Student Initiatives and Tutor Responses in a Medical Tutoring System

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Abstract

This paper attempts to classify student initiatives and tutor responses in transcripts of human tutoring sessions by looking at the interaction between them. We define a student initiative as any attempt by the student to seize control for changing the course of the dialogue. Student initiatives are classified in four dimensions: the surface form, the communicative goal, the content area, and the degree of certainty expressed. (Does the student hedge or not?) The tutor responses are classified in three dimensions: the surface form, the delivery mode, and the communicative goal. We undertook this research in order to discover how our intelligent tutoring system could respond more intelligently to the student. We are convinced that the recognition of initiatives depends on identification of student plans. This represents a first step in our system toward mixed-initiative dialogue.

Introduction

We are building an intelligent tutoring system for cardiovascular physiology, to help medical students learn to solve problems using causal reasoning. Our system, Circsim-Tutor, describes a problem to the student, asks the student to make predictions about qualitative changes in seven important cardiovascular variables, and then engages the student in a remedial tutoring dialogue. Most of the time the system retains the initiative, but sometimes the student asks a question or proposes an explanation and asks for confirmation or otherwise takes an initiative.

As a first step in this remedial dialogue the tutor asks the student a question intended to start the problem-solving process. If the student answers this question correctly then the system prompts the student to continue with a question about the next step. If the student produces a wrong answer then the system provides a hint and asks a follow-up question. If the student can not make progress with this guidance, the system will give a brief explanation and ask another follow up question. In any case the system is designed to keep control of the conversation, to keep the initiative throughout. Sometimes, however, instead of answering the question from the tutor the student tries to alter the course of the dialogue by asking a question, or producing a self-explanation (Chi, Glaser, & Farr 1988). We want Circsim-Tutor to be able to handle this kind of student behavior, so we set out to study student initiatives in human tutoring sessions in order to develop strategies for recognition and response.

The tutoring strategies and tactics our system uses are based on human tutoring sessions conducted keyboard-to-keyboard at Rush Medical College by two Professors of Physiology, Joel Michael and Allen Rovick. When faced with the problem of understanding and responding to student initiatives, we again turned to the work of expert tutors and analyzed initiatives and responses in the transcripts of 28 sessions. An earlier attempt to classify initiatives (Sanders et al. 1992) convinced us that we needed to try to understand student plans (Carberry 1990), but the categories developed did not help us to predict the tutor responses, so this year we began with the tutor responses instead (Shah & Evens 1996).

In this paper we describe both initiatives and responses in terms of the interaction between them. We begin by illustrating some of the difficulties we find in distinguishing student initiatives from student answers to questions. Then we describe our categories of student initiatives and show examples. Finally, we do the same with tutor responses. The examples shown below come from keyboard transcripts of sessions in which the tutor is a male professor of physiology. The students are first year medical students; some are male and some are female.

The first line in Example (1) below is labeled "K10-tu-39-2." This label indicates that this is keyboard session number 10, that the tutor is typing sentence 2 in turn 39. The abbreviation "st" indicates that the student is typing; "ti" indicates an interruption by the tutor; "si" an interruption by the student. For the sake of authenticity, we have left the typographical style in the original form.

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Distinguishing Student Initiatives from Answers to Questions

Before our system can determine how to respond to student initiatives, we must figure out whether the student is trying to answer a question or ask one or propose an explanation or engage in conversational repair or whatever. Some hedged answers look very much like questions. Students often use question marks as hedges, as well as adverbs like "maybe" or "sometimes." They also wrap both answers and explanations in "I think" or "I guess." We illustrate these phenomena through the following examples extracted from the transcripts. The sentences underlined are taken as initiatives.

(1)K10-tu-39-2: What other variable is under neural control-primarily?
K10-st-40-1: CC?
K10-tu-41-1: Yes.

In (1) the tutor is definitely convinced that "CC?" is not an initiative but a hedged answer.

