A Manual for SGML Mark Up in Tutoring Transcripts.

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1. Introduction.

The CIRCSIM-Tutor project has collected about 50 transcripts of physiology professors tutoring students individually. In these tutoring sessions the professor and student were in separate rooms, communicating only by typing on computer keyboards. These transcripts are our basic data from which we discover tutor goals and dialogue moves, ways to express each move, and how students respond.

To understand the behavior and language of human tutors and to produce a detailed knowledge representation for the tutorial planner and text generator in the next version of CST (version 3) we marked up the tutorial goal structure in the transcripts. Our analysis produces multiple nested annotations showing both global goals for tutoring and local goals for maintaining a coherent conversation and providing appropriate responses to the student. We are marking up the transcripts in an SGML style so some processing by computer is possible.

2. What We Are Marking Up

Here is an explanation of how the dialogue in the transcripts is structured. The tutoring sessions concern a particular topic in physiology, a mechanism called the *baroreceptor reflex,* which is part of blood pressure regulation.

() The session starts with the tutor and student introducing themselves in some way, and the student is given instructions.

() The student reads a description of a procedure that disturbs the blood pressure, for example, the patient loses a liter of blood.

() The student has a chart called the *predictions table*. It is a table containing the names of seven important physiological variables, and three *stages* in which they vary over time. The student is asked to predict a qualitative change: increase(+), decrease(–), or no change(0).

() The student's first job is to identify which of the variables in the predictions table is affected first, and whether it increases or decreases. Here is a predictions table, showing that the hemorrhage caused CVP to decrease

	DR	RR	SS
Central Venous Pressure (CVP)	—		
Inotropic State (IS)			
Stroke Volume (SV)			
Heart Rate (HR)			
Cardiac Output (CO)			
Total Peripheral Resistance (TPR)			
Mean Arterial Pressure (MAP)			

() Some conversation (teaching) between the teacher and the student may ensue until the student gets this first prediction correct.

() The student then predicts the changes in the other variables for the first (DR) stage, writing the prediction in the prediction table (which is in the student's possession) and typing the prediction to the tutor in the other room. Sometimes there is more conversation at this point.

(*) After the last DR prediction, the tutor starts to teach, usually until satisfied that the student understands the behavior of the seven variables in the DR stage.

() The student makes predictions for the RR phase for all seven variables. Again, some tutoring may happen while the student is predicting the variables one-by-one and transmitting the predictions to the tutor.

(*) The tutor teaches the RR phase

() The student makes SS phase predictions.

(*) The tutor teaches the SS phase.

It is those sections of the conversation marked (*) above which we are trying to analyze. The reason is that these sections most closely resemble the tutoring regime used by the Circsim-Tutor program, which in general does not attempt to teach until it has a set of predictions to work with. A substantial fraction of the dialogue is concerned with the mechanics of the session and collecting predictions from the student. This has not been included in the transcripts we are to mark up. We are also skipping any tutoring dialogue that took place while the predictions were being collected.

3. Why SGML Style?

SGML stands for Standard Generalized Markup Language. Compared with many other markup languages SGML has several strengths, such as:

- system independent: SGML-aware software exists for many computers.
- non-proprietary: it is an international standard.
- separates content from format: the text is annotated according to content and function, how the text is formatted is a separate question.
- control over information content
- human-readable: intermediate results are understandable and inspectable.

SGML consists of text markings added to plain text files. Data in the file is usually enclosed by start-tags and end-tags. A start-tag is delimited by "<" and ">" characters, an end-tag is delimited by "</" and ">".

Figure 3.1 shows an example taken from our own marked-up transcripts. The SGML tags are in upper case to distinguish them from the actual transcript dialogue. Actually SGML is not case sensitive.

An SGML tag consists of an *element* and optional *attributes*. In the first tag in Figure 3.1, the element is T-SHOWS-CONTRADICTION and the attribute is TYPE=NEURAL. It indicates that the entire fragment of dialogue (until the </T-SHOWS-CONTRADICTION> end-tag) is an attempt by the tutor to persuade the student of a self-contradiction in the student's answers. This fragment is divided into two parts: T-PRESENTS-CONTRADICTION (where the tutor presents to the student the relevant data) followed by T-TUTORS-CONTRADICTION (where the tutor gives the student the opportunity to notice there is a difficulty).

SGML markup follows this kind of context-free pattern, one element is divided into several lower-level elements. For example, a THESIS is divided into FRONT-MATTER followed by several CHAPTERS followed by a BIB. Then FRONT-MATTER is divided into TITLE-PAGE, CONTENTS, ACKNOWLEDGMENTS, and so on. Because we are allowed to create our own content tags, we can define our own new tag T-SHOWS-CONTRADICTION, which is divided into two pieces as shown.

The software that processes SGML files uses an SGML parser. The parser requires a special file describing the allowable tags, called the Document Type Definition, or DTD. The DTD is usually separate from the marked-up file, so you can use it to describe the allowable markings for a whole set of files. Inside the DTD are element definitions and attribute definitions. For example, part of the DTD for our transcripts might look like this:

```
<!ELEMENT T-SHOWS-CONTRADICTION - -
     (T-PRESENTS-CONTRADICTION? T-TUTORS-CONTRADICTION?)>
<!ATTLIST T-SHOWS-CONTRADICTION - -
     TYPE (3-VARS | NEURAL) #IMPLIED>
<!ELEMENT T-INFORMS - - CDATA>
```

Here the element definition for T-SHOWS-CONTRADICTION shows how to divide it into smaller elements. Its attribute definition shows that there is one attribute called TYPE, which can have the values 3-VARS or NEURAL. The element definition for T-INFORMS shows that it is primitive, it contains only actual transcript data. This example is a very simple one; there are many complicated options for the element and attribute definitions.

```
<T-SHOWS-CONTRADICTION TYPE=NEURAL>
     <T-PRESENTS-CONTRADICTION>
          <T-INFORMS INFO=VAR-VALUE ATTI=REFERENCE>
               You predicted that CC would go up.
          </T-INFORMS>
          <T-INFORMS INFO=DR-INFO  ATTI=REMIND>
               But remember that we're dealing with the
               period before there can be any neural
               changes.
          </T-INFORMS>
     </T-PRESENTS-CONTRADICTION>
     <T-TUTORS-CONTRADICTION>
          <T-ELICITS INFO=REASON>
               How can CC go up if it is under neural
               control?
          </T-ELICITS>
          <S-ANS CATG=INCORRECT>
               (Here the student gave some incorrect
               answer)
          </S-ANS>
          (etc.)
     </T-TUTORS-CONTRADICTION>
</T-SHOWS-CONTRADICTION>
```

Figure 3.1. SGML Marked-Up Transcript

After the marked-up file has been read by an SGML parser, several kinds of processing are possible. For my own work in writing a CST text generator, I can perform operations such as "extract every T-INFORMS which is inside of a neural T-PRESENTS-CONTRADICTION"

As we use the SGML markup and analyze more transcripts, we add and revise the tags as needed. The DTD ensures that we have some consistency in the markup. Also it catches spelling and markup errors. The software we are using is the LTNSL package from the University of Edinburgh. It will run on any Unix computer.

