Modelling Domain-Specific Self-regulatory Activities in Clinical Reasoning

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Abstract. BioWorld is a computer-based learning environment that supports medical students in their clinical reasoning about virtual cases. We model the regulatory processes sudents use in the context of BioWorld in an effort to see when they ask for tutorial guidance and how guidance can be improved. BioWorld provides assistance using an artificial physician to deliver hints when students request a consult. We analyzed the concurrent think aloud protocols and log-file trace data collected from 30 students who solved 3 cases with BioWorld. Our findings highlight the antecedents and functions of regulatory activities involved in help-seeking. We discuss the implications for tailoring the content of the hints provided by the consult tool to the specific needs of different students.

Keywords: Models of Learners, Metacognition, Tasks and Problem-Solving Processes, Domain-Specific Learning Applications.

1 Introduction

An important challenge in developing professional expertise in medical problem solving is the acquisition of skills that mediate proficiency. BioWorld is a computer-based learning environment designed to develop professional competence in clinical reasoning using cognitive apprenticeship as an instructional framework [1]. Students practice clinical reasoning and receive feedback on their problem-solving in the context of working with virtual patient cases. In this paper, we model how novices regulate clinical reasoning when asking for a consult in BioWorld.

The current study explicitly looks at self-regulation with respect to students' help-seeking behavior where students ask for help from an artificial physician that provides hints. We synthesized models of self-regulation and problem-solving in order to provide a domain-specific account of how novices use skills to regulate problem-solving [2-4]. In the initial stages of problem-solving, the *forethought* phase involves novices' attempts to orient and plan the steps involved in diagnosing the disease by formulating an action plan to test a hypothesis. The *performance* phase refers to the steps

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involved in executing the action plan, such as ordering a lab test, searching through the library, identifying a relevant symptom, and requesting a consult. In the *reflection* phase, novices evaluate and elaborate on the outcomes of the clinical process, in doing so, checking the available evidence as well as justifying the hypothesis. In the following section, we provide an overview of the methodological and analytical techniques that were used to study how novices engaged in these regulatory activities.

2 Modelling Skills in Regulating Problem-Solving

A sample of 30 second-year medical students solved three cases (Pheochromocytoma, Diabetes Mellitus Type 1, and Grave's disease) using BioWorld. Twenty-nine consult requests were sampled for the purposes of this analysis. A consult request was defined as clicking on the consult tool button with the aim of receiving a hint from the artificial physician in BioWorld. For the purpose of this analysis no hints were available when students asked for help. The actual feedback was disabled in an effort to study the regulatory activities that occurred both before and after students needed help, allowing us to gain a better understanding of why students requested consults. The log-files were examined for the behaviors that occurred before and after requesting help; these behaviors served as the boundaries of our unit of analysis when coding the concurrent think-aloud protocols.

2.1 Characteristics of Help-Seeking Behaviors

We examined the time taken prior to asking for a consult relative to the total amount of time taken to solve the case (i.e., consult request time / case solution duration). The resulting percentage indicates that students requested help during the later stages of problem solving. On average 83% of the time taken to solve the case had elapsed (*SD* = 18.0%) prior to asking for help. We compared the case solution duration to the length of time between the activities that occurred prior to and following each consult request (i.e., time duration between activity following and prior to consult request / total amount of time taken to solve the case). The resulting value suggests that students spent 10% of their overall problem solving behavior requesting a consult (*SD* = 7.1%).

Help-seeking varied across cases. In particular, 52% of consults were requested while diagnosing a rare disease (i.e., Pheochromocytoma) with lower frequency of help-seeking when solving more common diseases, such as Diabetes mellitus Type 1 and Grave's disease (i.e., 28% and 21%, respectively). It is noteworthy that 72% of consult requests were preceded by ordering a lab test. The students' consult requests were most commonly followed by either: (a) submitting the final diagnosis (28%), (b) changing their conviction in regards to their hypotheses (21%), or (c) reading a topic in the library (14%). These patterns suggest that students requested consults while reasoning about the implications of a lab test towards their own hypotheses as well as gathering additional information regarding either the tests or a particular disease.

2.2 Antecedent and Consequent Activities during Help-Seeking

The results show significant differences across the frequencies of regulatory activities that occurred before and after asking help in BioWorld. Students engaged in orientation activities 3.2 times more often before, as opposed to after, asking for help (f_{before} = 19 vs. f_{after} = 6; $\chi^2(1) = 6.67$, $p < .05$). The most frequent skills that students demonstrated during the orienting phase were identifying important information, such as the vital signs and symptoms and formulating their differential diagnoses (a.k.a. hypotheses) (f_{before} = 10 and 9 vs. f_{after} = 4 and 1, respectively).

