Educational System of English Tense for Japanese Learners by Forming Temporal Constraints on Tense

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Abstract: In this study, we developed an English-tense learning and education system that provides training in constructing tense constraints from given sentences. Temporal constraints refer to the condition that the correct choice should be met in English tense-choice questions. In this study, we organized the patterns of temporal constraints and guided learners to assemble them based on these patterns. We also introduced a visual representation to enhance the intuitive understanding of temporal constraints. We conducted an experimental evaluation of the proposed system to investigate its learning effectiveness. Additionally, in the experimental evaluation, we developed a system using graphic representation and a system without graphic representation and investigated the differences between them.

Keywords: Learning Support System of English grammar, Tense in English, Temporal Constraints, Graphic Representation

1. Introduction

In English language learning among Japanese native speakers, errors in verb tense largely depend on knowledge outside the text, including real world knowledge. As a result, correcting verb tense and aspect errors has been suggested to be difficult (Lee, 2008).

In this study, we focused on verb tense and aspect in the context of English tense multiple-choice exercises in which learners are required to select the appropriate verb form from a set of choices to fill in a blank. The process of solving English tense problems can be considered as (1) constructing constraints about the word that should fill in the blank in the problem sentence and (2) determining whether each choice satisfies all the constraints. We call these constraints “temporal constraints.” In English tense problems, temporal constraints are frequently encountered and are important among those constraints. Several errors of English are believed to occur in the (1). Therefore, we developed a learning and educational support system that trains learners to construct temporal constraints from the information contained in problem statements. To assist in the construction of tense constraints, we break down temporal constraints into patterns. By conducting the learning process of constructing temporal constraints based on each pattern, we aim to improve the accuracy of answering the questions and enhance the ability to explain the cognitive reasoning underlying the answers.

As a learning method for constructing temporal constraints, we envision an interactive process between learners and an educational support system that guides them in following (1) and (2). In Step (1), the system guides learners to construct temporal constraints from the problem text based on the temporal constraint patterns. In Step (2), the system allows learners to apply constraints to each choice and determine whether the constraints are satisfied. The constraints can be expressed in text format. However, we are afraid that some types of temporal constraints in text are difficult to intuitively apply to the choices in the Step (2). Therefore, we introduce a graphical-representation method to express these constraints.

The reasons for introducing the use of graphical representation are as follows.

Problems with English tenses require an understanding of the temporal relationships between events in English sentences. In general, time is recognized as a one-dimensional space from the past to future. Thus, by representing the timeline as a one-dimensional space and displaying a diagram that positions events on the timeline, the temporal relationship between the events can be clarified.

In this study, to verify the effectiveness of this graphical representation, we constructed and conducted an experimental evaluation of both a system with and without graphic representations. The following results were obtained for both systems. Before and after receiving support from the systems, a significant improvement was observed in both the accuracy of problem solving and the quality of explanations for the answers. By using systems to practice exercises repeatedly, learners can internalize the methods for constructing temporal constraints without relying on the systems.

2. Related works

Many educational systems of English grammar for Japanese learners have been developed (Le,2011)(Ozaki,2004)(Ozaki,2007). However, these systems don't aim to teach usage of verbs. The misuse of verbs such as tense and aspect is a typical error category for nonnative speakers of English. Correcting errors related to tense and aspect, which are directly related to the English verb tense, is considered difficult. This is because tenses and aspects heavily depend not only on information within the target sentence, such as adverbs and coordinating conjunctions, but also on the global context, such as knowledge of the real world outside the target sentence (Lee,2008). In the KJ Corpus, which annotates grammatical errors and performs syntactic analysis, article errors are the most frequent, followed by errors in singular/plural nouns, prepositions, and verb tenses.

