the prompts for EBI construction may give learners more opportunities to learn the lessons associated with any multiple and failure-related perspectives (e.g., failure to adapt to a new workplace or job change) from which the alternative solution is derived. While answering the prompts included in individual cases, learners may generate indices based on the circumstances that bring about failure as well as a possible explanation for this unexpected failure (e.g., overlooking the fit between the duties and working environment for a job and the interest and values of mentors). When generating the indices for a vicarious failure, learners can acquire a problem-related script that contains multiple competing perspectives (Tawfik & Kolodner, 2016). When learners are explicitly prompted to explore failure, infer the possible explanation for this failure, and revisit their existing knowledge, they can generate a problem-related script using diverse perspectives (Schank, 1999). Their script will then become more dynamic, much like the one in the character's memory. The more failure-related indices that are put into a learner's memory, the more similar their scripts will become to those of experienced practitioners and the broader their problem space becomes. Once more circumstances are taken into consideration, learners can better argue for alternative perspectives and better weigh their options for resolving a conflicting situation or synthesize other options to support their initial claims.

The learners provided with prompts for DBI construction also outperformed the control group in developing rebuttals. Once learners are prompted to explore failure, they are likely to generate more indices, which then extends their problem space, no matter which type of activity, i.e., either examining the individual case or comparing cases, is facilitated. Learners may have more chances to extend their scripts when they try to figure out the commonalities and differences of the circumstances surrounding the failures (Kolodner, 1993). When learners construct DBIs, they may distinguish between the situational facts that cause certain results and other facts that produce other results. Therefore, it is assumable that learners will think of more ways to rebut any conflicting arguments based on these situational differences.

In terms of cognitive load theory, it is noteworthy that learners who were asked to compare the four cases for 30 minutes outperformed the learners in the control group in offering rebuttals. According to the cognitive load theory (Chandler & Sweller, 1991), it is generally expected that learners may be cognitively overloaded when asked to compare several cases shown on separate pages. However, it is assumed that the subjects in both treatment groups successfully self-explained the differences or similarities and thus did well in terms of constructing rebuttals. To further verify this assumption, future research can assess students' cognitive loads and explore the positive or negative effects of different prompts on the cognitive processing of learning content.

However, no evidence was found which indicated that learners in the DBI group produced better counterarguments. It was an unexpected result because comparing cases does require identifying multiple perspectives for each case and figuring out which variables are related to which alternative perspectives. This result may be attributed to the small sample sizes used for the groups. The sample sizes were not large enough to draw any significant implications from the experiment. Although the ordered logistic regression for counterargument scores between the control group (M = 1.42, SD = 1.08) and the group using DBI (M = 1.75, SD = .73) found no statistically significant difference (Log Odds = .814, p = .063), it is anticipated that if an experiment using a larger number of participants were to be conducted, the differences caused by that treatment would become noticeable.

Meanwhile, no evidence was found to indicate which type of prompt design is most desirable for scaffolding learning from cases. Both EBI and DBI, once prompted, help reasoners retrieve and reuse cases. Either way, learners are encouraged to search for situational variables that cause failure and generate indices so that they can retrieve these cases when they encounter similar problematic situations. Learners, once prompted, can better acquire an extended problem-related script from a vicarious experience of failure, which can then act as a prior experience on which practitioners can rely when they encounter a new problem to solve.

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Overall, the finding of the current research parallels the results of the previous research in ill-defined domains such as diagnostic problem-solving (Chamberland et al., 2015), learning argumentation skills (Schworm & Renkl, 2007), and ill-structured problem-solving in the educational measurement domain (Chen, 2010). Opportunities to self-explain the concepts and principles underlying the examples enhance learner engagement when processing the given materials and reaching an understanding of the learning content. Likewise, in the current research, learners in the prompted condition outperformed the learners in the no-prompt group in the argumentation task because they constructed internal indices while answering the prompts attached to each case. The more meaningful the indices they constructed, the better they retained the lessons, and the more predictable the indices that they retrieved and then reused when solving the problems became.

In addition, the beneficial effects of indexing prompts support Sweller's (2011) contention that biologically secondary knowledge, also known as domain-specific knowledge, requires instructional support to be acquired successfully. Learners may better acquire domain-specific knowledge, such as domain principles reflected in the narratives of individual cases, when these learners are supported by instructional interventions such as prompts. In other words, learners rarely discover cultural knowledge without appropriate and explicit teaching and learning (Geary, 2008), which entails a cognitive process of selecting, organizing, and integrating new information. As cases contain context-specific experiences and lessons, assisting learners with indexing prompts will encourage them to process the information more effectively. Otherwise, learners may struggle with constructing the knowledge themselves and generate indices containing irrelevant or unhelpful information.

Conclusions

The result of this research shows that learners do well in constructing their initial claim with proper evidence when explicitly instructed. However, additional scaffolds should be provided to facilitate case indexing and promote the development of counter-argumentation and rebuttal skills in case library learning. This research offers empirical evidence that EBI prompts are effective in encouraging learners to explore other various competing perspectives when making counter-arguments. Moreover, both EBI and DBI prompts encourage learners to weigh multiple options and integrate them or rebut the counter-argument to consolidate their initial argument. The current research, however, does have its limitations. First, the research did not examine the direct effect of the prompts on the *content* of the generated indices. In order to solidify the positive relationship between indexing activities and the development of argumentation skills, empirical research should be followed to explore the process and content of indexing activities. Second, the learning sessions in problem-solving lasted a mere three weeks. This period is not a long enough time period in which to see the educational value of case library learning while using the constructivist approach, as most learners are not accustomed to this type of instruction. Third, the sample size was not large enough, and the learning domain was limited. To generalize the findings of this research to other contexts, more research should be done to examine the effects of the indexing prompts in case library learning with a larger number of students in various fields.

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