Talk & Dialogue:
A Festschrift for Lauren Resnick

Repeated Constructive Interaction for Sustainable Understanding in College Classroom

Naomi Miyake & Hajime Shirouzu,
with Chukyo Learning Science Group

Dr. Lauren Resnick

- Hiroshi Azuma & Giyoo Hatano send their warmest regards to Lauren, Bob, and everyone who know them.

- Once she visited Japan, ...
- Once I tried to visit her at LRDC, ...

The very long term goal of my research

- Teach cognitive science to
  - solve problems better,
  - learn better,
  - make intellectual judgments better
- Not only in school, but in everyday life

Research goals

1) Design a set of courses to teach cognitive science
2) Through collaborative learning, so that the participants learn how to learn collaboratively in the future, when learning becomes necessary

Outline

- Design of the collaborative course
  - Dynamic jigsaw
- Outcomes
  - Learning outcome six months after the course
  - Change of discourse within a semester
- Dialogue data to show how the learning progresses during this course

Two cautions

- This is a very preliminary report
  - JST support for 2000-2004
  - Continuation for 2005-2007
- This study does not have a control condition for comparison
  - Create a course, based on what we know about collaborative learning
  - Observe and collect data as the course develops
  - Find patterns of success and feedback the findings into design

Learning objectives

- Understand some basic characteristics of cognitive processes,
- Abstract them into a "portable" chunk of knowledge (or wisdom about how human mind works and how to know it),
- So that one can apply that knowledge in everyday situations.
  - Knowledge has to be restructured in their own words
  - Knowledge has to be kept for a long time

Stepwise goals of learning activities

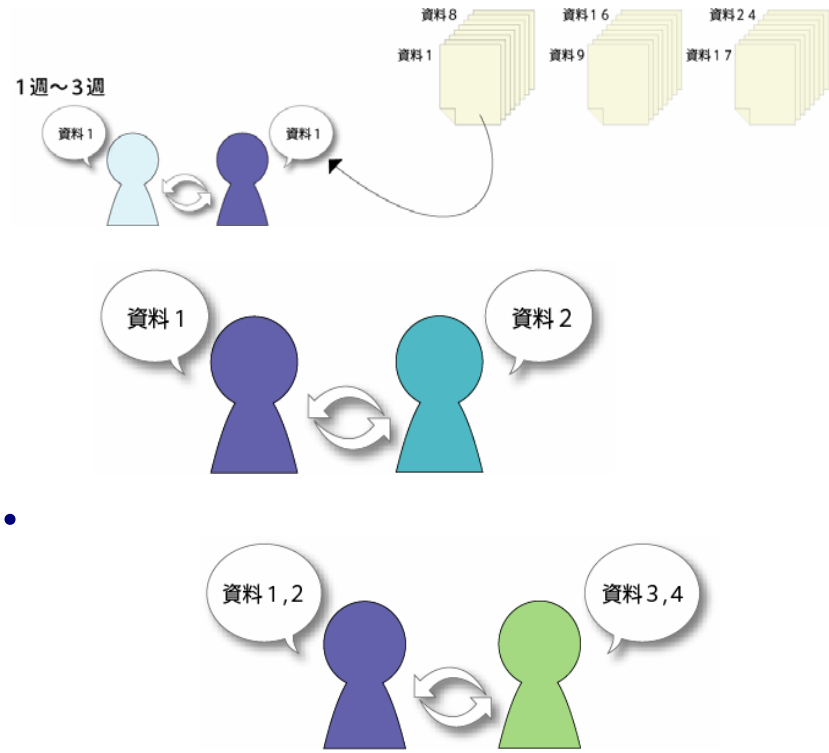
1) Understand one research finding by reading a text to be able to explain its main points, with its logical or evidential support.

2) Combine this understanding with other research findings to form a chunk, so that one can apply this wisdom when necessary.

3) Repeat this and gradually increase the number of research findings to cover.