Various methods have been proposed to support learning and education through the automatic detection and correction of errors(Page,2003)(Burstein,2003)(Liao,2016). However, there have been few developments in the creation of systems that specifically focus on thought processes involved in solving problems. As an educational system that focus on thought process, the system establishes thought process for arithmetic problems by having students select and arrange sentences from a provided collection of short sentences and pose questions in an appropriate order(Hirashima,2007). A system also focuses on developing thought process of programming using code puzzles(Ito,2020). Code puzzles are having students form programs by arranging statements that are ordered randomly. These systems are designed to have students form something in order to focus on thought process in solving problems. But they aren't systems for English tense. In terms of learning of English tense, what should be formed by students? We think forming temporal constraints is effective for students to learn thought process of English tense problems. So we developed educational systems that teach students how to form the temporal constraints required for correct answer choices in English tense choice questions.

As a method for teaching students how to form temporal constraints, we focused on using graphical representations. Some studies use them to assist Japanese in understanding English tenses(Tanaka, 2018)(Miura, 2010). However, these graphical representations are not intended for application in learning English tenses; therefore, we thought an extension of the graphical method is necessary. In this study, we developed graphical representations suitable for learning and educational support, as described in Section 3.2. We developed learning and educational support systems to help learners judge whether each choice is valid by comparing the temporal constraints and events represented by each choice graphically.

3. Basic Ideas

3.1 Temporal constraints

We analyzed the relationship between the validity of choices and temporal constraints for 24 English tense choice questions from standard university entrance exam questions in Japan, including past exam questions from the National Center for University Entrance Examinations

(2000-2018) and commercial study materials in Japan (Nakao,2016). Consequently, we found that temporal constraints can be classified into the following three types:
1. Constraint by specific words or phrases: “already”, ”by + time phrase”, and other specific adverbial or prepositional phrases determine the tense and aspect of the verb they modify.
2. Constraint by tense agreement: When the main clause is in the past tense, the subordinate clause also becomes past tense or past perfect tense.
3. Constraint based on the relationship between events: Constraints based on the context of the problem and common sense of the real world determine tense and aspects of verbs.

The systems that we developed allow learners to form these constraints in their sentences. For a system that uses graphical representations, the generated constraints can be incorporated into graphical representations.

3.2 Extending Graphical Representation

Based on the above problem analysis, we organized the necessary components for expressing the temporal constraints in a diagram as follows:
i) Event node: The element representing an event is expressed as a node, and the aspect of the event is expressed by the node type. These are shown in Figure 1.
ii)Timeline: We express the timeline using a horizontal arrow.
iii)Time of utterance: This is the time point when the problem statement was uttered.

In the timeline, the right side represents the future and the left side represents the past with respect to the point when the problem statement is uttered. For each event in the problem statement, we set the following components: i) ii) iii) For example, the graphical representation of the sentence “By the time the 2002 World Cup was held, soccer had already become a leading sport in Japan.” is shown in Figure 2.

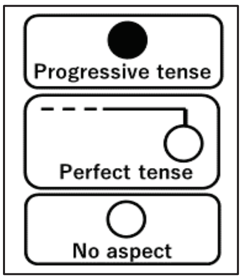

Figure1. Aspect Graphical Representations

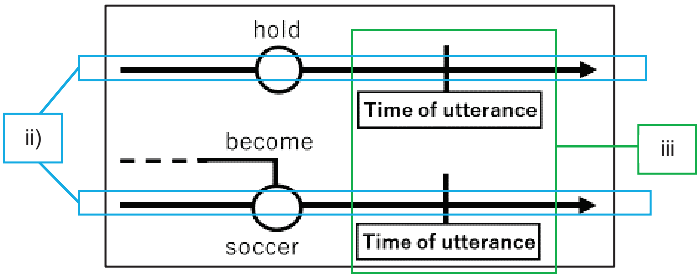

Figure2. Example of The Graphical Representation

3.3 Learning process in the system

The learning process in the system using graphical representations is shown in Table 1. On the other hand, system without using graphical representations, formation of graphical representations of temporal constraints and problem statement containing the choice of words and comparison of them are omitted, as described in Section 3.3.1.

