Collaboration as a scaffold for Schematic Knowledge Integration

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College level education is also changing...
Goals for college level learning

• Portability
  – Outcome can be “taken out” of class

• Dependability
  – Outcome works when necessary

• Sustainability
  – Outcome is durable and modifiable
How “portable” are lectures?

Five months after lectures

Exp：What do you remember？
Stdnt：well, he talked on meta cognition・・・baseball・・・Ichiro was mentioned・・・that’s all.

<table>
<thead>
<tr>
<th>Class type</th>
<th># of targets</th>
<th>% recall</th>
<th>Keywords only</th>
</tr>
</thead>
<tbody>
<tr>
<td>講義</td>
<td>11</td>
<td>2.2%</td>
<td>56.1%</td>
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</tbody>
</table>
Proposal

• Supporting acquisition of domain specific “adaptive” schemas is one of the conditions for achieving the portability, dependability and sustainability of learning outcomes.
Outline of my talk

• What is an “adaptive” schema of knowledge and how is it constructed?
• How could collaborative learning contribute to the acquisition of adaptive schemas?
• What are the conditions for effective collaborative learning?
• My research to support the proposal
• Future perspectives
Example of “adaptive” schema

Day arithmetic

When
Tuesday + Wednesday = Friday,

What is
Friday + Tuesday = ?
“What if there are many?”

\[
\begin{align*}
M + S_u &= F + W = \\
W + T_e &= T_h + F = \\
F + M &= S_a + M = \\
S_a + W &= T_e + T_h = \\
T_e + S_a &= S_u + M = \\
T_h + M &= W + T_e = \\
W + F &= S_u + T_h =
\end{align*}
\]
Local strategies

• “Memorize answers!”
• “Make a table and look up!”

• “There are rules…”
  – X + Sunday, then X is the answer.
  – X + Monday, then X’s next day is the answer.
  – X + Tuesday, then X’s next next day is the answer. ...
A new question

What is $m + b = ?$

“$m...n...O? \text{ Oh!}$”

<table>
<thead>
<tr>
<th>Learning activity</th>
<th>Answer is “O”</th>
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</thead>
<tbody>
<tr>
<td>Explanation only</td>
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<tr>
<td>With hands-on</td>
<td></td>
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<tr>
<td>Hands-on + discussion</td>
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</table>
A new question

What is

\[ m + b = ? \]

"m...n...O? Oh!"

**Schema adaptation**

<table>
<thead>
<tr>
<th>Learning activity</th>
<th>Answer is “O”</th>
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<tbody>
<tr>
<td>Explanation only</td>
<td>28%</td>
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<tr>
<td>With hands-on</td>
<td>44%</td>
</tr>
<tr>
<td>Hands-on+discussion</td>
<td>58%</td>
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</table>
The first approximation

- The acquisition of an adaptive schema seems to require
  - substantial amount of solving “similar” problems (direct experience)
  - explicit scrutiny of (reflection upon) the experience
  - encounter with a “new” problem

- All as each individual student’s construction
How could this expand in collaborative classrooms?

Hypothesis-Experiment Instruction

Which is the heaviest?
HEI: Standard procedure

1. A problem is presented with three or four answer alternatives.
2. Pupils choose one answer by themselves.
3. Pupils’ responses, counted by a show of hands, are tabulated on the blackboard.
4. Pupils are encouraged to explain and discuss their choices with one another.
5. Pupils choose an alternative once again. They may change their choices.
6. Pupils observe an experiment or reading a given passage, to test their predictions.
Series of questions

• What if a clay ball is changed into different shapes, a flat pancake, or a long sausage?
• Would a baby’s body weight change if she drinks a bottle of milk (200cc)?
• Would your body weight change if you drink a carton of milk (1000cc)?
• Would dissolving sugar in water change the weight of the water? ...
Outcome

• Students gain solid conceptual understanding
• Students discussion promotes
  – More explicit verbalization of the concept
  – Higher motivation to observe the experiment, and to learn more
    (Inagaki & Hatano, 1972: 83, 2005)
  – Better understanding about scientific experimentation
    (Itakura, and his group members)
HEI Mechanism