Dynamic jigsaw

- Jigsaw as a tool for collaborative reflection.
- Combine this to cover 20 to 30 research findings.



Why Jigsaw?

- Effective collaborative learning assumes each participant has
  - an initial idea or ideas,
  - a means for externalizing such ideas for reflection, and
  - chances to “monitor” the different ideas from a slightly abstract viewpoint
- Jigsaw can be devised to fulfill these assumptions.

Dynamic jigsaw as a scheme

Among N pieces of literature ($n_{1...N}$),

- Select one, n_i, to take charge of it.
- Become expert of n_i.
- Exchange and seek integration of n_i and n_{i+1}.
- Exchange and seek integration of n_i+n_{i+1} and m_i+m_{i+1} (2X2).
- Exchange and seek integration of $n_i+n_{i+1}+ m_i+ m_{i+1}$ and other four (4X4).
- ...
- Write a summary of n_1 to N, including n_i.

Scale of our study

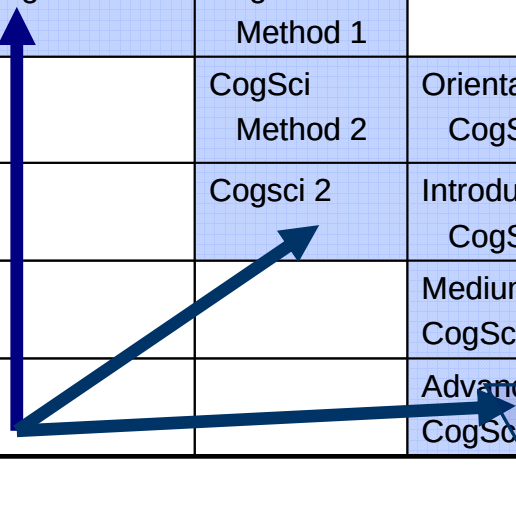
JST CREST: 2000-2004; SORST: 2005-2007

- Two 90 min. classes per semester
- Four semesters for the first two years of college
- Dynamic jigsaw is for the sophomores.

- Seventy students per year on average
- Data collection since 2000
- Serious data collection since 2003

Classes under study

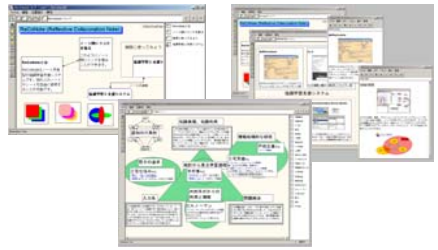
	Admitted in 2001	Admitted in 2002	Admitted in 2003	Admitted in 2004
Spring 2001	Orientation to CogSci			
Fall 2001	CogSci Method 1			
Spring 2002	CogSci Method 2	Orientation to CogSci		
Fall 2002	CogSci 2	CogSci Method 1		
Spring 2003		CogSci Method 2	Orientation to CogSci A/B	
Fall 2003		Cogsci 2	Introduction to CogSci A/B	
Spring 2004			Medium CogSci CogSc Method 1	Orientation to CogSci A/B
Fall 2004			Advanced CogSci CogSci Method 2	Introduction to CogSci A/B



