Understanding Support of Causal Relationship between Events in Historical Learning

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SUMMARY In historical learning, to grasp the causal relationship between historical events and to understand factors that bring about important events are significant for fostering the historical thinking. However, some students are not able to find historical events that have causal relationships. This skill is important for inferring about events that will occur in the future by comparing modern-day issues with events that occurred in the past - that is, historical events [2]. This paradigm asked students to organize the causal relationships of historical events and those of events in the modern-day, but their validity was not evaluated. Kojiri et al. proposed a learning paradigm of discovering lessons from historical events in order to utilize it as the knowledge for our future activities [6]. In this paradigm, students were asked to abstract the flow of the given historical events that have causal relationships so as to discover the lessons. This learning paradigm focused on the process of discovering the lessons, but the process of selecting the historical events with the causal relationships was not supported. Understanding the flow of the history and aware of the important factors that cause significant events in history is cornerstones for improving historical thinking. Important factors are estimated by the historical events that have causal relationships. Horiguchi et al. developed a platform that enables students to arrange historical events along the sequential relationships, such as chronological time line, but it did not focus a causal relationships [7].

The view of observing the historical events is different among individuals, so the historical events that individuals think to have causal relationships are not always the same. For instance, by the currency reforming by Tsunayoshi Tokugawa, who is a 5th Shogun in Edo era, the amount of the currency increased and the economy got activated. On the other hand, the currency reforming rose the prices and people’s life got hard. Therefore, from the positive viewpoint, the currency reforming has a causal relationship with the activation of the economy. From the negative viewpoint, it has causal relationships with price rise and hard life. Both causal relationships are valid but students may select either one according to their viewpoints. To know and discuss such viewpoint differences with others is also meaningful to improve the historical thinking skill. Therefore, it is not appropriate to define the correct causal relationships and make students understand them. In order to make students understand their own viewpoints and notice viewpoint differences among others, the concept map is one of the effective tool to use [8].

One of the authors of this paper introduced a kind of the concept map, which we call a causal relation graph, into his middle school classes. This causal relation graph consists of nodes representing historical events and links representing

1. Introduction

Historical thinking skill is a reasoning skill to analyze and explain the historical events [1], [2]. This skill is important for inferring about events that will occur in the future [3], [4]. Such skill brings us knowledge for our future activities in many fields, such as politics, environmental issues, or architecture [5]. The skill should be learned through the historical learning. However, especially in Japan, students tend to memorize facts in historical learning and historical thinking skill is merely acquired.

Considerable researches have focused on cultivating the historical thinking. Kojiri et al. proposed a learning paradigm which fosters students’ skills of inferring the future by comparing modern-day issues with events that occurred in the past - that is, historical events [2]. This paradigm asked students to organize the causal relationships of historical events and those of events in the modern-day, but their validity was not evaluated. Kojiri et al. proposed a learning paradigm of discovering lessons from historical events in order to utilize it as the knowledge for our future activities [6]. In this paradigm, students were asked to abstract the flow of the given historical events that have causal relationships so as to discover the lessons. This learning paradigm focused on the process of discovering the lessons, but the process of selecting the historical events with the causal relationships was not supported.

Understanding the flow of the history and aware of the important factors that cause significant events in history is cornerstones for improving historical thinking. Important factors are estimated by the historical events that have causal relationships. Horiguchi et al. developed a platform that enables students to arrange historical events along the sequential relationships, such as chronological time line, but it did not focus a causal relationships [7].

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One of the authors of this paper introduced a kind of the concept map, which we call a causal relation graph, into his middle school classes. This causal relation graph consists of nodes representing historical events and links representing
correspond to the state change as the state changes is the key to create the causal relation graph. In addition, it defines the causal relation graph whose links are arranged state changes between historical events by arranging state changes. This paper proposes thinking steps for valid causal relations and develop a support system for drawing a valid causal relation graph in the historical learning. When events have a causal relationship, a state change in one event causes the other event. Therefore, to consider state changes is the key to create the causal relation graph. This paper proposes thinking steps for valid causal relationships between historical events by arranging state changes. In addition, it defines the causal relation graph whose links correspond to the state change as the valid causal relation graph and develops the system that supports students to create the valid causal relation graph. In our system, firstly, the interface for arranging state changes of historical people according to the historical events is given. Then, the interface for drawing the causal relation graph of historical events is provided in which arranged state changes are automatically indicated on the created links in the causal relation graph. By observing the indicated state changes on the links, students are able to check by themselves whether their causal relation graphs correctly represent the causal relationships between historical events.