4. The Hierarchy of Goal Structure

CIRCSIM-Tutor v. 3 requires a set of tutorial and conversational goal schemata in order to produce coherent conversations.

Tutorial goals are expanded in a hierarchy, as shown in Figure 4.1. At the highest levels, ***T-tutors-procedure*** and ***T-tutors-stage*** show the tutoring of the particular procedure and stage of the reflex response. Our transcripts show the following procedures: pacemaker, centrifuge, alpha agonist, transfusion, hemorrhage. We have three stages such as DR, RR, and SS. DR (Direct Response) stage shows changes immediately after the perturbation and before baroreceptors are activated. RR (Reflex Response) stage has changes that happen due to the result of the activation of baroreceptors. SS (Steady State) stage shows the results of the restabilized system.

The ***T-tutors-stage*** expands to:

T-introduces-stage	"Let's take a look at your predictions in DR."
	"There are some errors in the DR."
	"Let's consider your predictions."
T-corrects-variable	"Take the SV first, can you tell me...."
	"You have TPR left. How is TPR controlled?"
T-concludes-stage	"All of your other DR predictions were correct."
	"OK, you have finished DR."
	"All of your other predictions were correct."

Below the ***T-corrects-variable*** level, two sections of dialogue are generated for each variable that the student did not predict correctly. ***T-introduces-variable*** introduces the variable as a referent in the conversation and ***T-tutors-variable*** does the actual tutoring. Tutoring requires at least three levels of goals below the variable level: the method level, the topic level, and the primitive level. The method level shows how to teach about a variable. The topic level represents each item that must be taught. These content items largely involve domain content. The primitive level shows how this information is communicated to the student.