(2)K4-tu-45-3: What else affects the SV?
K4-st-46-1: <u>Well, if SV is volume pumped per beat, and we already know that the number of beats is increased</u>
K4-ti-47-1: Are you stuck?
K4-st-48-1: <u>How about the RAP, which may have an effect on how much blood is reaching the ventricle.</u>
K4-tu-49-1: Definitely, RAP affects ventricular filling.
K4-tu-49-2: What's the relationship?

In (2) the tutor seems to be encouraging the student to produce an explanation.

At the moment Circsim-Tutor starts by trying to interpret the student input as an answer. If it cannot make a connection between the tutor question and the student input then it tries to interpret the student input as an initiative.

Examples like these convinced us that we could classify both initiatives and responses better if we studied them together. We decided to try to categorize student initiatives along four dimensions:

- Surface Form
- Communicative Goal
- Focus or Content
- Degree of certainty expressed- Is the student hedging or not? (as in Lakoff 1973)

Classification of Student Initiatives

We start our initiative classification with the surface form because it is the area in which we find it easiest to agree.

Surface Form

The student input comes in the forms: interrogative, declarative, imperative, fragment and pause. Figure 1 shows the different forms of the input. We have included pauses here because a long pause on the part of the student causes our expert tutors to drop the current tutoring plan and make a new one. They seem to assume a goal of overcoming an obstacle in the student's plan. Just the surface form by itself is not enough for the system to deduce the student's plan, as it does not account for student intentions, and may carry ambiguity.

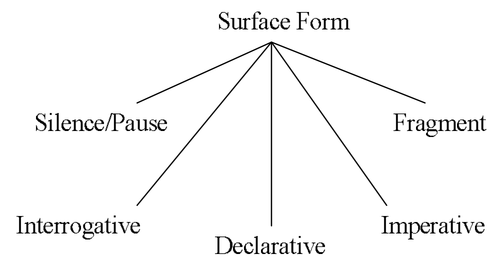

Figure 1. Classification of the surface form of student input.

Communicative Goal/Intention

Stampe (1975) argued that what makes a request a request is the intention with which it is made; and what determines its success is whether its recipient can infer the intention from the linguistic form in context. Agreeing with Stampe's notion we tried to come up with a set of goals.

The different types of goals that the students have in their mind before making a conversational move, are illustrated with examples from the transcripts (see Figure 2).

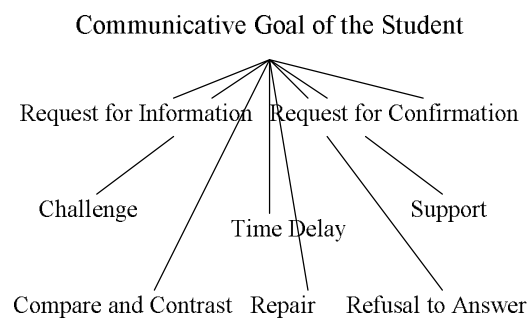

Figure 2. The Goal Hierarchy for Student Initiatives

Requests for information and confirmation are the most common categories.

Request for Information. This plan/goal produces a direct interpretation of the initiative as a request that the tutor inform the student about the topic in focus. This can be satisfied by explaining the topic or releasing the information appropriate to the student's current goal. For example:

(3) K2-tu-44-5: What comes after that?
K2-st-45-1: MAP will be the next to decrease
K2-tu-46-1: Sure.
K2-tu-46-2: And now we have a way to keep the MAP in line.
K2-tu-46-3: We have not got enough time to finish the exercise.
K2-tu-46-4: If you want to discuss it with me in class, I'd be happy to.
K2-tu-46-5: Thanks very much for your help.
K2-st-49-1: I think I would like to further discuss the idea of RAP.
K2-st-49-2: Unless compliance is involved, I still do not understand why the pressure in the right atrium decrease with an increase in right atrial filling.
K2-st-49-3: I will attempt to first find the answer in the monograph assigned.
K2-st-49-4: Thank you for this fulfilling session!
K2-tu-50-1: Wait
K2-tu-50-2: I apparently left you with the seriously wrong impression.
K2-tu-50-3: RAP goes up with the increased atrial filling and down with smaller central blood volumes.
K2-tu-50-4: The two do not go in opposite directions.
K2-tu-50-5: I think we do need to talk about this some more.
K2-tu-50-6: Please call me or drop into my office.