There are several researches that support students to understand causal relationships [9]–[11]. All these researches tried to teach the correct causal relationships for example, Horiguchi et al. defined the correct causal relationships between historical events beforehand and gave awareness information of incorrectness using pseudo-haptics of the tablet device, if students created the incorrect causal relationships [11]. However, as we have explained, since there are various viewpoints of observing the historical events, we consider that it is not appropriate to define correct causal relationships between historical events and make students create the causal relation graph based on them. If the causal relation graph has been created according to the students’ viewpoints, the validity of the created causal relation graph is difficult to evaluate by the system. Instead of providing feedback based on the evaluation of the created causal relation graph, our system shows the information by which students are able to check the validity of the causal relationships by themselves. That is, the system shows the state changes derived by the students themselves to the corresponding links in their causal relation graphs. Our system does not teach correct causal relationships, but encourages students to draw the valid causal relation graph based on their own viewpoints.

2. Support of Creating Valid Causal Relation Graph of Historical Events

2.1 Valid Causal Relation Graph

Causal relationship graph represents the causal relationships of historical events and takes the form of a directed graph. Nodes correspond to the historical events and directed links show the causal relationship. Node at the bottom of the link is the cause of the node at the top of the link. Concept map is applied in the various learning situation for various purposes [12]–[14]. Most of these researches assume that students understand the “meaning of the relation” correctly and created concept maps reflect the students’ understandings. However, not all students can clearly understand the “meaning of the relation.” Our research focuses on such students who do not understand the meaning of the causal relationships clearly. Our research promotes them to create the valid causal relation graph by being conscious of the meaning of the causal relationships.

History text describes the historical events along the time sequences. Events are the set of actions that have special meaning in history and are often given names. The number of actions to define events is not unique. For instance, let’s assume the PyeongChang Olympic Games. PyeongChang Olympic Games is the name of the event that indicates the whole games. On the other hand, when we focus on the figure skating in the PyeongChang Olympic Games, Yuzuru Hanyu becoming the gold medalist is also the event. The definition of events depends on the given historical text or historical teacher who asks students to consider the causal relationships.

Funada insisted that, when two events have causal relationships, there are factors that can explain their relationships [15]. We define “state change of historical people” as one of such factors. Events often occur as results of state changes of historical people. When events occurred, states of historical people tend to change. Assuming a valid causal relationship, state changes triggered by a cause event can explain the emergence of the effect event. Therefore, if there are causal relationships between historical events, there is a state change of the same historical person that can explain it. In Fig. 1, “state change b of person Y” explains the causal relationships between event A (cause event) and event B (ef-
Events. Links connect two nodes. If an event \( v \)\(_1\) affects event \( v \)\(_2\), it is represented as \( e = (v_1, v_2) \). Historical event occurs by the change of the historical people’s states. It also leads to the change of the historical people’s states. State change is defined by a person, his/her attribute, and a type of change. If an event \( v \) emerges as a result of state change \( s_1 \) and state change \( s_2 \) happens after it, it is represented as \( v = (s_1, s_2) \). When there are two events where \( v_1 = (s_1, s_2) \) and \( v_2 = (s_3, s_4) \), \( v_1 \) and \( v_2 \) has a causal relationship when \( s_{12} = s_{21} \).

Figure 2 is an example of the causal relation graph that focuses the outbreak of peasant uprisings during the Muromachi period in Japan (1336–1573). The overview of this history is shown in Table 1. Let’s assume that underlined texts show the events occurred during this period. In Fig. 2, historical events are represented by circles and causal relationships are indicated by directed links. Example of state changes between historical events are shown as blue messages on links. Consider the impact that the “formation of self-governing villages” had on other historical events. By the “formation of self-governing villages,” the solidarity of the peasants got strengthened, which contributed to the “peasant uprisings,” so there is a valid causal relationship between “formation of self-governing villages” and “peasant uprisings.” On the other hand, the “development of a money economy” was not derived by strengthening solidarity of the peasants, so there is no causal relationship between the “formation of self-governing villages” and the “development of a money economy.”