Table1. Learning Process in the System Using Graphical Representations

Step	Learning process in the system using graphical representations
1	For each of English question, the learner selects the validity of the answer with “○” for valid and “×” for invalid. If learners are unsure at the current stage, they can select “?”.
2	After considering the temporal constraints of the problem in a sentence using a fill-in-the-blank template, we form them as graphical representations.
3	Represent the problem statement containing a choice of words using graphical representations.
4	Compare the graphical representation of the temporal constraints created in Step 2 with the graphical representation of the answer choices created in Step 3 and determine whether the answer choice satisfies the temporal constraints.
5	The learner selects which part of the choice graphical representations they compared to graphical representations of temporal constraints. This helps eliminate random answers, estimates errors and reminds learners that they should focus their attention.
6	Step3 to Step5 are repeated for each choice.
7	After completing the comparison using graphical representations, the validity of each choice is selected as an answer by choosing "○" for valid or "×" for invalid.

4. Implementation

In this study, we constructed systems and implemented 10 problems that contained two types of constraints as a prototype: constraints by specific words or phrases and constraints by tense agreement. The constructed systems followed the learning flow described in Section 3.3. Systems are implemented using the C# language in Visual Studio 2022.

4.1 Forming and comparing graphical representations of temporal constraints with graphical representations of each choice

Temporal constraints were created as text by filling in the fill-in-the-blank template, as shown in Figure 3. Constraint types are displayed on the menu as guidelines to make learners aware of the pattern of constraints. By following a certain abstract pattern, learners learn to construct temporal constraints. If the learner makes a mistake, the system provides advice tailored to the blank space to help the learner arrive at the correct answer.

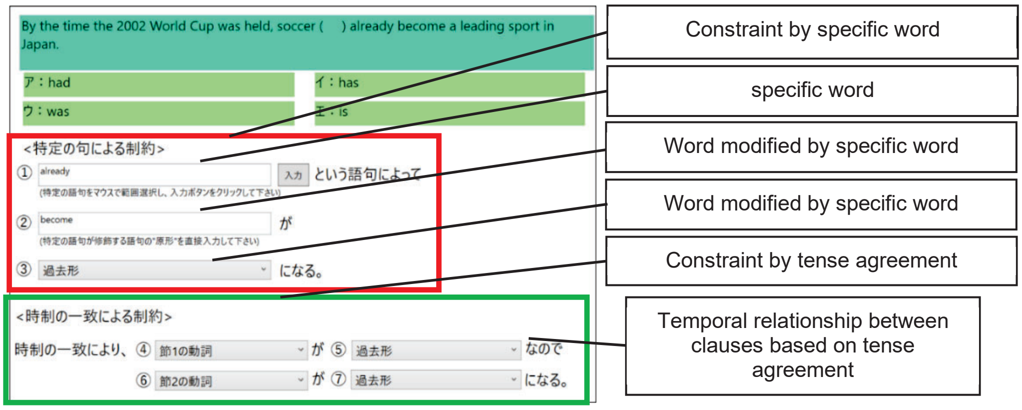

Figure3. Screen for Creating Temporal Constraints (as a text)

4.2 Forming and comparing graphical representations

Learners visualize the problem statement, including temporal constraints and each choice. They form graphical representations by specifying the temporal constraints and aspects of the node, as indicated by the red boxes in Figures 4 and 5. By visually comparing them, learners can judge whether each choice satisfies temporal constraints.

