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Activity Analysis Support System by Causal Relation Check Between Sub-activities

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Abstract: When we encounter problems while performing specific activities, we need to identify the cause of the problem to fix it. An activity is composed of several small activities (sub-activities) and the cause might lie in either one of them. We therefore need to analyze the components of the activity to identify the cause. However, since valid sub-activities are not defined, it is difficult to perform a sufficient analysis of the activity. The objective of this research is to propose a method for analyzing an activity and identifying the problematic sub-activity. To attain this goal, valid sub-activities should be defined. This research proposes an activity model that represents the relations between an activity and its sub-activities. In addition, it constructs an activity analysis system with functions to provide hints for deriving sub-activities and verify the validity of the derived sub-activities.

Keywords: Problem analysis, activity model, validity check

1. Introduction

Project Based Learning (PBL) has often been adopted for cultivating problem-solving skills. In PBL, students acquire knowledge and skills by finding and solving problems in small groups. However, sometimes these activities are not practiced successfully because the student lacks the skill to practice the activities. There are several studies that support PBL; many focus primarily on constructing the groupware that facilitates communication by enabling the exchange of products and opinions within the group (Rizal, Rusdiana, Setiawan, & Siahaan, 2021) (Chen, et al., 2021). However, most do not support the learning of the problem-solving skill itself. Problem solving is accomplished by analyzing the problem, formulating a solution, and implementing it, so support at each step is necessary. This study focuses on analyzing the problem and develops a support system for problem analysis.

Some studies support the identification of the cause of a problem by presenting a method for analyzing the problem. Harich et al. proposed a worksheet that enables group problem solving by repeatedly asking the question "Why?" until a consensus is reached within the group (Harich & Rosas, 2020). The problem analysis methods presented in these studies can derive the cause of a problem, but do not guarantee the validity of the derived cause. For the derivation of valid causes, there are studies in which the system takes the place of the derivation or adaptively supports the derivation based on problem domain knowledge. For instance, Mori et al. focused on analyzing the research problem of the educational technology domain (Mori, Hayashi, & Seta, 2019). They constructed an ontology for conducting such research and proposed a system for generating questions that allow the user to consider the elements based on the ontology. Since these studies support valid analysis based on the system's problem domain knowledge, these studies can only support problem analysis within the scope of the system's problem domain knowledge. Since there are many different types of everyday problems, it is not possible to describe all the problem domain knowledge in advance. We must propose a generic method of problem analysis rather than have the system carry the knowledge of the problem domain.

Problem analysis is the activity of understanding the structure of the problem and discovering its causes. In the analysis, the elements that compose the problem should be derived. However, it is difficult to derive enough elements that can form the problem.

Therefore, we define the conditions of what should be derived in the problem analysis. We also clarify what needs to be considered to derive elements that satisfy the conditions and construct an analysis support system that leads the analysis and judges whether the analyzed elements satisfy the conditions.

Among the many types of problems we face in daily life, this research focuses on problems that occur during activities—problems that interfere with an activity's successful performance. Therefore, the problem analysis is to derive the sub-activities of the activity.

2. Activity Model

An activity is an action sequence taken to achieve a goal and is composed of several sub-activities. Figure 1 shows the activity model. Activities have a condition that indicates the state in which they can be performed. The difference between the pre-state and post-state can be regarded as the sub-activity's effect.

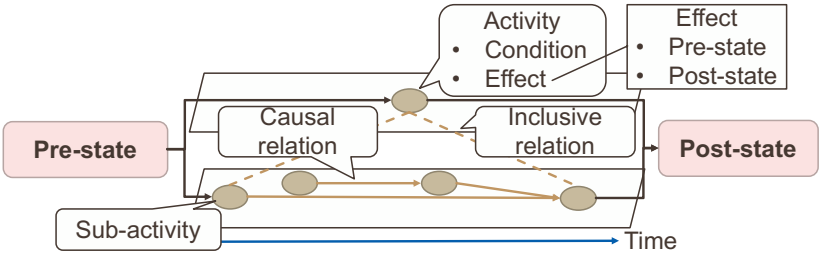

Figure 1. Diagram of Activity Model

The sub-activity sequence can achieve the same activity as the original activity, so the sub-activities must have the same effect as the original activity. In addition, the sub-activities should have a causal relation with each other where the post-state of the causal activity becomes the condition for the resulting activity.

3. Activity Analysis Support System

This study constructs a system to support user analysis of activities based on the activity model. Figure 2 shows the configuration of the system.

It consists of an interface, a validity judgment function, and a hint function.

