Empirical Evidence for the Existence and Uses of Metacognition in Computer Science Problem Solving

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Outline

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Schemata

Schemata (noun, plural of schema): A collection of mental structures.

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- Used to organize current knowledge and provide a framework for future understanding.

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- Used to organize current knowledge and provide a framework for future understanding.
- Influence attention.
- One can quickly classify new perceptions into schemata and act without effort.

Metacognition

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Unified Definition:

- Executive processes that are used to:
  - direct and monitor cognition,
  - monitor and evaluate what is being done, and
  - interact with performance and learning components

  while learning a new task.

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- A domain-specific vocabular needs to be developed to determine specific cognitive processes influencing probelm solving in CS.

Moores et al. 2006

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- This relationship is based on problem complexity.
- Future studies need to clarify this relationship.

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Participants

Students enrolled in either:

- Computer Science II
- Data Structures and Algorithms

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- $n = 11$

The Room

Participants were given access to:

- A computer with:
  - internet access,
  - old programs, and
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- Textbooks on Java, C, C++
- A paper copy of the problem

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Confounding Variables

Accounted for:

- Years of professional experience vs.
- Years university experience

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Unexplored:

- Caffeine
- Sleep deprivation
- Empty stomach
- Stress

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The study took place in a room with two subjects:

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An interview was conducted after the student solved the problem.

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Metacognitive and Schematic Processes

Metacongitive Processes

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- Start, Revisit Goals

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- Start, Revisit Goals
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- Verbalize Low Prior Knowledge

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- Write Code

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- Write Code
- Compile

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- Write Code
- Compile
- Execute

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- Design
- Write Code
- Compile
- Execute
- Diagnose

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- Fix Code

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Summary of Results

56% of time spent in Schemata.

- 27% in *Write Code*

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44% of time spent in Metacongition.

- 17% in *Inspect*
- 13% in *Start, Revisit Goals*

Summary of Interactions

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Inspect/*Compare* $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Start, Revisit Goals $\overset{12\%}{\rightarrow}$ *Inspect*/*Compare*

Summary of Interactions

$$\textit{Inspect}/\textit{Compare} \xrightarrow{12\%} \textit{Start, Revisit Goals}$$

$$\textit{Start, Revisit Goals} \xrightarrow{12\%} \textit{Inspect}/\textit{Compare}$$

$$\textit{Start, Revisit Goals} \xrightarrow{0\%} \textit{Compile}/\textit{Execute}$$

$$\textit{Compile}/\textit{Execute} \xrightarrow{12\%} \textit{Start, Revisit Goals}$$

Summary of Interactions

Inspect/*Compare* $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Start, Revisit Goals $\overset{12\%}{\rightarrow}$ *Inspect*/*Compare*

Start, Revisit Goals $\overset{0\%}{\rightarrow}$ *Compile*/*Execute*

Compile/*Execute* $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Write Code $\overset{33\%}{\rightarrow}$ *Inspect*/*Compare*

Inspect/*Compare*/*Understand Problem, Plan* $\overset{26\%}{\rightarrow}$ *Write Code*

Summary of Interactions

Inspect/*Compare* $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Start, Revisit Goals $\overset{12\%}{\rightarrow}$ *Inspect*/*Compare*

Start, Revisit Goals $\overset{0\%}{\rightarrow}$ *Compile*/*Execute*

Compile/*Execute* $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Write Code $\overset{33\%}{\rightarrow}$ *Inspect*/*Compare*

Inspect/*Compare*/*Understand Problem, Plan* $\overset{26\%}{\rightarrow}$ *Write Code*

Start, Revisit Goals $\overset{47\%}{\rightarrow}$ *Write Code*

Summary of Interactions

Inspect/*Compare* $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Start, Revisit Goals $\overset{12\%}{\rightarrow}$ *Inspect*/*Compare*

Start, Revisit Goals $\overset{0\%}{\rightarrow}$ *Compile*/*Execute*

Compile/*Execute* $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Write Code $\overset{33\%}{\rightarrow}$ *Inspect*/*Compare*