Classes

Freshmen Spring & Fall

Concept Mapping tool
for sharing externalizations

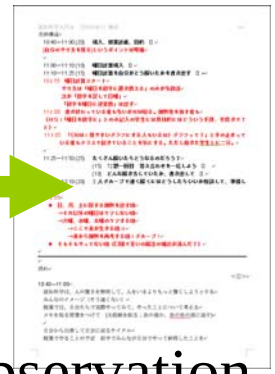


Sophomores Spring & Fall

Data collection of classes

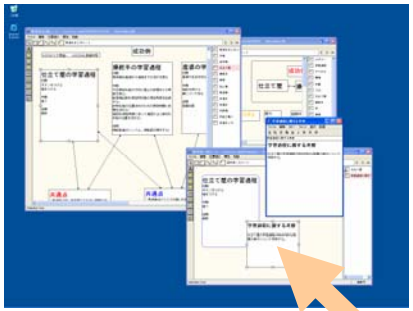
Teaching plan

Class



Observation notes

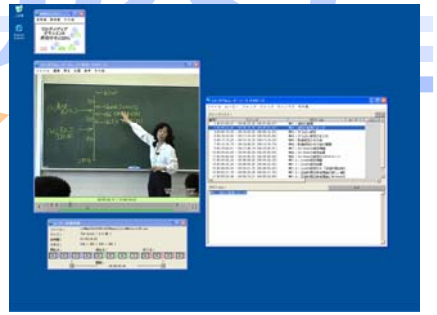
ReCoNote



System log

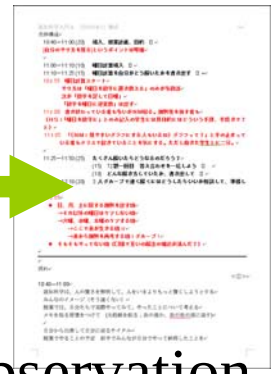
Video records of class activities

CMS

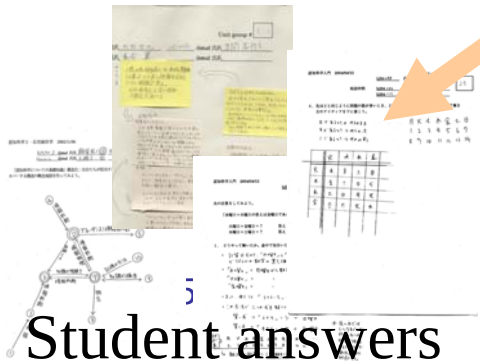


Class

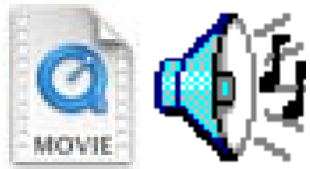
Teaching plan



Observation notes



Student answers



Audio data of group activities

Outcomes and dialogues

1）Retrospective interview four to six months after the completion of the two-year course

2）Class dialogue data of the dynamic jigsaw (2004)

Remembering "a lecture"

5 months later

EXP: What do you remember?
ST: … uhh, he talked about meta-cognition, and uhh, he talked about the baseball player, Ichiro, and, and …that's all."

Class type	# of targets	% recall Facts + Implication	% recall Keywords
Lectures	11	2.2%	56.1%

Remembering “a lecture”

5 months later

“ (What did you remember?) … uhh, he talks about meta-cognition, and uhh, he talks about the baseball player, Ichiro, and, and …nothing.”

Class type	# of targets	% recall Facts + Implication	% recall Keywords
Lectures	11	2.2%	56.1%

Remembering from jigsaw

EXP: What did you read? What kind of a story?
ST: Okay. It was about an experiment of pigeon's memory. If we destroy a particular part of her brain, it can still distinguish the edible things from the non-edible, but cannot tell a triangle from other figures. So, the functions needed for living are distributed among different parts of the brain, even pigeon's brain"

4 months later

Class type	# of targets	% recall Facts + Implication	% recall Keywords
Lectures	11	2.2%	56.1%
Jigsaw	22	15.8%	7.7%

Remembering from jigsaw

EXP: What did you read? What kind of a story?
ST: Okay. It was about an experiment of pigeon's memory. If we destroy a particular part of her brain, it can still distinguish the edible things from the non-edible, but cannot tell a triangle from other figures. So, the functions needed for living are distributed among different parts of the brain, even pigeon's brain"

4 months later

Class type	# of targets	% recall Facts + Implication	% recall Keywords
Lectures	11	2.2%	56.1%
Jigsaw	22	15.8%	7.7%