### 2.2 Approach for Creating Valid Causal Relation Graph

In order to create valid causal relation graph, students need to recognize the state changes by the historical events. In addition, students need to consider the effect of the state change to the other event. For the purpose of making students consider them, this paper proposes the steps for creating a valid causal relation graph as shown in Fig. 3.

Firstly, students read the historical text and understand its detail. Secondly, they grasp the state changes of historical people along with the historical events. Finally, they find the state changes that affect to the occurrence of other historical events and historical events that have causal relationships to create the causal relation graph. By considering state changes consciously, students are able to consider the valid causal relationships.

For students who are not able to derive the valid causal relationships tend to skip the second step. That is, they do not consciously focus on grasping the state changes. In addition, even if they grasp the state changes, some of them may not find the events that have causal relationships and connect the events to form the causal relation graph. Therefore, this research proposes the system in which students must follow these steps and must consider the state changes in creating a causal relation graph. In addition, it gives awareness information regarding to the state in creating the causal relation graph. By creating the causal relation graph using the system, students are not only able to create a valid causal relation graph, but also to understand the definition of the causal relationships.

In order to support grasping state changes in the historical people, the system provides the form for arranging state changes from a historical text as a state transition map. The state transition map was proposed by our research group in which state changes of historical people along with the historical events can be organized [6]. The state transition map is used to grasp the state changes from the historical text and arrange them. Since historical text usually describes the occurrence of the state changes just after events have been occurred, state transition map focuses on arranging “whose state has been changed to what after which events” and does not represent the continuous states of historical people. Figure 4 shows the state transition map of the historical text shown in Table 1. In this map, circles on top show the historical events \( v \) along the time sequence. Vertical lines from the circles represent the timing that each events have occurred. Rows correspond to the historical people’s state changes along the historical events. The blue squares describe each state changes of the historical people. State changes that

### Table 1 Example historical text

| During the mid-Muromachi period, the solidarity of the people strengthened due to the formation of self-governing villages. In addition to it, the development of a money economy caused the peasants to accumulate debt. This led to frequent peasant uprisings. These frequent uprisings weakened the authority of Muromachi Bakufu, and finally, led to the destruction of Muromachi Bakufu. |  |

| Fig. 2 Example of causal relation graph with state changes of historical text shown in Table 1 |  |

| Fig. 3 Steps for creating a valid causal relation graph |  |
are occurred after the historical events are represented by arranging the blue squares to the right side of the vertical lines of the corresponding historical events. That is, assuming that event $v = (s_1, s_2)$, the blue square corresponding of $s_2$ is depicted in the right of the event line of $v$. $s_1$, the state change that triggers the event $v$, is not depicted, since the timing of occurring such state change is often not clearly mentioned in the historical text.

Since the state change which is occurred after the cause event should be the trigger of the effect event, the state changes after the cause event in the state transition map should correspond to the links that are derived from the node of the cause event. That is, if two events $v_1 = (s_{11}, s_{12})$, $v_2 = (s_{21}, s_{22})$ have a causal relationship, $s_{12}$ should be $s_{21}$. In the state transition map, $s_{12}$ is depicted at the right side of the event line of $v_1$, but $s_{21}$ is not represented clearly. Students should notice that $s_{21}$ is $s_{12}$ when creating the causal relation graph. For example, if the student creates the state transition map as shown in Fig. 5 (a) and connects historical events 1 and 3 in the causal relation graph as shown in Fig. 5 (b), state change after the historical event 1, such as “state change of Person A”, should explain the causal relationships between historical events 1 and 3. However, it is difficult for students to recognize that state change of the cause event is the trigger of the result event. In order to understand such relation between the state change in the state transition map and links in the causal relation graph, our system provides the interface to draw a causal relation graph in which the state changes after the cause event in the state transition map are emerged on the links in the causal relation graph. Such information may promote students to notice that the state change of the cause event is the trigger of the result event and reconsider the validity of their causal relation graphs.

### 3. System for Supporting Creation of Causal Relation Graph

We have developed a system for supporting students to create valid causal relation graph. Figure 6 shows the framework of the system. The system consists of two sub-systems: a state transition map generation support system and a causal relation graph generation support system. A state transition map generation support system provides the interface for creating a state transition map. Created state transition map is stored as the State transition map data. A causal relation graph generation support system provides the interface for creating a causal relation graph. It shows the state changes that are acquired from the State transition map data on the link. History data contains historical text, historical events, and people for individual history themes, which is prepared beforehand. Both sub-systems read such data to show in the interface.