• Students create different explanations about alternatives
• Students who chose the same alternative are encouraged to incorporate opinions given by the other students with same alternative.
• Students need to falsify given by those who chose different alternatives.
The second approximation

- The acquisition of robust scientific schemas seems to require:
  - Externalization of alternative explanations or different solutions
  - Explicit categorization of (reflection upon) the externalized explanations
  - Integration of explanation with reality (experimental results)
  - Repeated exposure of carefully sequenced set of problems
The second approximation

- The acquisition of robust scientific schemas seems to require:
  - **Externalization** of alternative explanations or different solutions
  - **Explicit categorization** of (reflection upon) the externalized explanations
  - **Integration** of explanation with reality (experimental results)
  - **Repeated** exposure of carefully sequenced set of problems
Basic components of collaboration

• Make each person’s own idea visible ⇔ compare

• Others’ ideas are visible

↑

Notice differences

Don’t converge!

Construct schemas
Conditions for effective collaboration

- Novices can express their ideas,
  - One needs resource to have “idea”
  - They also need support for externalization
- There are chances to compare one’s own with others’ ideas
  - Needs support to see “different” categories
  - Needs support to constructively integrate
- There are chances for modifying their original ideas, as well as expanding them.
For adaptive schema formation

• Repeat the whole process
  – With direct (hands-on) experiences worth reflecting on
  – From simpler, smaller scale collaboration to more complex, grander scale activities
  – On carefully sequenced materials
Why collaboration?

• Support individual construction of adaptive schemata

• Produce data for process analyses
  – For formative evaluation
  – For students’ reflection on their own learning
Research context
since 2000

• **Topic:** Common Sense CogSci
  - Problem solving skills, meta cognitive skills, knowledge about how human works, learning skills for future...

• **Target**: c70 CogSci undergraduates

• **Staff**: Two faculty members
  + 2 to 3 / class

• **Two 90 min. classes per semester**

• **Four semesters for the first two years**
Concrete strategies

- Support for having one’s own idea
  - Jigsaw method with variations
- Support for externalization
  - Reflective Collaboration Notes
- Support for comparison
- Support for re-construction
  - Repeat the activity set cyclically
Classes

Freshmen  Spring & Fall
Classes

Freshmen Spring & Fall

Concept Mapping tool for sharing externalizations
Classes

Freshmen  Spring & Fall

Concept Mapping tool for sharing externalizations

Sophomores  Spring & Fall
Classes

Freshmen  Spring & Fall

Sophomores  Spring & Fall

Concept Mapping tool for sharing externalizations
Blended curricula preparing for collaborative learning

From simple, short text exchange to more complex, longer texts’ repeated exchange.
### Target classes

*four classes/semester × two years*

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>Course</th>
<th>Admitted in 2001</th>
<th>Admitted in 2002</th>
<th>Admitted in 2003</th>
<th>Admitted in 2004</th>
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<tbody>
<tr>
<td>2002</td>
<td>Fall</td>
<td>CogSci Method 1</td>
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<tr>
<td>2003</td>
<td>Fall</td>
<td>Cogsci 2</td>
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<td>Introduction to CogSci A/B</td>
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<tr>
<td>2004</td>
<td>Fall</td>
<td>Advanced CogSci</td>
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<td>Orientation to CogSci A/B</td>
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<tr>
<td>2001</td>
<td>Spring</td>
<td>Orientation to CogSci</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Introduction to CogSci A/B</td>
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<td></td>
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</tr>
</tbody>
</table>
2nd Fall semester: Dynamic jigsaw

Twenty-four research texts, collaboratively explain 24 research texts to
deepen and expand comprehension

言語・概念獲得、生得性
認知プロセス、知識処理
認知的バイアス、社会的相互作用、日常的認知

資料例

科学的発見と確認バイアス
知識が豊富にあることの功罪
状況・課題理解と問題解決
推移率理解と文化差
感情システムの進化論的説明
ハトの日常適応知識の脳内分散
社会的認知：認知的不協和
社会的認知：同調とステレオタイプ
Dynamic Jigsaw