2）Class dialogue data of the dynamic jigsaw

One Recorder per Student

They talk in Japanese…

Target class of dialogue analyses

	Admitted in 2001	Admitted in 2002	Admitted in 2003	Admitted in 2004
Spring 2001	Orientation to CogSci			
Fall 2001	CogSci Method 1			
Spring 2002	CogSci Method 2	Orientation to CogSci		
Fall 2002	CogSci 2	CogSci Method 1		
Spring 2003		CogSci Method 2	Orientation to CogSci A/B	
Fall 2003		Cogsci 2	Introduction to CogSci A/B	
Spring 2004			Medium CogSci CogSci Method 1	Orientation to CogSci A/B
Fall 2004			Advanced CogSci CogSci Method 2	Introduction to CogSci A/B

"Advanced Cognitive Science" 2004

- Seventy-five sophomores
- Fifteen classes of 90 min/week (except for the last two weeks)
- September to December

- The students have studied followings prior to this class
  - Problem solving (IDEAL by Bransford and Stein)
  - Memory
  - Knowledge representation (semantic net notation)
  - Introductory perception
  - Theories of expertization

Learning materials

- Material
  - Twenty-four literature pieces

Eight on development
Eight on perception and knowledge representation
Eight from problem solving, culture and society

Essentialism


認知科学上験資料　2004　資料番号 04_106　1/2

子どもたちの中の心理学的な本質主義

なぜかさい子どもたちは、「お日さんは絶対消防士にはなれないんだ」と主張するのだろうかまた、子どもの考を内観から引き離された大たちが、大人になってからなんとかして自分の殻を破ろうとするのはなぜかうさらには、熱心な美術収集家が画家のオリジナルに望外な値段をはらうのはなぜなのだろうこれらはまったく異なった文脈で起きるばらばらな事柄にも見えるが、どれも「心理学的本質主義」という考え方の枠組みで理解することができる。

心理学的な本質主義とは、特定のカテゴリー（例えば「ライオン」「女性」など）が、その根底に、直接は観察することができない本質を持つという考えである。その本質は外から見ることはできないが、そのものがあるカテゴリに属するメンバーであることを保証する。生物学の領域で言えば、本質とは、ある生き物が成長したり、子どもを生んだり、（オタマジャクシがカエルになるなどのように）変態したりしても、その生き物の中に存在し続ける「質」である。化学の領域で言えば、水が固体でも気体でも液体でも「水」であるように、ある物質が、形や大きさや状態を変えても残り、そのものがそのものであることを保証する「質」である。

この考えは、どこから来るのだろうか？最近の研究では、心理学的な本質主義は成長の早い時期から見られる認知的バイアスであることと提案されている。これらの研究によれば、年少の子どもは、単語を学ぶとき、新しいカテゴリメンバーにそのカテゴリについて持っていた知識を一般化して当てはめるとき、ものの内側に何があってどんな働きをしているのかについて推測するとき、学習して身につけられることがらに対して生まれつき持っている性質がどんな影響をもたらすかを考えるとき、さらにはものごとの因果関係を説明するときなどさまざまな場面で、直接は見ることができないものの本質をつかんでいることがわかる。これらの結果からは、子どもたちが幼いときから、隠れた、目に見えない特徴を探そうとする傾向を持っているのだと考えることができる。

本質主義はどこに現れてくるか

子どもにせよ大人にせよ人が本質主義的なものの考え方をするという証拠はどこにあるのだろうか？Medin と Ortony は、本質主義は「場所取り」だと考えればよいという。本質がなんであるかはわからないうちから、場所だけは確保しておくのように、あるカテゴリがある本質を示す、と決めてかかるのである。例として、子どもたちはよく、男と女の間には決定的な違いがあると信じているが、実際それがどのような違いなのかについてはまったく何のアイディアもない、ということがある。しかし、ものごとにそういった本質があると考えることによって、さまざまな推論をおこなうことができ、またそれらがどういう構造をもっているかを知ることができる。