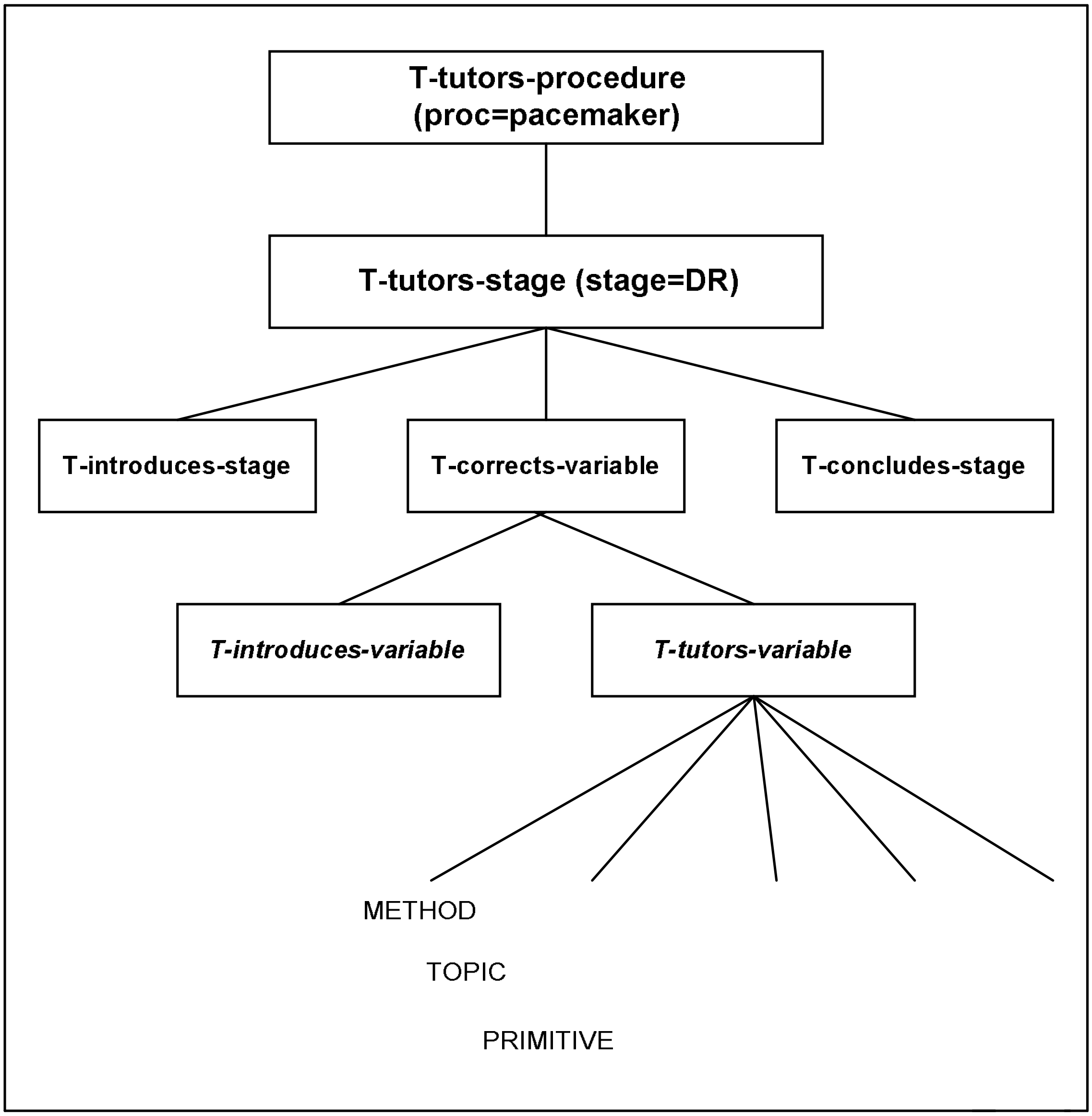

Figure 4.1 Goal Hierarchy I

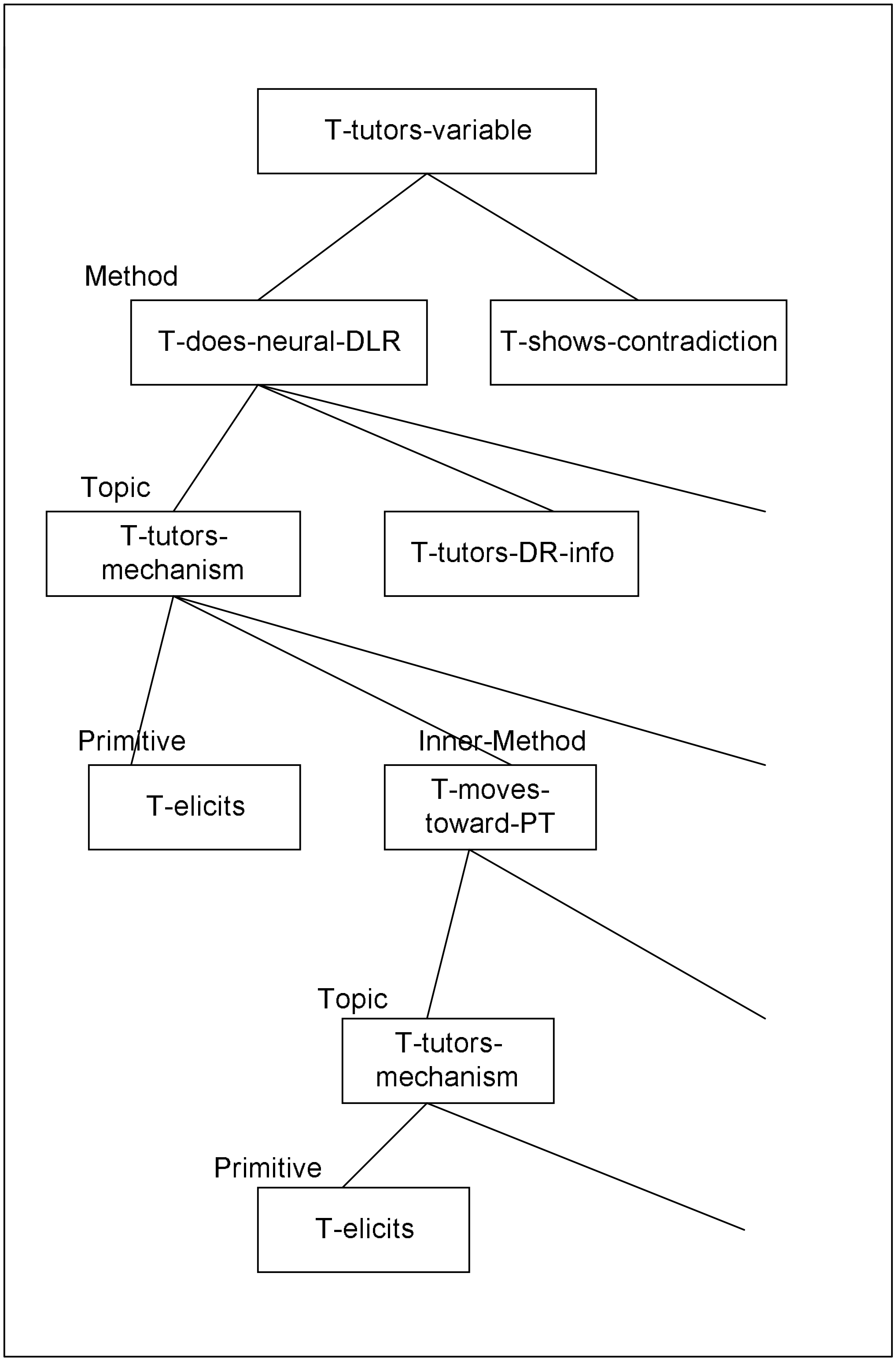

Figure. 4.2 Goal Hierarchy II

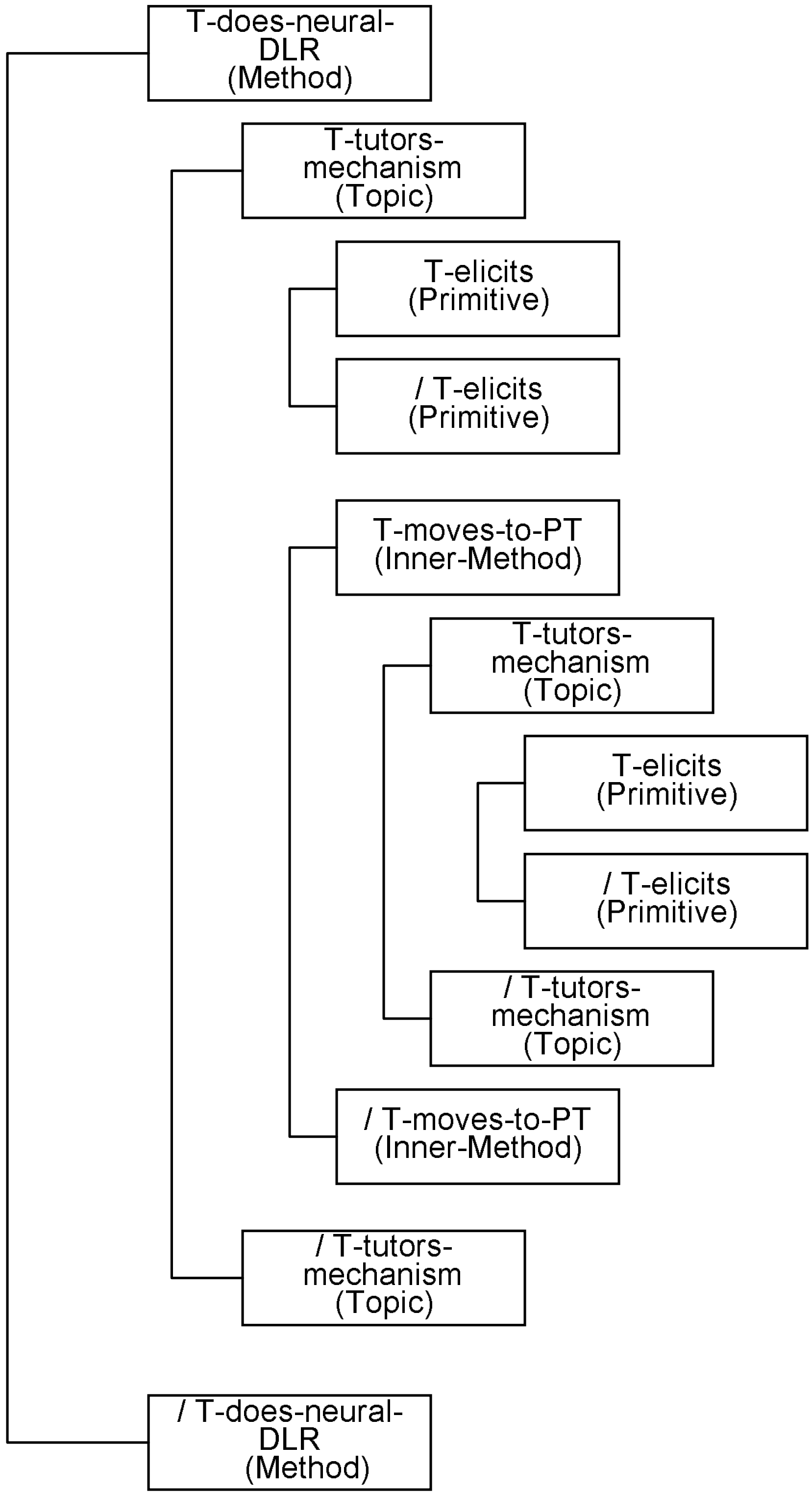

Figure.4.3 Nested Goal structure

5. The Categories of Methods, Topics , and Primitives

5.1. The Method Level

The method level can be used to express various types of deductive reasoning, interactive questioning and exploration of anomalies.

To refine ***T-tutors-variable*** the tutor chooses a method depending on a number of factors, including domain knowledge (e.g., the mechanism of action of a variable), dialogue history (e.g., the student's previous utterance) and the student model (e.g., how well the student is doing).

Here is a collection of method-level tutoring goals we have observed in the transcripts:

T-does-neural-DLR

If the variable is controlled by the nervous system, the tutor often chooses the question and answer style method ***T-does-neural-DLR***. (DLR stands for directed line of reasoning, a form of Socratic dialogue.)

tu: Can you tell me how TPR is controlled?
st: Autonomic nervous system.
tu: And the predictions that you are making are
for the period before any neural changes take place.
So what about TPR?
st: No change.

T-tutors-via-determinants

For non-neural variables the most common schema is ***T-tutors-via-determinants***. With this method the tutor corrects the value of a variable by invoking a relationship with another core variable.

tu: What parameter determines the value of RAP?
st: CO.
tu: What relationship do they have?
st: Inverse.
tu: Right, then what is the value of RAP?

T-moves-forward

This method is similar to ***T-tutors-via-determinants*** but it applies when the determinant has already been mentioned in the conversation. Compared with the ***T-does-neural-DLR*** method and the ***T-tutors-via-determinants*** method, this method is less directly based on the domain reasoning used by the tutor to solve the problem.

tu: [Since CO goes up early in the response, that will
cause RAP to fall.] Now what will happen to SV?

T-shows-contradiction

With this method, the tutor corrects the student's error by pointing out a physiological inconsistency in the student's answers.

tu: You said that RAP goes up but earlier you said that CO went up.
How is that possible?

T-explores-anomaly

This method is superficially similar, but it is used in cases where the reported facts only appear inconsistent. Its goal is to ensure that the student really understands the deeper qualitative relationships among the variables.

tu: So, we have HR down, SV up and CO down. How is that possible?

T-diagnoses-error

This method is used when the tutor wants to identify the student's problem. Although the computer tutor may not be able to handle this method, we observe in the transcripts that human tutors do it sometimes.

tu: Why do you think that TPR will decrease?

T-tutors-via-deeper-concepts

This is used to give more detailed explanations to the student after failing to get a correct answer from the student by using only the seven core variables. This method gives information to the student (or elicits it from the student) in terms of a more detailed physiological model. It can be used as an inner-method.