Inspect/*Compare*/*Understand Problem, Plan* $\overset{26\%}{\rightarrow}$ *Write Code*

Start, Revisit Goals $\overset{47\%}{\rightarrow}$ *Write Code*

Diagnose $\overset{30\%}{\rightarrow}$ *Start, Revisit Goals*

Understand Problem, Plan $\overset{30\%}{\rightarrow}$ *Start, Revisit Goals*

Summary of Interactions

Inspect/Compare $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Start, Revisit Goals $\overset{12\%}{\rightarrow}$ *Inspect/Compare*

Start, Revisit Goals $\overset{0\%}{\rightarrow}$ *Compile/Execute*

Compile/Execute $\overset{12\%}{\rightarrow}$ *Start, Revisit Goals*

Write Code $\overset{33\%}{\rightarrow}$ *Inspect/Compare*

Inspect/Compare/Understand Problem, Plan $\overset{26\%}{\rightarrow}$ *Write Code*

Start, Revisit Goals $\overset{47\%}{\rightarrow}$ *Write Code*

Diagnose $\overset{30\%}{\rightarrow}$ *Start, Revisit Goals*

Understand Problem, Plan $\overset{30\%}{\rightarrow}$ *Start, Revisit Goals*

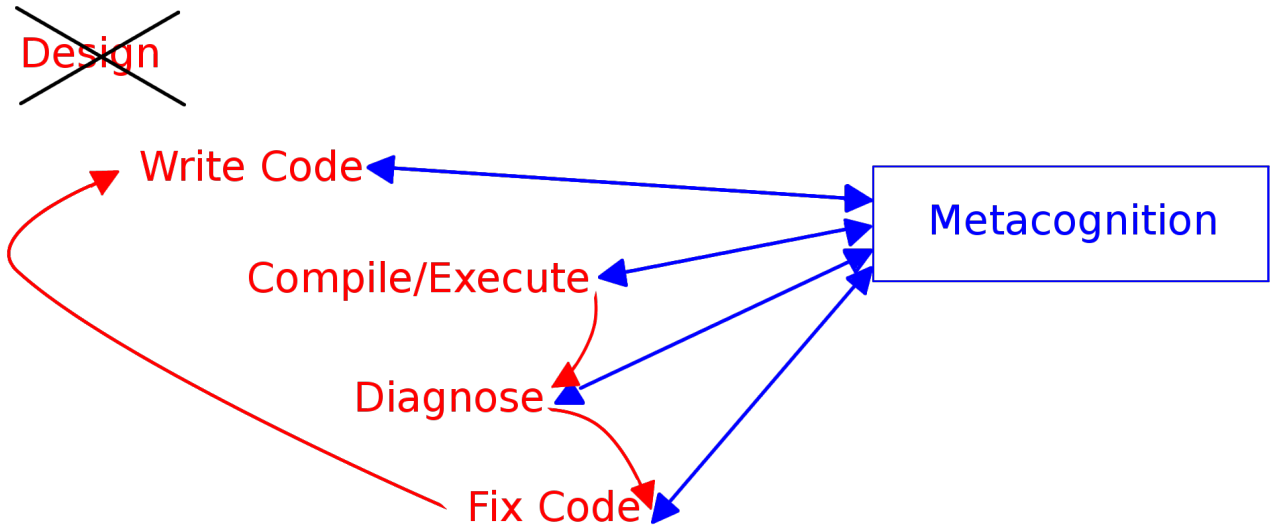
Fix Code $\overset{33\%}{\rightarrow}$ *Inspect/Compare*

Fix Code $\overset{30\%}{\rightarrow}$ *Compile/Execute*

Inspect/Compare $\overset{29\%}{\rightarrow}$ *Diagnose*

Overview of Interactions

All interactions occuring with frequency greater than 3% are shown with an arrow:



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- Often (51%) code was inspected and fixed before checking for compile/execute errors.
- Often (30%) diagnosed errors were outside the current goal, requiring a switch to a previous goal before continuing.

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