たとえば、あいまいなカテゴリのメンバーを決定する時、子どもと大人がどのような手続きを使うかをテストするために、次のような実験を行った。5歳児と大学生に、図のような、ほとんど同じに見えるような2つのものの一つを示し、これらのアイディアはいくつかの点で違う、と告げた（例えば「一匹は犬で一匹はオオカミである」もしくは「一匹は動物でもう一匹はおもちゃである」など）。そして、どちらのアイディアがどちらであるかを決めるように教示した。それから、ア

図：実験に使用したサンプルアイテム


認知科学上験資料　2004　資料番号 04_106　2/2

イテムの内部、起源や出身、行動、年を調べることは、答えをチェックするのに有効であるかどうかをたずねた。

その結果、子どもも大人も、そのアイテムは外から見える行動だけではなく、内部の性質や起源によっても特徴付けることができると信じていたことが示された。5歳児も大人も、同じように、起源や内部を調べることはまったの同じに見える動物のうち、どちらがたてどちらがオオカミであるかを決める重要な手がかりとなると答えたが、彼らがではオオカミと犬とで内臓が2つ違うのかを知っていたとは考えられない。彼らはいずれも、本質的に何かが見えないところで違う、ということだけを信じていたと思われる。

ことばと本質主義

本質が外からは観察できないものだとすると、人は何によってその本質をつかんだり、人に伝えたりしようとするのだろううものの本質について判断したり伝えたりするとき、ことばが重要な役割を果たす。

あるカテゴリのメンバーを表現するのに使用することばが、子どもたちのそのカテゴリについての判断に影響する。数えることのできる名詞は、形容詞句や動詞句よりも、あるカテゴリが時間を超えて安定しており、一貫性があることを意味する。例えば、ある研究では、5~7歳の子どもたちに対して、数えられる名詞句を用いた説明（「ローズは 8 歳です。ローズはたくさんにんじんを食べます。彼女は［にんじんを一切ださん］です。」）か、もしくは動詞句を用いた説明（「ローズは 8 歳です。ローズはたくさんにんじんを食べます。彼女はできるときはいつでもにんじんを食べます。」）を聞かせた。その後、その子どもたちに、「ローズは大人になってもたくさんにんじんを食べるでしょうか。」「もし彼女の家族がにんじんを食べるのをやめさせようとしたら、彼女は食べるのをやめるでしょうか。」などの質問をして、このカテゴリメンバーが時間や環境の変化を超えてどのくらい安定していると思うかを調査した。結果、数えられる名詞を使った説明（「にんじんを食べ屋さん」）を聞いた子どもたちは、動詞句による説明（「そうできるときはいつでもにんじんを食べます」）を聞いた子どもたちよりも、個人の特性が時間や環境を超えて安定しているだろうと判断することが見出された。

一般的な名詞句、は本質を表現する表現の仕方であり、あるカテゴリが一貫していて、さまざまなことについて推論が可能であることを意味する。4歳児に新しいことがらを一般的な言い方を用いて説明する（例えば「熊の毛皮には3つの層があります」など）、彼らはこの表現をカテゴリメンバーのほとんどもしくは全てにあてまる典型的な事実だとして扱う、一般的な名詞は子どもたちの中にどんどん蓄積されていき、[illegible]