Request for Confirmation. The student generates an explanation and asks for confirmation of this theory. Sometimes a simple yes or no is a sufficient response. For example:

(4)K6-st-60-1: Does the direct affect steady state more than the reflexes?
K6-tu-61-1: Yes.

More often the tutor responds more elaborately, especially when the student's explanation is wrong.

(5) K10-st-56-2: Does RAP increase initially with increasing CO and then taper off as CO continues to I?
K10-tu-57-1: no. When CO increases it transfers increased quantities of blood from the venous system into the arterial system, decreasing the CBV (central blood volume) and increasing the arterial blood volume (and pressure).
K10-tu-57-2: What would happen to the central venous pressure when CBV goes down?
K10-st-58-1: It decreases.
K10-tu-59-1: Yes.

Here the student reveals a serious misconception and the tutor tries to remediate this error.

(6) K7-st-66-1: Is the RR with regards to the initial situation or to the DR?
K7-tu-67-1: The predictions that you make for RR should be how things change from the DR.

Repair. Both the tutor and the student express their thoughts in a way that is not always perfect or clear. The repair initiative is often a request for clarification or it may be a request for rephrasing or correction. Fox (1993) points out that such repairs involve, in effect, a reconstruction of the initial utterance.

The context of discourse and the task at hand are important determinants of the kind of repair construction. In our transcripts student requests for repair take several different forms. Example (7) shows a request for rephrasing.

(7) K4-tu-83-6: How are the falls in TPR and in CC connected to the decrease in MAP?
K4-st-84-1: I don't think I understand the question.
K4-tu-85-1: What are the determinants of MAP?
K4-st-86-1: MAP is determined by TPR and CO, so if the TPR is decreasing then the CO is decreasing too, given the fact that CC is also decreased.

The student asks for repair in turn K4-st-84-1. Basically he asks for restatement of the question in a more precise or specific way. The tutor rephrases the question so that the student can understand it.

(8)K28-tu-104-2: I guess that weve cover your errors.
K28-tu-104-3: Is there anything else that you want to go over?
K28-st-105-1: I said that RAP would be down, wouldn't it be up in SS as a result of Co being down in SS
K28-tu-106-1: Yes, I had written it down wrong.
K28-tu-106-2: I'm glad that you caught it.

Example (8) illustrates self-correction as well as other-correction. Actually the student predicted an increase in RAP in the DR stage, no change in RAP in the RR stage, and decrease in RAP in the SS stage. The tutor did not notice the error and let it pass. The student realized the error and tried to correct it in a curious fashion.

Inability to Answer. Sometimes the student does not know the answer and utters an explicit statement of her inability to give the answer (refuses to answer, and just gives up). This initiative appears to be taken as a kind of giving up participating in the game, yet the student is obliged to utter something following the rules of the game. The tutor responds in the form of an explanation on the topic or offers help (see example 24).

(9)K1-tu-61-1: Think again sympathetic firing is being decreased.
K1-st-62-1: I don't know.
K1-tu-60-1: When MAP goes up it increases baroceptor nerve impulse input to the CV centers.
K1-tu-60-2: Sympathetic output TO ALL OF THE CV EFFECTORES is inversely related to the afferent input rate.
K1-tu-60-3: Parasympathetic output to the pacemaker is directly related to the input afferent rate.
K1-tu-60-4: {PAUSE} Still stuck?

Challenge. This kind of response reflects some sort of disagreement with what the tutor has said. The use of clue words like "but", especially at the start of the sentence, often indicates that the initiative is taken as a challenge to the tutor's preceding utterance. This act may happen as a result of not accepting the truth of the tutor's previous statement completely.