1 ~ 3rd week

4 ~ 6th week

7th week
Support tools

• Making thinking visible
  – Externalize fragmental ideas
  – Spatially arrange the fragments into a concept map

• Making modifications of externalizations easy
  – Reflective Collaboration Note
Reflective Collaboration Note
Structuring explanation
Reflective Collaboration Note
Structuring explanation
Reflective Collaboration Note
Data for evaluation (2002-2004)

- システムログ
- 教案
- ワークノートのPDFデータ
- CMS
- 授業ビデオ記録のデータ
- 教案+実績報告
- プロトコル

授業
273回（400時間）

グループ活動記録のデータ
64回（900グループ）

授業検討会
52回

ワークノートのPDFデータ
43204枚

ソース、Chukyo
Are the outcomes “portable”?  
How much do they “remember”?

Six months to one year later

Exp : What do you remember? What kind of a story?  
Stdnt : Ah, how pigeons remember things, if you break some particular part of its brain, it still can distinguish what is edible and what is not, you know they can tell the difference with the partly damaged brain, but not which three dots make a triangle and so forth, artificial things. Even pigeons brain is network-structured for survival.

<table>
<thead>
<tr>
<th>Class type</th>
<th># of targets</th>
<th>% recall Facts + Implication</th>
<th>Keywords only</th>
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<tr>
<td>lecture</td>
<td>11</td>
<td>2.2%</td>
<td>56.1%</td>
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<tr>
<td>Coll. Ref.</td>
<td>22</td>
<td>15.8%</td>
<td>7.7%</td>
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</tbody>
</table>
Quantitative evaluation

- Individual knowledge building activities increase (over lectures)
- More integration efforts expressed in final reports (30% to over 90%)
- Some students spontaneously pair together to work for class, who are found more engaged in knowledge integration activities than solos.
Pair reflection

- Number of text read with care on relation between theme and evidence
  - Pair: 9.8 / Solo: 6.3

- Number of questions written on BBS
  - Pair: 1.9 / Solo: 0.5

- Pairs were found to be engaged in frequent QA during these activities.
Quality of questions:
One of qualitative evaluations

• Are students’ understandings “portable” in the sense of their abstractness, and/or generality?
Length of explanations by one student

![Bar chart showing the length of explanations by one student over time.]
Number of texts explained in 90 min.

<図1 M,T両者の資料比率推移(左がM,右がT)>
Number of texts explained in 90 min.

<図1 M,T両者の資料比率推移(左がM, 右がT)>

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Number of texts explained in 90 min.

<図1 M, T両者の資料比率推移(左がM, 右がT)>

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06/12/03 47
Number of texts explained in 90 min.

<図1 M,T両者の資料比率推移(左がM, 右がT)>
### Component structure of the explanations

<table>
<thead>
<tr>
<th>Theme</th>
<th>The theme of the findings</th>
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</thead>
<tbody>
<tr>
<td>Evidence</td>
<td>Experiments, observations, systems, line of logic…</td>
</tr>
<tr>
<td>Implications</td>
<td>Author’s interpretations and implications</td>
</tr>
<tr>
<td>Connections</td>
<td>Student’s interpretations and abstractions</td>
</tr>
</tbody>
</table>
SORST, Chukyo

11/09 Prctc
12/07 4X4
12/15 8X8
2/Nov. (1st explanation to others)