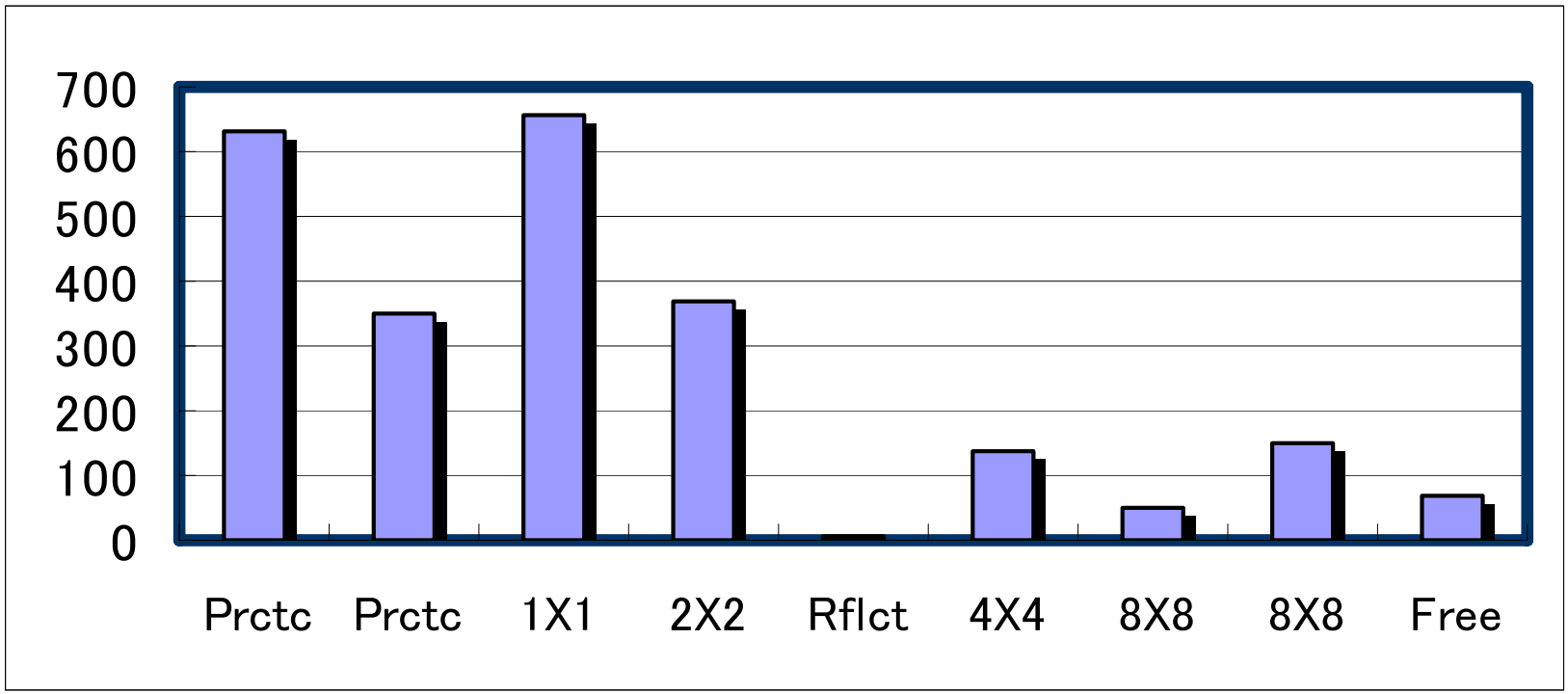
出典：Gelman, S.A. (2004) Psychological essentialism in children. *TICS* 8 pp.404-409 [抜粋翻訳]

Two sided A4 each

The dynamic jigsaw for Y.O.

19/Oct	Select 116 of (115, 116)
26/Oct	Answer quiz on 116, 115
02/Nov	Practice explaining 116 to TA
09/Nov	Practice explaining 115 to TA
16/Nov	1X1 115 & 116
30/Nov	2X2 (115,116)&(113,114)
07/Dec	Reflection on 2X2
08/Dec	4X4 (113-116)&(109-112)
14/Dec	8X8 (109-116)&(117-124)
15/Dec	8X8 (109-116)&(101-108)
22/Dec	Free jigsaw

Length of explanations of 116



Y.O.