Students were 1.9 times more likely to engage in planning activities before requesting a consult (f_{before} = 43 vs. f_{after} = 23; $\chi^2(1) = 6.06$, $p < .05$). The descriptive statistics suggest that students preferred initially to formulate an action plan (f_{before} = 22 vs. f_{after} = 8) and organize thoughts by self-questioning (f_{before} = 16 vs. f_{after} = 6).

Students were 2.1 times more likely to engage in the monitoring phase while regulating their clinical activities before they requested a consult (f_{before} = 33 vs. f_{after} = 16; $\chi^2(1) = 5.90$, $p < .05$). Before students requested a consult, the descriptive statistics suggest that students were more likely to notice instances of confusion pertaining to their hypotheses (f_{before} = 11 vs. f_{after} = 8). Students were also more likely to obtain a non-pertinent lab test as opposed to a pertinent one before they asked for help (f_{before} = 15 and 5 vs. f_{after} = 3 and 0).

After requesting a consult, students were in the evaluation phase 2 times more often than before they had asked for help (f_{before} = 12 vs. f_{after} = 24; $\chi^2(1) = 4.00$, $p < .05$). In evaluating the outcomes of the clinical process, the descriptive statistics suggest that students were more likely to either: (a) justify the correct diagnosis as more probable or the incorrect diagnosis as less probable (f_{before} = 1 vs. f_{after} = 6) as well as the incorrect diagnosis as more probable or the correct diagnosis as less probable (f_{before} = 0 vs. f_{after} = 2); and (b) give up or quit solving the case (f_{before} = 0 vs. f_{after} = 5).

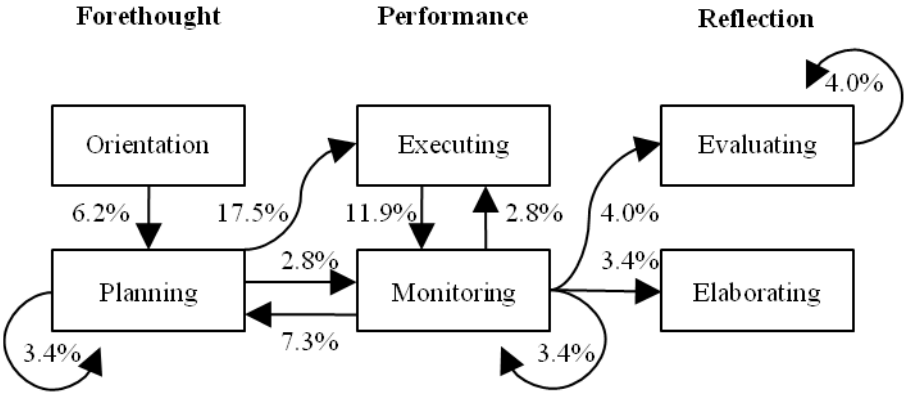

Fig. 1. State Transitions across Phases of Self-Regulation while Seeking Help

The use of monitoring activities served as a hub for the regulation of clinical reasoning while seeking help with BioWorld. Figure 2 shows the ten most frequent transitions that occurred between the different regulatory activities. The results show that 20.9% of these transitions had monitoring activities as their starting point, while 18.1% resulted in monitoring activities. These transitions clustered together in that students first engaged in orientation (6.2% of all transitions), and then moved to formulate a plan (17.5% of all transitions), execute the plan (11.9% of all transitions), and make adjustments while monitoring progress (7.3% of all transitions). Based on the outcomes of the monitoring activities, students shifted from the performance by engaging in the reflection phase or re-orienting their efforts to solve the problem.

3 Discussion

This aim of this study was to model regulatory activities in problem-solving during help-seeking in the context of BioWorld. Help-seeking accounted for a tenth of the time taken to solve the problem. The findings show that students most often requested help while solving the most complex case, Pheochromocytoma. Help-seeking activities occurred most often after ordering a lab test. A non-pertinent lab test was an indication to students that their diagnosis was incorrect and that they needed to evaluate and regulate their clinical reasoning processes. Students interpreted the outcomes of the lab test correctly, but needed assistance to reorient themselves when facing an impasse. Students often engaged in planning the clinical process by self-questioning and formulating an action plan and as such future hints will support these activities. Furthermore, students often gave up after requesting help and thus our hints will be designed to encourage reflection and motivational support to students who are experiencing frustration while solving the problem. These findings are indicative of the need to assess the reasons why students request help in order to ensure that the artificial physician tailors each hint to the specific needs of different students.

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