Figure 7 shows a screenshot of the interface for the state transition map generation support system. By selecting a history theme from the History Selection Area, a brief historical overview is appeared in the Text Display Area, and the student is allowed to create a state transition map in the State Transition Map Display Area. At this time, historical
events and historical people are already shown on the State Transition Map Display Area. When the student selects a part of the text from Text Display Area using a cursor which he/she may think representing the state change, the window for inputting the state change is appeared as shown in Fig. 8. In this window, selected text by the student is shown on the top. In the system, the state changes are represented in the form of “<Type of state> is <Type of change>”, so the student needs to describe <Type of state> and <Type of change> of the selected text in this window. Type of State Input Area consists of editable empty list. When the window has been appeared, editable empty area is shown and the student can input <Type of state> freely. The inputted words are registered to the list and are able to be selected in the further input. That is, the student can input <Type of state> freely in the empty area or can select one from the list that consists of states that are inputted by the student himself/herself. This function prevents the student to input the same state for several times. On the other hand, <Type of change> is limited to “UP” or “DOWN.” We believe it promotes the student to find “state change” easily and prevents them of confusing “event” as “state change.” In addition, most of “state change” can express by using the word “UP” and “DOWN.” For example, let’s consider the state changes shown in Fig. 2. “Solidarity of peasants gets strengthened” is expressed as “Strengths of the solidarity of peasant is UP”, “Peasant debt gets accumulated” is translated to “Amount of peasant debt is UP”, and “The authority of Muromachi Bakufu gets weakened” is represented as “The authority of Muromachi Bakufu is DOWN.”

When the state change is inputted, the blue square describing the state change is appeared in the right side of State Transition Map Display Area as shown in Fig. 9. By selecting the blue square and moves to the intersection of a historical person and an event, the state change of the person after the event is defined to the state transition map. Figure 10 shows the State Transition Map Display Area in the interface in which several state changes were inputted. In some squares, full text of the state changes are not displayed. Because of the size of the square, the system only displays limited number of words in the square. If the description of the state change is long, the whole text may not be appeared. By moving the cursor over the square, the whole text appears.

By clicking on the Render Graph Button in Fig. 7, the system switches over to the causal relation graph generation support system. Figure 11 shows a screenshot of the interface for the causal relation graph generation support system. When the interface emerges, the historical events are displayed in the Historical Event Display Area and no nodes and links are depicted in the Causal Relation Graph Display Area. The student can indicate a causal relationship in the causal relation graph by left clicking a cause event, right clicking an effect event in the Historical Event Display Area, and then pushing the Render Button. In the Causal Relation Graph Display Area, historical events are depicted from left to right in the order of the causal relationship. All nodes are rearranged every time the cause and the effect events are selected so as to draw the historical events from left to right. The example of causal relation graph depicted in the Causal Relation Graph Display Area is shown as Fig. 12.

State changes generated by a cause event, which is in-
putted in the interface for the state transition map generation support system, are revealed by moving the cursor over the link of the causal relation graph as shown as Fig. 13. If more than one state changes is defined, both are emerged on the link. Revealing the state changes in this way, students are able to check whether a created causal relationship is valid or not. In addition, they may notice that they should consider the state change in finding the events with the causal relationships.

4. Experimental Trial

4.1 Experimental Setting

We conducted two trials to evaluate the validity of understanding state changes and the effectiveness of the support systems. As for the first trial, 5 university students (A-E) were recruited as participants. As for the second trial, 8 middle school students (a-h) were participants. As instructional materials, we have prepared an instructional video and several written passages on the theme “Transition from the Great Depression to World War II.” These instructional materials contain very simple and basic information. The video was about 10 minutes and passages for each event were about 500 words. In addition, we gave historical events and historical people to students. By giving historical events and historical people, students could focus on considering the causal relationships. An example of the state transition map and the causal relation graph created by one of the authors is shown in Fig. 14. Since the way of observing the history is different among students, it is not only the valid causal relation graph. However, the number of the state changes and the number of links of the causal relation graph that is created in the experiment can be estimated by this example.