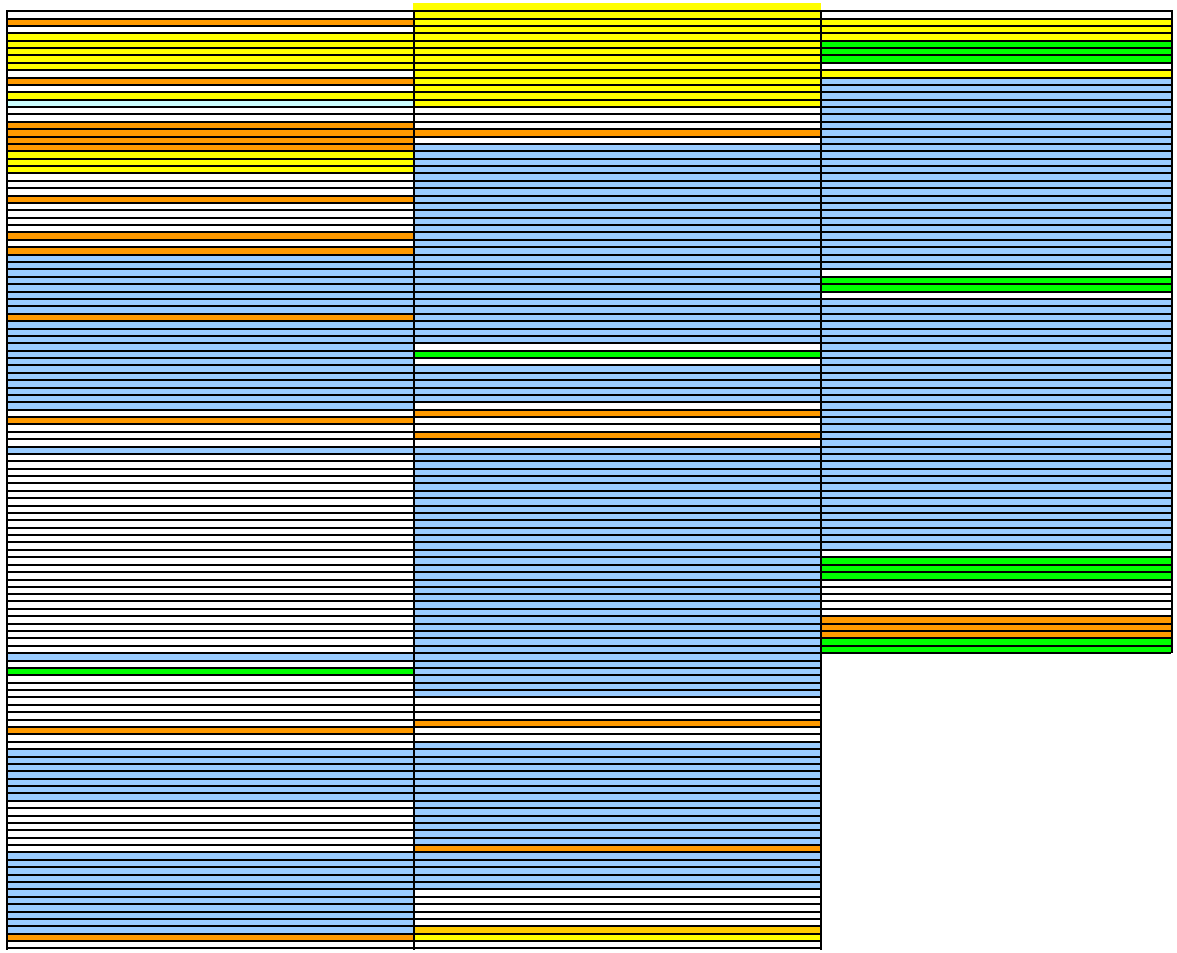
Component structure of the explanations

Theme	The theme of the findings
Evidence	Experiments, observations, systems, line of logic…
Implications	Author's interpretations and implications
Connections	Student's interpretations and abstractions

11/09 Prctc

12/07 4X4

12/15 8X8



Emerging pattern

- Y.O. gives more concise explanation towards the end.
- The dynamic jigsaw activity requires him to
  - take a close look at the text
  - get help for deeper reading from TA's
  - shorten his explanation to the limit in 8X8
  - re-organize evidence to select and elaborate one's easiest for him to explain
  - answer similar questions to select focus
  - clarify his explanation for understanding through discussions and confusions during exchanges.

What are 113, 4, 5, & 6?