tu: The central venous compartment is a compliant structure
that contains a certain volume of blood ...

5.1.1. Inner Method Level

The tutor can refer to a more detailed physiological model. This is often triggered by a student error or the student use of a particular term coming from a deeper model. The nested ***T-moves-toward-PT*** method shown in the following Figure is an instance of the tutor's using a more detailed model. This method shows the way to approach the one of seven variables that are the prediction table or the baroreceptor reflex. These inner dialogues also follow the method / topic / primitive hierarchy and are nested inside the topic that provoked the student's near-miss response. We especially want to add this feature to our tutoring system because it is a way of tailoring our responses to the student's individual needs.

```
<T-does-neural-DLR>
  <T-tutors-mechanism>
    <T-elicits >
    tu:What is primary mechanism of control of TPR?
    <S-ans, catg=near-miss>
    st:Radious of arterioles.
    </S-ans>
    <T-ack  type=positive>
    tu:Yes.
    </T-ack>
    </T-elicits>

    <T-moves-toward-PT  method-type=inner>
      <T-tutors-mechanism  var=RA>
        <T-elicits  DM="and">
    tu:And what is the primary mechanism by which arteriolar
                radius is controlled??
    <S-ans, catg=correct>
    st:Sympathetics.
    </S-ans>
        </T-elicits>
      </T-tutors-mechanism>
    </T-moves-toward-PT>

  </T-tutors-mechanism>

        ...
</T-does-neural-DLR>
```

The following example shows another inner-method ***T-moves-to-previous-concepts***.

```
<T-tutors-determinant  var=RA>
  <T-elicits>
 tu:If I have a single blood vessel, what parameter most
              strongly determines its resistance to flow?
 <S-ans  catg=near-miss>
 st:Diameter.
 </S-ans>
  </T-elicits>

  <T-moves-to-previous-concepts  method-type=inner>
    <T-tutors-determinant  var=RA>
      <T-elicits  DM="and">
 tu:And physiologically, what determines the diameter of
              the blood vessels?
 <S-ans  catg=correct>
 st:The sympathetic tone supplied to its smooth
              musculature.
 </S-ans>
 <T-ack  type=positive>
 tu:Right.
 </T-ack>
      </T-elicits>
    </T-tutors-determinant>
  </T-moves-to-previous-concepts>

</T-tutors-determinant>
```

5.2. The Topic Level

The topic level represents each item that must be taught. These content items largely involve domain content. A method typically consists of a series of topic operators. For example, the following topic operators can be used to build the ***T-tutors-via-determinants*** form mentioned above.

T-tutors-determinant

tu: What are the determinants of RAP?

T-tutors-relationship

tu: How does the value of CO affect the value of RAP?

T-tutors-value

tu: So, what would happen to RAP?

To build the ***T-does-neural-DLR*** form, the tutor may use the following topic operators, followed by ***T-tutors-value***.

T-tutors-definition

tu: Can you tell me what you think that IS means?

T-tutors-mechanism

tu: Can you tell me how TPR is controlled?