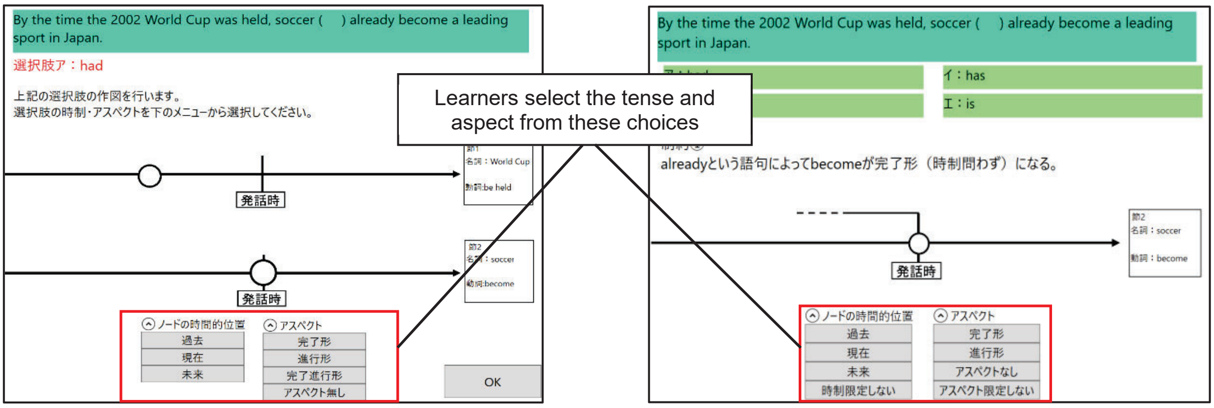

Figure4.Forming Graphical Representations (Temporal Constraints)

Figure5. Forming Graphical Representations (problem statement including choices)

5. Experimental Evaluation

5.1 Hypothesis of the experiment

In the experiment, we validated the following experimental hypotheses.

<u>Hypothesis 1:</u> Prompting learners to consider temporal constraints improves the accuracy of

their responses to questions and increases the quality of their explanations for judging the validity of their choices.

Hypothesis 2: Repeated practice exercises will help establish a consistent approach to judge the validity of each choice.

5.2 Experimental procedure

Participants were divided into two groups: Group A used a system with graphical representations, and Group B used a system without graphical representations. Five Japanese university students were recruited for each group and were given 10 English tense choice questions. Experimental procedure was performed according to Section 3.3 above. From the data obtained Step 1 and Step 7 in Section 3.3, aggregate how the reasons for each choice of "○", "×", and "?" changed. Thus, it can be said that experimental Hypothesis 1 is supported if the accuracy rate improves and the justifications for the validity of each choice provided by the learners become clearer, or if there is a reduction in ambiguous reasoning. In addition, if the reasoning for each choice in the system before learning becomes clearer through the repeated practice of problem-solving, Hypothesis 2 is supported.

5.3 Results

5.3.1 The correct answer rate

The correct answer rates for the questions in Groups A and B are shown in Figures 6 and 7. Here, the correct answer to a question means that all choices for that question are correctly answered with "○" or "×". In both groups, "the correct answer rate improved significantly before and after using systems"(*result1*).

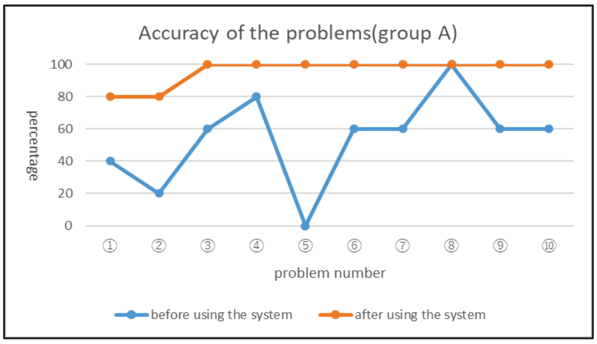

Figure6. Accuracy of the Problems (group A)