113	ELIZA & Doctor; do we need process to achieve AI?
114	BUGGY: system and how it was used for teachers
115	BROOKS: modality interference
116	Declarative vs. procedural knowledge

16/Nov: While checking their notes, his partner voices a question about the text.

646	NT	We have written that knowledge gets transformed from declarative to procedural. Is this final?
649-655	YO	Yes, we finalized it…ah… maybe, we can put it as a last comment.
666-675	NT	We have talked.. from declarative to procedural transformation rather extensively. But couldn't it be reversed, like the other way around? Is this actually related to automatization? I don't understand.
686-687	YO	We don't have good examples of autmatization, yeah.

30/Nov -1: After the pair exchanged their practice explanations, YO develops his own interpretation

441-445	YO	I just thought… we might not use procedural knowledge intentionally, but to be conscious about it is, maybe, cognitive science…
446	TN	Ah…
447-448	YO	So, those human behavior is difficult to explain,
449-450	KT	…but we make them explainable in words.
451-464	YO	Let me try again, cognitive science is a process of transforming procedural knowledge into declarative knowledge. How's that?

30/Nov-2 : Exchanging explanations leads into further confusion

896-902	TY	113 says that there have been two sects of AI. Colby thinks the outputs are important, but Weisenbaum thinks about the algorithms in order to make an AI sysmte human-like.
		<exchange 114, 115 and 116, then make relations>
1376-90	TY	So, Colby's AI is procedural, because it depends on pattern matching, while Weisenbaum's is declarative because it aims at describing the internal?
1391-1401	YO	Uhm, I thought it was the other way around. Weisenbaum puts both types of knowledge into AI, but Colby uses only the declarative knowledge. But I think you might be right…

7/Dec :In 4x4, he clarifies his viewpoint

518-520	YO	It's strange to say that pattern matching cannot be used to mimic human intelligence. It doesn't mimic how humans use knowledge or the situation.
548-564	AW	Buggy mimics human errors. So it's similar to pattern matching.
574-575	YO	If Buggy is a pattern matching system, then it's the same as what Colby does.
578-579	AW	It's based on rules of how children make errors, based on thousands cases.
601-604	YO	Then the way Buggy makes mistakes is the same as children make mistakes, then Buggy has some mechanism of making mistakes. That's why this is useful for learning.
608-622	AW	No, no, no. Buggy just mimics children. …We should read 114.
627	YO	If that's the reason, Buggy is like Colby.

15/Dec : He confirms his view when he gives a shorter, more concise explanation.

	YO	< while explaining 109~116 >
1298-1302	YO	In 113, the surface is declarative knowledge, and the inside is procedural knowledge, and if you want to make an AI system, you need to know the procedural knowledge.
1322	KM	I can't relate this 114 to others.
1323-1333	YO	We can think of 114 as a trial to implement the procedural knowledge into AI, and its implication is that externalizing the procedural knowledge does something good.

22/Dec : A "novice" audience helps voicing

1403-07	YO	114 says that externalization makes the internal processes visible, and
1408	KT	Yeah
1408-13	YO	For example, when you teach arithmetic to a child and he makes an error, you might not be able to find why. But by externalizing the cognitive model you can, you can…
1414	KT	I see, I see,
1415	YO	uh, how should I say it?
1416	KT	…we can know what happens in the head of a child and causes an error.
1417-27	YO	Yes, yes, yes, yes, yes. That's the proof that it (=externalizing the cognitive model) is useful.

Constructive interaction and dynamic jigsaw

- Monitor provides a slightly more abstract perspective to help each to generalize the experience.
- The dynamic jigsaw facilitates the role of the monitor, which helps clarify the essence of explanations
- The activity structure enforces the explanations to be concise, so that they could be “portable.”

We continue...

- Establish cases where students learn, and identify successful and unsuccessful learning activities.
- Establish a microgenetic process of this level of knowledge construction
- Find matches between activity types and student achievements.
- Propose a new structure for college education to accommodate future needs.