(10)K20-tu-46-2: But you forgot that the real pacemaker is dead and this guy's HR is determined by the broken artificial pacemaker.
K20-st-47-2: OOPS.
K20-st-47-2: BUT I WAS JUST READING EARLIER TODAY IN SMITH AND KAMPINE ABOUT HOW SANS CAN 'TURN ON' OTHER AREAS AND INFLUENCE HR WITHOUT ACTING FIRST ON THE SA NODE
K20-tu-48-1: It happens sometimes (extopic pacemaker) and sometimes it doesn't.
K20-tu-48-2: The description of this patient is asking you to assume that his HR is solely under the control of the artificial pacemaker.

Support. It shows agreement with the tutor's claim. The student supports the tutor's point of view by accepting the knowledge the tutor is trying to give.

(11)K4-tu-59-1: Let me remind you of the vascular function curve.
K4-tu-59-2: It shows the relationship between central venous P (same as RAP) and CO when CO is the independent variable.
K4-tu-59-3: DO you remember that?
K4-st-61-1: Yes. I guess I do now.
K4-st-60-2: A decrease in CVP would be in response to an increased CO.

Time Delay/Extension. Sometimes all that the tutor sees is a student pause. The student is busy in working the problem out and needs time to come up with a correct answer. The tutor's offer of help is the typical response to student pauses.

(12)K16-tu-17-1: Make your next prediction please
K16-st-18-1: {Pause}
K16-tu-19-1: Do you need any help to make a prediction at this point
K16-st-20-1: I am thinking …
K16-st-20-2: I just need a second more
K16-tu-21-1: Ok

Compare and Contrast. It happens very often that the student confuses two parameters or state of affairs and asks the tutor to explain the difference between them.

(13)K10-tu-61-1: Let's put in in the correct order, RAP (the dependent variable) is inversely proportional to CO (the independent one).
K10-tu-61-2: OK?
K10-st-62-1: What's the difference?
K10-tu-63-1: If RAP is the independent variable and it goes up, you get increased filling and increased SV (i.e.> CO).
K10-tu-63-2: That's Starling's Law.
K10-st-64-1: Okay.

Focus of Attention or Content

Initiatives are not fully understood until their focus has been determined. We incorporate information about the focus of attention defining the discourse structure. Grosz & Sidner (1986) characterize focus as a discourse element on which the understanding system can concentrate. A focus/content hierarchy is shown in Figure 3.

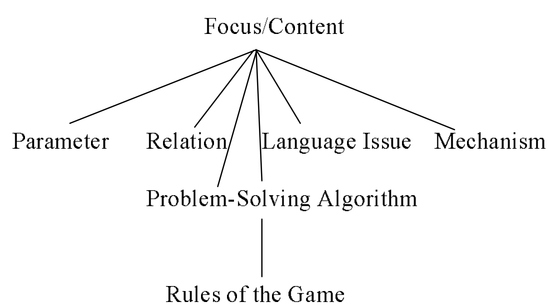

Figure 3. The Focus/Content Hierarchy for Student Initiatives.

Degree of Certainty-Hedging

Our transcripts of expert tutoring sessions contain many types of hedges in the student input. Almost any speech act can be hedged, although imperatives are not hedged as often as declarative or interrogative sentences in our data. We finally decided to treat hedging as a separate dimension because it reflects different shades of meaning in the student input. In our transcripts we see many types of hedges in the form of adverbs like maybe, perhaps; in the form of verbs like: I think, I guess, and, most often, question marks. Examples are:

(14)K13-tu-23-1: Now what?
K13-st-24-1: Cc i maybe

(15)K3-tu-53-1: The venous return may not change for a couple of minutes but what about the rate at which blood is being removed vfrom the central blood compartment?
K3-st-54-1: That rate would increase, perhaps increasing RAP???

(16) K2-tu-48-1: Sure.
K2-tu-48-2: And now we have a way to keep the MAP in line.
K2-tu-48-3: We have not got enough time to finish the exercise.
K2-tu-48-4: If you want to discuss it with me in class, I'd be happy to.
K2-tu-48-5: Thanks very much for your help.
K2-st-49-1: I think I would like to further discuss the idea of RAP.
K2-st-49-2: Unless compliance is involved, I still do not understand why the pressure in the right atrium decrease with an increase in right atrial filling.