T-tutors-DR-info

tu: The predictions that you are making are for the period before
any neural changes take place.

When the tutor wants to teach by showing a contradiction, the ***T-presents-contradiction*** and ***T-tutors-contradiction*** topics are needed.

T-presents-contradiction

tu: You predicted that it would go up. But remember that we're dealing with the period before there can be any neural changes.

T-tutors-contradiction

tu: How can CC go up if it's under neural control? (And then the tutor expands tutoring by giving the answer.)

Whenever a deeper conceptual model has been introduced, the tutor must eventually return to the core variable which started the discussion. The topic ***T-tutors-PT-entry*** can be used for this purpose:

T-tutors-PT-entry

tu: What parameter in the prediction table reflects the filling of the left ventricle?

Inside of the ***T-diagnoses-errors*** method the ***T-identifies-problem*** topic is used to diagnose a problem:

T-identifies-problem

tu: Why do you think that TPR will decrease?

T-tutors-compliance-info

tu: The central venous compartment is a compliant structure that contains a certain volume of blood.

The ***T-explores-anomaly*** method is expanded by the ***T-presents-anomaly*** and ***T-tutors-anomaly*** topics.

T-presents-anomaly

case 1 tu: So, in DR HR is up, CO is up, but SV is down.

case 2 tu: So, CO decreases even though SV increases.

case 3 tu: So, we have HR down, SV up and CO down.

T-tutors-anomaly

case 1 tu: How is this possible?
st: That HR increases outstrip SV decreases in this case.

case 2 tu: How can you explain this?
st: The decrease due to the lowered heart rate is greater then the increase due to increased stroke volume.

case 3 tu: How is this possible?
st: HR is down more than SV is up.

The ***T-tutors-consequence-value*** topic is used to show the value of a variable as a consequence of the value of a determinant. The determinant, its value, and the variable being tutored are usually mentioned within this topic, and the value of the variable is elicited. This topic occurs inside of the ***T-moves-forward*** method.

T-tutors-consequence-value

tu: When RAP increases what effect would that have on SV?
st: SV would increases also.
tu: Sure.

5.3. The Primitive Level

The topics share the primitive operators ***T-elicits*** and ***T-informs***. The ***T-elicits*** operator is used when we want the student to participate actively by answering a question. With ***T-informs*** the tutor gives some information to the student.

T-elicits info=var-value

tu: What is the value of cardiac output [CO]?

T-informs info=DR-info attitude=remind

tu: Remember, we are dealing with the period before any change in nervous activity occurs.

T-informs narrative-mode=summary

tu: So HR increases and that makes CO go up ...

6. Categories of Arguments

At any level operators can have arguments such as the variable name or the information desired. Other arguments refer to interpersonal aspects of an utterance or textual aspects. Arguments are also inherited from higher level, enclosing goals.

Here is a primitive-level goal showing several types of arguments:

<T-elicits info=determinant attitude=rephrase-question narrative-mode=reference attempts=2>

Information can be any piece of content we are trying to inform or elicit. If ***information*** is the same as the information in a former level then it can be omitted. ***Attitude*** shows the tutor's personal intentions and ***narrative-mode*** implies textual meanings. The number of ***attempts*** shows how many times the tutor asked questions about the same topic. Following, we show our argument groups that we have defined from our reading of the transcripts.

(A) Variable

We have 7 core variables: HR, IS, TPR, CO, MAP, CVP, SV.
There are other variables that appear infrequently. Some older transcripts use CC in place of IS and RAP in place of CVP.

(1) *var = HR*
(2) *var = BV* (Blood Volume)

(B) Type

(1) *method-type = inner*:

This is used when the method type is inner-method.

```
 <T-moves-toward-PT  method-type=inner>
    <T-tutors-mechanism  var=RA>
       <T-elicits  DM="and">
K12-tu-39-2: And what is the primary mechanism by which
             arteriolar radius is controlled?
          ...
```

(2) *type = neural*

```
<T-shows-contradiction type=neural>
    K11-tu-55-4: But (if) CC is under neural control,
     how would it be affected in the DR period?
    K11-st-56-1: I EDV.
    K11-tu-57-1: You can't have it both ways.
</T-shows-contradiction>
```

(3) *type = 3-vars* or *type = 2-vars*

```
<T-explores-anomaly  type=3-vars>
    K25-tu-62-1: So, in DR HR is up, CO is up, but SV is down.
</T-explores-anomaly>
```

(4) *type = explain-DR* or *type = mention-DR*

Sometimes the tutor explains the meaning of the DR stage and sometimes just mentions the name of the DR stage as a reminder.

case 1:

```
 <T-informs  info=DR-info  type=explain-DR  atti=remind>
K12-tu-35-4: Remember that we're dealing with the short
             period before you get a reflex response.
 </T-informs>
```

case 2:

```
 <T-informs  type=mention-DR  DM="so">
K27-tu-60-1: So, in the DR .....
 </T-informs>
```

(C) Information

(1) *info = var-value*

```
 <T-informs  info=var-value>
K10-tu-41-2: You predicted that it would go up.
 </T-informs>
```

(2) *info = reason*

```
 <T-elicits  info=reason>
K25-tu-66-3: What must be true if all three of these
             predictions are correct?
 </T-elicits>
```

(3) *info = HR-vs-SV*

```
 <T-informs  info=HR-vs-SV  atti=speak-to-answer>
K14-tu-49-2: It is true that CO=SV x HR.
 </T-informs>
```

(4) *info = EDV-anatomy*

```
 <T-elicits  info=EDV-anatomy >
K22-tu-42-1: When you talk about EDV what structure in the
             heart are you referring to?
 </T-elicits>
```

(5) *info = PT-info*

```
      <T-informs  info=PT-info>
K22-tu-46-2: However, neither of these are in the
             predictions table.
      </T-informs>
```

(6) *info = DR-info*

```
 <T-informs  info=DR-info>
K12-tu-35-4: Remember that we're dealing with the short
             period before you get a reflex response.
 </T-informs>
```

(7) *info = RR-info*

```
 <T-informs  info=RR-info>
K45-tu-102-2: Now we are trying to think about what
             happens to the system when the baroreceptor
             reflex is activated.
 </T-informs>
```

(8) *info = neural-info*

```
 <T-informs  info=neural-info>
K11-tu-57-2: CC is under neural control
 </T-informs>
```

(9) *info = Starling's law*
(10) *info = determinant-value*
(11) *info = determinant (of variable)*
(12) *info = relationship (between 2 variables)*
(13) *info = definition*

(D) Attempt

default value is 1.