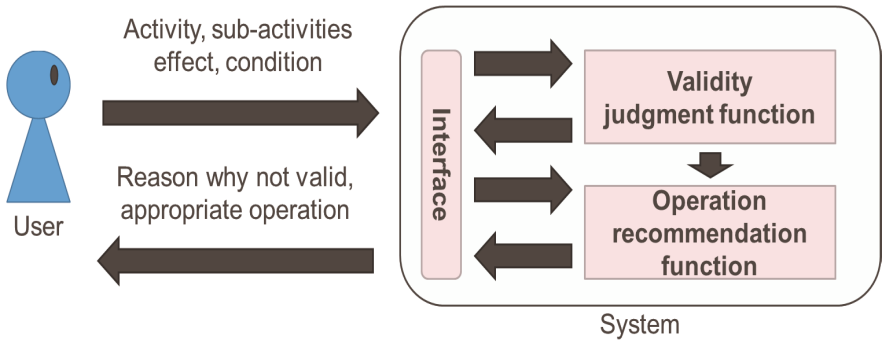

Figure 2. Diagram of System Configuration

Imagining the scenes in which the activities are actually performed is effective for deriving the sub-activities. Therefore, our interface lets the user describe the activity/sub-activities with the scene.

The validity judgment function checks whether the derived sub-activities satisfy the conditions. It consists of an effect sufficiency judgment function that judges whether all candidate sub-activities have an effect, a coherence judgment function that checks whether all sub-activities are connected by a causal relation, and a consistency judgment function that determines whether the effect of the entire sub-activities sequence is consistent with that of the original activity. The hint function suggests what to consider to derive a valid sub-activities sequence.

The user can input the activity to be analyzed, the candidate sub-activities, and the effects and conditions of the activity/candidate sub-activities into the interface. When the user requests a validity judgment of the sub-activities, the validity judgment function judges whether the candidate sub-activities entered by the user are valid or not and provides reasons if it is not valid. When the user requests a hint recommendation, the hint function recommends the appropriate operation based on the validity judgment result.

Figure 3 shows the system interface, consisting of an activity display area and an operation area. In the operation area, the user can input the activity, sub-activity, and effect and condition that the user derived in his or her analysis. The activity display area shows the inputted sub-activities and their causal relations. The sub-activity is shown in table format with the name of the sub-activity on top and its effect and condition below. The causal relation is represented by the arc between sub-activities. The system searches two sub-activities, one whose condition is the same as the effect of the other, and, if found, draws an arc between them.

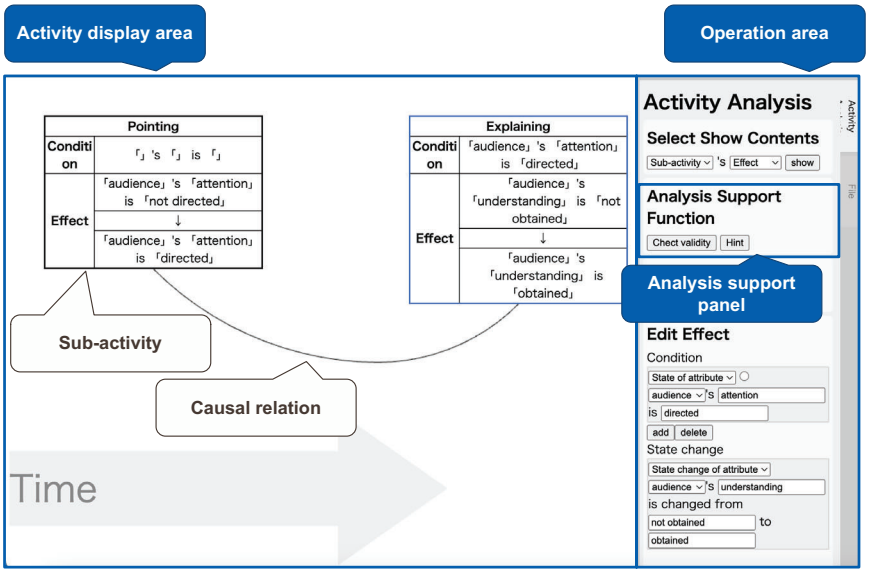

Figure 3. System Interface

The analysis support panel in the operation area contains two buttons: a button that asks to check the validity of the input sub-activities and a button that requests a hint. When the validation check button is pressed, it displays a message indicating that the sub-activity is valid if it is judged to be valid. If not, it displays the reason why it is not valid. When the hint button is pressed, it displays a message telling the user what to do next.

4. Conclusion

This paper proposes an activity model and the activity analysis support system based on it. The activity analysis support system provides an interface that lets the user consider not only the sub-activity but also its condition and effect. It also provides a function that judges whether the candidate sub-activity sequence is valid and gives hints that inform the user what to consider to derive a valid sub-activity sequence. As our next step, we will conduct experiments to evaluate the validity of the activity model and the effectiveness of the proposed system.

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