First, the students were instructed to watch and read the instructional materials and to draw a causal relation graph (CRG 1) on the paper using a pen. On the paper, the historical events are described, so students needed to consider the causal relationships among them. At this point, the definition of the causal relationships was explained to the students. Next, we had them generate state transition maps using the state transition map generation support system. In the system, historical events and historical people were depicted. Students needed to consider the state changes of the given historical people according to the historical events. After that, they were allowed to modify their original graphs using the causal relation graph generation support system (CRG 3). Finally, the students were asked to answer the questionnaire. If the causal relation graphs were changed from CRG 1 to CRG 2, to consider the state change might promote students to reconsider the causal relationships that they have defined. If the causal relation graphs were changed from CRG 2 to CRG 3, to understand state changes that correspond to individual causal relationships makes students aware of the invalid causal relationships. Therefore, based on the change of the causal relation graphs and the questionnaire results, the validity of understanding state changes and the effectiveness of the system showing the state changes on the causal relation graph are evaluated.

4.2 Experimental Results

Table 2 shows whether the causal relation graphs were changed before and after generating state transition maps and before and after using the system. Y means that the students changed their causal relation graphs and N means that they did not. In this experiment, no students changed the
causal relation graphs to invalid one. Authors have checked all causal relationships and found out that all modified links were successfully explained by the state changes.

Table 3 shows the responses of the students on the questionnaire. The students were asked to select one answer from given five options ranging from a definite “1. No” to a definite “5. Yes.” “-” means that the students did not give the answer. It happened because these questions were at the back of the questionnaire sheets and some students did not notice of the questions. Question (i) asks whether they had any experience in considering causal relationships in learning history. Question (ii) asks about what they feel about the effectiveness of considering the state changes in understanding the causal relationships. Questions (iii) to (v) are regarding to the system: the usability of constructing the state transition map (iii), the usability of constructing the causal relation graph (iv), and the effectiveness of showing the state changes on the links in the causal relation graph (v). For all questions, students were able to give comments through the free description forms. Table 4 is the remarkable comments acquired in the free description forms. All these comments were acquired by students who answered 4 or 5 for each questions. No comments were given by students who answered 1, 2 or 3. There were no remarkable comments for questions (i) and (iv).

4.3 Consideration

According to Table 2, 7 out of 13 students in total made changes causal relation graph either after generating the state transition maps (from CRG 1 to CRG 2) or after creating the causal relation graph (from CRG 2 to CRG 3). Among the university students, the change of the causal relation graph was observed after generating the state transition maps, while that was observed after creating the causal relation graph for middle school students. We would infer that such differences depends on whether the students could
consider the meaning of deriving the state changes and find the corresponding links on the causal relation graph when generating the state transition map. That is, the university students could infer why they needed to consider the state changes and checked the validity of created links while generating the state transition map, but the middle school students did not. The middle school students found the relations between the state changes and the causal relationships when the system showed the state changes on the links of the causal relation graph.

The Pearson correlation coefficient between the change of the causal relation graph and the experience of considering the causal relationships as shown in the question (i) indicates that there is a weak negative correlation ($r = -0.248$).

### 5. Conclusion

This study focused on creating valid causal relation graph
in the context of the history. We introduced a thinking step of organizing state changes, which helps students to understand the definition of the causal relationship. We also implemented the system in which students are able to follow the thinking steps and are aware of the relations between state changes and causal relationships. The experimental trials demonstrated that to consider the state changes gave them trigger of reconsidering the causal relationships that they have defined. For the university students, producing state transition maps was effective, while the system functions for indicating the corresponding state changes helped the middle school students. We also found that whether the causal relation graph was changed or not has correlation with the number of derived state changes in the state transition map. For our next step, we need to come up with additional instructional aids for this kind of students who did not derive enough state changes from given text.

Current experiment was conducted in the experimental setting with a small number of students. Although it was meaningful that not only university students but also the middle school students have accepted the additional step of thinking state changes and the support system, we need further experiments to evaluate the effectiveness of the additional thinking step and the support system in the real classroom setting of the middle school students.

In the current system, the history data is stored manually by authors. The system currently contains history data of only 5 themes. In order to introduce this system into the real classroom, more themes should be prepared. Therefore, we plan to develop an authoring tool for inputting the historical data, which enables teachers to add more history data according to their purposes.

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