(1) *attempts = 2*

```
<T-tutors-value>
  <T-elicits>
  K11-tu-57-2: Then what is the value of CC?
  <s-ans catg=incorrect>
    . . .
  </T-elicits>
    . . .
  <T-elicits attempts=2 >
  K11-tu-61-1: So what's your prediction about CC?
  </T-elicits>
```

(E) Discourse Marker

(1) *DM = "and"*

```
 <T-elicits  DM="and">
K48-tu-48-2: And during DR what changes in ANS activity
             occur?.
 </T-elicits>
```

(2) *DM = " but"*
(3) *DM = "so"*
(4) *DM = " now"*
(5) *DM = " then"*
(6) *DM = " therefore"*
(7) *DM = " first"*
(8) *DM = " well"*
(9) *DM = " since"*
(10) *DM = "however"*

(F) Attitude

(1) *atti = rephrase-question*

```
K14-tu-47-2: Now, what two parameters in the predictions
             table together determine the value of the SV?
K14-st-48-1: CO and HR.

K14-tu-49-1: No.
K14-tu-49-2: It is true that CO=SV x HR.
 <T-elicits  atti=rephrase-question  attempts=2>
K14-tu-49-3: What I was asking is what determines how much
             blood is ejected from the heart each time it
             beats (the SV)?
 </T-elicits>
```

(2) *atti = bolster-answer*
case1:

```
K20-tu-34-1: What are the determinants of SV?
K20-st-35-2: Determinants are end-diastolic volume,
             afterload i. e. MAP, and I think to a small
             degree, heart rate.
K20-tu-36-1: Well that's partly correct.
 <T-informs  atti=bolster-answer>
K20-tu-36-2: EDV is certainly a determinant.
 </T-informs>
```

case 2:

```
K25-tu-52-2: But what determines the volume of blood in
             the central venous compartment?
K25-st-53-1: How about CO?
 <T-informs  atti=bolster-answer>
K25-tu-54-1: Certainly, CO is the determinant I'm looking
             for here.
 </T-informs>
```

(3) *atti = qualify-answer*

Qualify-answer is a case when the student's answer was a near-miss or partially-correct and the tutor corrected it

```
K20-tu-34-1: What are the determinants of SV?
K20-st-35-2: Determinants are end-diastolic volume,
             afterload i. e. MAP, and I think to a small
             degree, heart rate.
K20-tu-36-1: Well that's partly correct.
K20-tu-36-2: EDV is certainly a determinant.
 <T-informs  atti=qualify-answer>
K20-tu-36-3: Afterload (I. E. aortic pressure is important
             but only when it (MAP) is very high.
K20-tu-36-4: Otherwise MAP has little effect on SV.
 </T-informs>
```

(4) *atti = reject-answer*

Reject-answer is a case where the student's answer is not correct, and it would be perfectly permissible for the tutor to say to and not address it at all.

```
K14-tu-41-2: what parameter in the predictions table
             relates to the volume that will be present in
             the central venous compartment?
K14-st-42-1: Co and SV.
K14-tu-43-1: Well CO certainly does
      <T-informs  atti=reject-answer>
SV is a determinant of CO.
      </T-informs>
```

(5) *atti = give-answer*

case 1:

```
K13-tu-37-3: First, what parameter determines the value of
             RAP?
K13-st-38-1: Venous return and peripheral resistance
             influences return.
K13-tu-39-1: Not in the way that you seem to think.
 <T-informs  atti=give-answer>
K13-tu-39-2: CO is made to vary
 </T-informs>
```

case 2:

```
K14-tu-43-2: Do you know how RAP will change if something
             produces a change in CO?
K14-st-44-1: If CO increases then RAP should also
             increase.
K14-tu-45-1: No.
 <T-informs  atti=give-answer>
K14-tu-45-2: When a change in CO is the independent
             variable (the thing changed) then RAP changes
             as the dependent variable IN THE OPPOSITE
             DIRECTION (CO and RAP are inversely related
             under these conditions).
 </T-informs>
```

(6) *attti = repeat-answer*

```
K22-tu-44-1 so what does alter RAP?
K22-st-45-1: Venous resistance and blood volume
K22-tu-46-1: You are correct,
      <T-informs  atti=repeat-answer>
 both of these would alter RAP.
      </T-informs>
```

(7) *atti = speak-to-answer*

Speak-to-answer is the case where the student's answer was not correct, but there was enough of a correct idea in it that the tutor did not simply reject it. Similarly the student might have misapplied a completely correct idea.

```
K14-tu-47-2: Now, what two parameters in the predictions
             table together determine the value of the SV?
K14-st-48-1: CO and HR.
K14-tu-49-1: No.
 <T-informs  info=CO-equation  atti=speak-to-answer>
K14-tu-49-2: It is true that CO=SV x HR.
 </T-informs>
```

(8) *atti = give-hint*

```
K14-tu-31-4: What parameter DOES determine RAP?
K14-st-32-1: Map.
 <T-informs  info=CVP  atti=give-hint>
K14-tu-35-1: RAP is approximately equivalent to central
             venous pressure.
 </T-informs>
```

(9) *atti = rephrase-answer*

```
K11-tu-49-3: How is TPR controlled?
K11-st-50-1: Sympathetic vasoconstriction.
K11-tu-51-1: Right.
 <T-informs atti=rephrase-answer>
K11-tu-51-2: TPR is primarily under neural control.
 </T-informs>
```

(10) *atti = remind*

case 1:

```
 <T-informs  atti=remind>
K10-tu-43-1: But remember that we're dealing with the
             period before there can be any neural
             changes.
 </T-informs>
```

case 2:

```
 <T-informs  atti=remind>
K12-tu-35-4: Remember that we're dealing with the short
             period before you get a reflex response.
 </T-informs>
```

(G) Narrative-mode

(1) *narrative-mode = reference*

case 1:

```
 <T-informs  narrative-mode=reference>
K27-tu-68-3: You predicted that CC would be unchanged and
             that RAP increased.
 </T-informs>
```

case 2:

```
 <T-informs  narrative-mode=reference>
K48-tu-44-3: You predicted that TPR would increase.
 </T-informs>
```

(2) *narrative-mode = summary*

case 1:

```
 <T-informs  narrative-mode=summary>
K27-tu-72-1: So, we have HR down, SV up and CO down.
 </T-informs>
```

case 2:

```
 <T-informs  narrative-mode=summary>
K25-tu-62-1: So, in DR HR is up, CO is up, but SV is down.
 </T-informs>
```