Uhh, this sentence, I think, came first in the chapter...
The latter half said...
about the procedural knowledge,...
about how the procedural knowledge is represented or what kinds of the procedural knowledge there are...
and about many examples
Uhh, concerning to #116 literature,
its main theme is on…
the declarative knowledge and the procedural knowledge
Let me explain it briefly before going into details.
This is like “practice is better than learning.”
Ahh, how can I say?
It is often said
what cannot be learned through words
can be learned by body.
Ahh, the procedural knowledge corresponds to the latter.
116 is, let me see,
It tells you there are declarative and procedural knowledge
—and then—
Ah, it says there are occasions when the declarative skills get
Converted into procedural skills.
116 explains there are cases that that conversion occurs
Then, ah, let me start,
That the conversion is the theme of this text,
but—
Well, first of all, I think you need to understand, what each of these types
of knowledge is, so in order to do that,
let me see,
Declarative knowledge is often, ah,
Communicated verbally.
It is language-dependent knowledge.
Very schematic description of Y.O.’s understanding process

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4</td>
<td>Integration with confidence, expansion</td>
</tr>
<tr>
<td>Level 3</td>
<td>Integration neutral</td>
</tr>
<tr>
<td>Level 2</td>
<td>Integration with doubts, misunderstandings</td>
</tr>
<tr>
<td>Level 1</td>
<td>Trials of integration</td>
</tr>
</tbody>
</table>
Pattern of growth (Y.O.)
Pattern of growth (Y.O.)

Reaches satisfactory explanation
Pattern of growth (Y.O.)

- Reaches satisfactory explanation
- Objected by paired friend
Pattern of growth (Y.O.)

Reaches satisfactory explanation

Try a different approach

Objected by paired friend
Pattern of growth (Y.O.)

Reaches satisfactory explanation

Gives the previous Explanation w/ confidence

Try a different approach

Objected by paired friend

Study, Practice, 1 by 1, 2 by 2, 4 by 4, 8 by 8, Reflection
Are leaned outcomes dependable?
Learning of learning skills

• Awareness of better comprehension by “explaining in my own words.”
  – Dynamic jigsaw
• “It is my own understanding, could be different from others (but that’s okay)” feeling
• Now I know how to ask questions.
• Some visible changes in work pattern in junior years and after
How about sustainability?

• Life-long, life-wide learning (LIFE)
• …Learning for the Future?
  (Schwartz & Martin, 2005)

• One of the current hot topics, but we are not there yet.
Toward longer term effects...

- Support for adaptively utilize outcome from one class to other classes.
- Support of integrating learning outcomes from a set of related courses.
- Enhancement of self-regulatory learning skills to make above activities possible.
ReCoNote Viewer: overview
ReCoNote Viewer: mutual linking
Growth of individual's
Leanring Sciences

• Create theories of learning, test the theories in practice, and then feed the data with observation into further theorization

"Learning science is to make possible the kind of learning for everybody at the level no human has ever experienced”

(Bereiter, 2002)

• Toward designing collaborative supports for integrated knowledge, portable, dependable and sustainable for the future.
Thank you.

Colleagues and students
Yoshio Miyake
Hajime Shirouzu
Shinichi Tanaka
Katsuhisa Yuasa
Yuya Yamanaka
Tomoe Ozeki
Eijiro Tsuchiya
Sayaka Tohyama
Shinnosuke Takahashi
Aki Igarashi
Kayo Uetani

Funded by
JST/JSPS
Schema-formation by relating lecture to personal experiences

• **Personal Experience Condition**
  - “Relate Dr. X’s talk to your own experiences”
  - “For example, (E relates to his

• **Key Word Condition**
  - “Recall Dr. X’s lecture using (your own) keywords.”
  - (By showing pre-set keywords) what do you recall with these?
Total recall

- One week
- One month

# of recalls

- PE
- KW

One week Later
One month Later
再生内容 - 質的比較

Factual & Conclusive statements vs. Conclusive statements with supportive evidence

# of recalls

- PE
- KW

<table>
<thead>
<tr>
<th></th>
<th>Facts Only</th>
<th>Conclusions Only</th>
<th>Conclusions w/Evidence</th>
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<tbody>
<tr>
<td># of recalls</td>
<td></td>
<td></td>
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<tr>
<td>50</td>
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Collaborative reflection

- Read text
- Explain to others
  - Supported by ICT
- Relate others’ explanations to one’s own
- Explain the integrated explanation to others

...... REPEAT