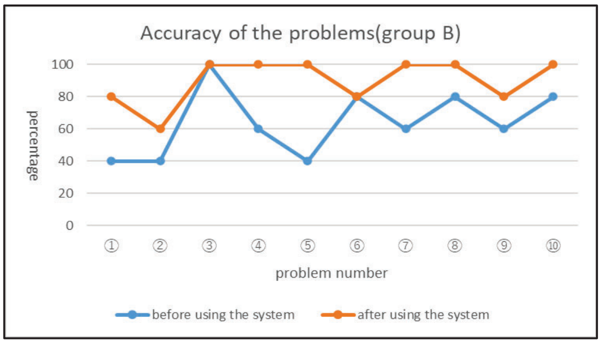

Figure7. Accuracy of the Problems (group B)

5.3.2 Changes in reasoning before and after system learning

We scored the validity reasoning for each choice before and after learning with systems as follows: Items that provide clear reasoning(2 points). Items that describe the type of temporal constraints, but do not provide specific measures to address the issue(1 point). Items that are clearly ambiguous, such as "I thought it seemed like it."(0 point).

The total number of choices for the 10 questions was 165. Assuming that all 165 justifications for the choices are clear (2 points), the percentage of clarity in justifications before and after system learning for each group is shown in Figures 8 and 9.

In the justifications after system learning, it is clear that both Group A and B have clearer justifications than before system learning for all 10 questions. Therefore, we find that "using the system improves quality of explanations for the reasoning of the validity of the choices"(*result2*). Thus, the Experimental Hypothesis 1 is supported by the *result1* and the *result2*.Furthermore, the changes in learners' understanding through repeated practice can be seen from the score changes in questions ①-⑩ before system learning in Figures 8 and 9. As a result, "gradual improvement can be observed as the number of questions increases"(*result3*). Although this experiment used only 10 questions, we can expect sufficient improvement if we increase the number of questions. Therefore, we can say that the Experimental Hypothesis 2 is supported by the *result3*.

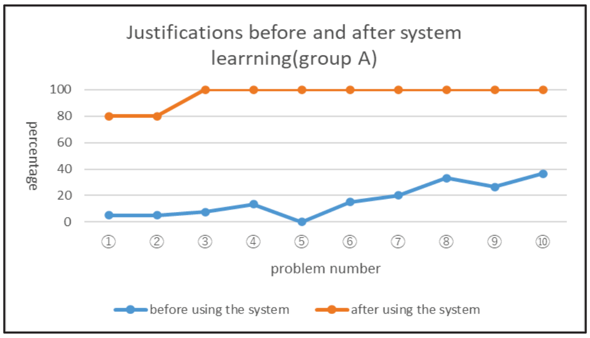

Figure8. Justifications Before and After System Learning (group A)

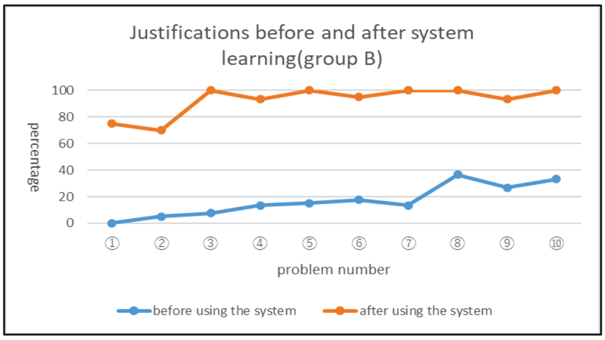

Figure9. Justifications Before and After System Learning (group B)

6. Conclusion

In this study, we developed learning education support systems that teach learners to construct temporal constraints based on information on English tense-choice problems. The experimental results showed that we could get "the correct answer rate improved significantly before and after using systems"(*result1*), "using the system improves quality of explanations for the reasoning of the validity of the choices"(*result2*) and "gradual improvement can be observed as the number of questions increases"(*result3*) in Section 5.3. However, based on their responses to the questionnaire, some students noted that the graphic representations were effective. Therefore, we plan to conduct experiments to assess the effectiveness of graphics tailored to the learners' English proficiency levels.

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