(H) Softener

(1) *softener = "can you tell me"*

```
 <T-elicits  softener="can you tell me">
K10-tu-29-4: Can you tell me how TPR is controlled?
 </T-elicits>
```

(2) *softener = "do you think that"*
(3) *softener = "do you know"*

(I) Time-qualifier

(1) *TimeQ = "during DR"*

```
 <T-elicits  TimeQ="during DR">
K48-tu-48-2: During DR what changes in ANS activity occur?
 </T-elicits>
```

(2) T*imeQ = "in DR"*
(3) *TimeQ = "in the DR"*
(4) T*imeQ = "during the DR period"*
(5) *TimeQ = "in the DR period"*
(6) *TimeQ = "- DR"*

(J) Context-setting-clause

(1) *context-setting-clause = "if CVP is down"*

```
 <T-elicits  context-setting-clause="if CVP is down">
K25-tu-60-3: So, if CVP is down what happens to (RAP and)
             SV?
 </T-elicits>
```

(2) *context-setting-clause = "given this info"*

```
 <T-elicits  context-setting-clause="given this info">
K20-tu-36-8: So what do you think happens to SV, given
             this info?
 </T-elicits>
```

(3) *context-setting-clause = "that being the case"*

```
 <T-elicits  context-setting-clause="that being the case">
K26-tu-72-3: That being the case, what will happen to RAP-
             DR in this situation?
 </T-elicits>
```

(4) *context-setting-clause = "when CO decreases"*
(5) *context-setting-clause = "if all three of these predictions are correct"*
(6) *context-setting-clause = "if something causes to CO to change that"*
(7) *context-setting-clause = "if it is under neural control"*

(K) Specify-value

(1) *specify-value = "go up"*

```
 <T-informs  specify-value="go up" >
K25-tu-56-2: You predicted that CO-DR would go up.
 </T-informs>
```

(2) *specify-value = "decrease"*

```
 <T-elicits  specify-value="decrease">
K27-tu-50-2: Why do you think that TPR will decrease?
 <T-elicits>
```

(3) *specify-value = "increase"*
(4) *specify-value = "no change"*
(5) *specify-value = "go down"*
(6) *specify-value = "i"*
(7) *specify-value = " up"*
(8) *specify-value = "down"*
(9) *specify-value = "unchanged"*

7. Student's Answer Categories and Tutor's Acknowledgment Type

The transcripts show several kinds of student answer categories as follows:

- *correct*
- *clearly incorrect*
- *near miss*, which is pedagogically useful but not the desired answer
- *don't know*, where the student said something equivalent to "I don't know"
- *partially correct*, meaning some part of the answer is correct and the rest is incorrect
- *corrext-with-wrong-reason*, which is used to show that the student is giving right answer but the reason is wrong.

Following are several kinds of tutor acknowledgments.

- *positive*
- *negative*
- *partially correct*

The following example is the usual case of a positive tutor's response to a correct student answer.

```
 <T-elicits  DM="so">
tu: So what would happen to RAP?
  <S-ans  catg=correct>
st: D, SV D.
  </S-ans>
  <T-ack  type=positive>
tu: Great.
  </T-ack>
 </T-elicits>
```

In the case of a *partially-correct* answer we marked one more argument ***detail. Detail*** shows what kind of answer, for each part of the student's answer, in order.

```
 <T-elicits>
tu: What are the determinants of SV?
  <S-ans  catg=partially-correct  detail="near-miss
             correct incorrect">
st: Determinants are end-diastolic volume, afterload i. e.
             MAP, and I think to a small degree, heart
             rate.
  </S-ans>
  <T-ack  type=partially-correct>
tu: Well that's partly correct.
  </T-ack>
 </T-elicits>
```

The following example shows the case of a *correct-with-wrong-reason* answer.

```
 <T-informs>
tu: You predicted that CO would decrease (and that's
             correct).
 </T-informs>
 <T-elicits info=relationship>
tu: What effect would that change in CO have on RAP?
  <S-ans  catg=correct-with-wrong-reason>
st: Would it increase because of less TPR meaning more
             venous return.
  </S-ans>
 </T-elicits>
```

Sometimes the student gives an answer without confidence. In these cases we marked one more argument "*type=hedge*".

```
 <T-elicits>
tu: What other variable is under neural control-primarily?
 <S-ans  catg=correct type=hedge>
st: CC?
 </S-ans>
 <T-ack  type=positive>
tu: Yes.
 </T-ack>
 </T-elicits>
```

Depending upon the category of student answer, the tutor may continue with the current strategy or choose a new one. If the student's answer is correct, the tutor moves to the next goal, sometimes giving an acknowledgment such as "good" or "right". In response to a student answer that is clearly incorrect, the tutor may change to a new method which sometimes will build on the student's answer. Other possibilities are to ask the question again in a different way, or to give the student the answer so that tutoring can continue. In any of these cases, the tutor may address the student's wrong answer before continuing with hierarchical expansion of the tutoring plan. This feature is a way of tailoring our responses to the student's needs.

8. Split Case

A primary purpose of markup is annotating tutorial goals. Tutorial goals do not always correspond to single sentences. Frequently one sentence expresses several goals in different parts of the sentence. In these cases we can split up the sentences according to the goals.

In this section we illustrate three common ways of splitting a single sentence among several goals.

8.1 Subordinate clause or phrase.

The following examples have several different goals, each in the different clause in a single sentence.

(1) Tu: But if CC is under neural control, how would it be affected in the DR period?

```
<T-presents-contradiction>
  <T-informs  info=neural-info  DM="but">
 tu:(But if) CC is under neural control,
  </T-informs>
</T-presents-contradiction>


<T-tutors-contradiction>
  <T-elicits  info=reason TimeQ="in the DR period">
  how would it be affected in the DR period?
  </T-elicits>
```

Note that we have placed parentheses around "But if" because we want to generate this information separately.

2) Tu: Then if IS is only affected by changes in sympathetic stimulation of the heart muscle, what must be the value of IS in the DR period?

Sometimes a tutorial goal will point to a part of a sentence, if it is too complicated to split up.

```
<T-tutors-mechanism>
  <T-informs  info=neural-info>
 K47-tu-60-1: (Then if) IS is only affected by changes in
              sympathetic stimulation of the heart muscle,
  </T-informs>
</T-tutors-mechanism>


<T-tutors-DR-info>
  <T-informs  type=mention-DR>
 /* see next sentence */
  </T-informs>
</T-tutors-DR-info>


<T-tutors-value>
  <T-elicits  TimeQ="in the DR period">
  what must be the value of IS in the DR period?.
     ...
```

(3) Tu: So, in the DR will there be any change in TPR?

```
<T-tutors-DR-info>
   <T-informs  type=mention-DR  DM="so">
  K27-tu-60-1: So, in the DR
   </T-informs>
</T-tutors-DR-info>


<T-tutors-value>
   <T-elicits>
   will there be any change in TPR?
      ...
```

8.2 Implicit case

In the following examples the tutor informs the student what the determinant is by simply *using* it. We add the goal to inform about the determinant because the student has in fact been informed by this maneuver. In these examples the turor did not explicitly say "CO is the determinant of RAP." However, the student was informed of that anyway.