The use of a disclaimer such as unless compliance is involved, further neutralizes the implied force of the sentence.

(17)K24-tu-48-1: Why did you say d?
K24-st-49-1: Because I thought that the pacemaker is stuck at 50, but I guess sympathetic come into play here, right?

(18)K12-tu-93-1: no. I'm agreeing with you the vessels are dialated.
K12-tu-93-2: I was just giving you information that you could use to determine how the reflex accomplish that.
K12-st-94-1: Dilation results in increasing the vessel radius and thus tpr goes down (exponentially by a factor of 4???)

Tutor Responses to Student Initiatives

Our study of the keyboard-to-keyboard transcripts suggests that we can approach the problem of responding to student initiatives in Circsim-Tutor from three perspectives:

- Surface Form
- Delivery Mode
- Communicative Goal

The tutor uses different delivery modes like explanation, hinting, and directed line of reasoning to express different communicative goals. Some important delivery modes are (Hume et al. 1996):

- Hinting
- Directed Line of Reasoning
- Tutor Monologue

We classified the tutor responses to student initiatives into ten categories:

- Acknowledgment
- Explanation
- Summary
- Instruction in the "Rules of The Game"
- Teaching the Sublanguage
- Teaching the Problem Solving Algorithms
- Help in Response to Pause
- Probing the Student's Inference Process
- Brushing Off
- Conversational Repair

Acknowledgment. The response to a request for confirmation can be a simple 'yes' or, 'no' with some explanation, or can be complex depending upon the degree of truth sustained by the student initiatives.

See examples 2(K4-tu-49-1 & K2-tu-49-2), 4, and 5.

Explanation. When the tutors find that the student is facing great difficulty in understanding the concepts, they adopt the strategy of explaining the underlying parameters and their causal relations. There are occasions when the communicative goal is the same but the delivery mode (style) is different.

(19)K16-st-38-1: I think I am getting contractility mixed up with stroke volume...
K16-st-38-2: Contractility is the force of contraction that i think goes up with increased heart rate, but i am not sure how
K16-tu-39-1: Ok, let me explain.
K16-tu-39-2: The length-tension relationship of muscle says that as length goes up (as the ventricle fills more) the force of contraction will increase.
K16-tu-39-3: Changes in contractility result in changes in force at the same fiber length or same filling.

K16-tu-39-4: What input to the heart causes contractility to change?

Summary. The tutors choose to summarize often in all types of tutoring dialogue. They often use this strategy of reinforcing important concepts in responding to student initiatives.

(20)K13-st-56-3: Im not sure if 120 bpm is fast enough to cause that.
K13-tu-57-1: Probably not.
K13-tu-57-2: But more to the point, both tpr and cc change only when the reflex alters the activity in the ans.
K13-tu-57-3: And since dr is BEFORE the reflex can act, both must be 0 in dr.
K13-tu-57-4: Let's go on to the next column.

Instruction in the "Rules of The Game." In this response the tutor is demanding that the student stop hedging.

(21)K13-st-24-1: Cc i maybe
K13-tu-25-1: No maybe's allowed.

Teaching the Sublanguage. The tutor is concerned about teaching correct usage of physiology language. Indeed this is one of the most important reasons for implementing a natural language dialogue in CIRCSIM-Tutor.

(22)K12-st-46-1: Does the rate of blood removal from the central veins mean that blood entering the right atrium , if so i think venous return does go up immed.
K12-tu-47-1: We need to get our terminology straight.

Teaching the Problem-Solving Algorithm. A major goal of the tutor is making sure that the student understands how to solve problems.

(23)K12-st-62-2: I'm just hesitant to say what comes first.
K12-st-62-3: I'll go with tpr i to slow blood flow back to heart (i don't really like this idea)
K12-tu-63-1: Well let's see if we can get at the first question I asked and then we'll come back to TPR.