1) Tu: How about the influence of a change in CO on RAP?

```
<T-tutors-determinant>
   <T-informs  atti=give-answer>
  ** see CO in next sentence**
   </T-informs>
</T-tutors-determinant>

<T-tutors-relationship  from-var=CO  to-var=RAP>
   <T-elicits>
  K11-tu-65-2: How about the influence of a change in CO on
               RAP?
```

2) Tu: Do you remember a relationship between CO and RAP?

```
<T-tutors-determinant>
   <T-informs  atti=give-answer>
  ** see CO in next sentence**
   </T-informs>
</T-tutors-determinant>


<T-tutors-relationship  from-var=CO  to-var=RAP>
   <T-elicits  softener="do you remember">
  K22-tu-46-3: Do you remember a relationship between CO and
               RAP?
```

8.3 Acknowledgment + informs or elicits answers.

1)Tu: Right, so what does alter RAP?

```
     . . .
  <T-ack  type=positive>
  K22-tu-44-1: Right,
  </T-ack>
   </T-elicits>

   <T-elicits  attempts=2  DM="so">
   so what does alter RAP?
     . . .
```

2) Tu: You are correct, both of these would alter RAP.

```
    . . .
<T-ack  type=positive>
K22-tu-46-1: You are correct,
</T-ack>
 </T-elicits>


 <T-moves-toward-PT  method-type=inner>
    <T-tutors-PT-entry>
       <T-informs  atti=repeat-answer>
 both of these would alter RAP.
       </T-informs>


         . . .
```

9.The Marked-up Examples

Figure 9.1, shows the whole picture of a markup for the correction of variable CC in the DR stage of the pacemaker procedure according to our goal hierarchy rules and levels. The ***T-tutors-stage*** goal is expanded with ***T-introduces-stage, T-corrects-variable,*** and ***T-concludes-stage*** subgoals. First of all, the tutor elicits the mechanism with the method ***T-does-neural-DLR*** and the topic ***T-tutors-mechanism***. After getting a correct answer from the student, the tutor changes his topic to ***T-tutors-DR-info***. Within this topic the tutor explains about the DR period. Then the tutor changes topic to ***T-tutors-value,*** usually the final topic, to obtain the final correct answer for the value of the tutored variable. The category of student answer is marked but it is not included inside of the tutor's goal hierarchy. The tutor's acknowledgment is treated the same.

Figure 9.2 shows the markup of a response to a "near-miss" student answer. It is a part of a whole markup for variable RAP. In this example, the tutor asked for the determinant of RAP. So it is marked up with the method of ***T-tutors-via-determinant***, the topic is ***T-tutors-determinant***, and the primitive is ***T-elicits***. Due to the near-miss answer (CVP), tutoring is expanded with the deep-concept method. After that, the ***T-moves-toward-PT*** inner-method is used to get the tutoring back to a variable that is in the prediction table. After one more near-miss answer, the ***T-moves-toward-PT*** inner-method is used again. After getting the right answer for CO, the inner-method is ended. So, the tutoring of value is included in the original method level.

```
<T-tutors-procedure  proc=proc-pacemaker>
  <T-tutors-stage  stage=DR>
    <T-introduces-stage>
      <T-informs>
            tu: Pretty good job!
      </T-informs>
    </T-introduces-stage>


    <T-corrects-variable  var=CC>
      <T-tutors-variable>
        <T-does-neural-DLR>
          <T-tutors-mechanism>
            <T-elicits>
           tu: What input to the heart causes contractility to
                       change?
           <S-ans  catg=correct>
           st: Sympathetic stimulation.
           </S-ans>
           <T-ack  type=positive>
           tu: Right.
           </T-ack>
            </T-elicits>
          </T-tutors-mechanism>


          <T-tutors-DR-info>
            <T-informs  type=explain-DR>
           tu: The DR occurs during the period of time before any
                       reflex response to the perturbation of the
                       system takes place.
            </T-informs>
          </T-tutors-DR-info>


          <T-tutors-value>
            <T-elicits  DM="so"  TimeQ="during the DR period">
           tu: So, predict what change will occur to CC during the DR
                       period.
           <S-ans  catg=correct>
           st: None.
           </S-ans>
            </T-elicits>
          </T-tutors-value>


        </T-does-neural-DLR>
      </T-tutors-variable>
    </T-corrects-variable>

    <T-concludes-stage>
      <T-informs>
            tu: All of your other DR predictions were correct, so
                       please read page 6 so we can go on.
      </T-informs>
    </T-concludes-stage>

  </T-tutors-stage>
</T-tutors-procedure>
```

Figure 9.1. Mark-up of Correction of variable CC

```
<T-tutors-via-determinants  var=RAP>
  <T-tutors-determinant>
    <T-elicits>
    tu:What parameter determines RAP?*
    <S-ans  catg=near-miss>
    st:CVP.
    </S-ans>
    </T-elicits>

    <T-moves-toward-PT  method-type=inner>
      <T-tutors-determinant  var=CVP>
        <T-elicits>
    tu:What determines CVP?
    <S-ans  catg=near-miss>
    st:Blood volume [CBV].
    </S-ans>
        </T-elicits>
      </T-tutors-determinant>
    </T-moves-toward-PT>

    <T-moves-toward-PT>
      <T-tutors-determinant  var=CBV>
        <T-elicits>
    tu:What determines CBV?
    <S-ans  catg=correct>
    st:CO.
    </S-ans>
        </T-elicits>
      </T-tutors-determinant>
    </T-moves-toward-PT>
  </T-tutors-determinant>

  <T-tutors-value>
    <T-elicits>
    tu: How would RAP change?
    <S-ans  catg=correct>
    st: Decrease.
    </S-ans>
    <T-ack  type=positive>
    tu: Correct.
    </T-ack>
    </T-elicits>
  </T-tutors-value>
</T-tutors-via-determinant>
```

Figure 9.2. Mark-up of Response to a “near miss” Student Answer

[*] In this transcript RAP is a core variable and CVP is a more detailed physiological concept.