Help in Response to Pause. When the tutor notices a delay on the student side, he intervenes to offer his help. This is another tutor tactic to help the student in active learning. This response works as a rejoinder for the pause initiative.

(24)K5-st-45-1: I don
[big pause here]
K5-ti-46-1: Need help?

The tutor takes control of the turn and offers his help.

Probing the Student's Inference Processes. The tutor encourages the student in active learning through self explanation. This also helps the tutor to update his model of the student. For example:

(25)K5-st-102-2: But I'll bet that's not right.
K5-tu-103-1: Well you're right in your bet.
K5-tu-103-2: Stroke Volume decreases because Cardiac Contractility decreases.
K5-tu-103-3: That doesn't mean that RAP has to be decreased!
K5-tu-103-4: Let me remind you again of the vascular function curve.
K5-tu-103-5: Does that help?
K5-st-104-1: RAP I.
K5-tu-105-1: Would you explain?
K5-tu-105-2: You're right but I just want to hear what you're thinking.

Brushing Off. Sometimes the tutor decides to avoid or put off further discussion and bring the dialogue back to issues of higher priority. The same kind of response is used when the tutor does not understand what the student is driving at.

(26)K16-st-46-2: Is sympa stimulation the only factor influencing cc?
K16-tu-47-1: It is in the experiment we are discussing today.
K16-tu-47-2: All of your other DR predictions were correct, so please read page 6 so we can go on.

Here the tutor seems to take control of the dialogue, following his own goals rather than responding to those of the student.

Conversational Repair. Repair is done to avoid misunderstanding and correct misconceptions. If the misunderstanding is not noticed at once, the conversation may break down at later stage. So it is very important to make an attempt to resolve the issue immediately. The extracts of conversation taken from various transcripts of tutorial sessions shown in the following examples depict some forms of conversational repair.

(27) K5-tu-87-1: So?
K5-st-88-1: I don't understand.
K5-tu-89-1: How does CC D affect CO?

(28)K11-st-58-1: But, it is ALSO under intrinsic control
K11-tu-59-1: You are confusing Starling's Law with a change in contractility.
K11-tu-59-2: The length/tension relation of the heart is not a change in contractility.
K11-tu-59-3: A change in contractility moves the length/tension curve from one location to another.

K11-tu-59-4: Increased contractility means that at a given EDV you get more contractility performance out of the ventricle.
K11-st-60-1: Ok
K11-tu-61-1: So what's your prediction about CC?
K11-st-62-1: O
K11-tu-63-1: Wright again. [sic]

Future Work and Conclusion

We have described the classification of student initiatives and tutor responses based on the interaction between them. In the process we examined the factors involved in generating cooperative dialogue where the tutor takes the responsibility of helping the student learn to solve problems in the domain of circulatory physiology. We believe that elicitation of self-explanation (Chi et al. 1994), enhances tutoring, and brings positive effects on the students in terms of acquiring problem solving skills. We further believe that understanding the student plan and recognizing the communicative goals are important factors in generating the responses. Our long term goal is to make the Circsim-Tutor system generate appropriate responses when the student takes the initiative in the natural language dialogue. This will lead to the system allowing some limited mixed-initiative interaction. Our next step is to persuade some colleagues to classify the full set of 145 initiatives using these categories so that we can make sure that we have acceptable inter-rater reliability.

As we try to acquire some theoretical perspective for a higher level analysis, we are impressed by the work of Allen & Perrault (1980), and the argument made by Traum & Allen (1994) that sometimes questions do more than just provide implication of student's goals, and something more than the adoption of the goals of an utterer is used in the formulation of a response to a question. We believe that the plan-based approach and specification of the characteristics that any plan inference would need for the interaction in the domain of cardiovascular medicine. The student is acting with some goal and some plan for reaching that goal. Our system must try to recognize the goal and understand the plan. Our strategy is based on the attempt made by Grosz & Sidner (1986) to establish the link between intentional structures, discourse structures, and attentional state.

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