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CRITICAL THINKING: THE VITAL CONNECTION AMONG DEVELOPMENTAL COURSES

Critical Thinking

Writing

Math

Reading
"The goal of instruction should be to allow students to deal sensibly with problems that often involve evidence, quantitative consideration, logical arguments, and uncertainty; without the ability to think critically and independently, citizens are easy prey to dogmatists, flimflam artists, and purveyors of simple solutions to complex problems." —American Association for the Advancement of Science, 1989
ASSUMPTION #2

“For logic, by perfecting and by sharpening the tools of thought, makes men and women more critical—and thus makes less likely their being misled by all the pseudo-reasonings to which they are incessantly exposed in various parts of the world today.” —Alfred Tarski, Introduction to Logic and to the Methodology of Deductive Sciences, 1994
OBJECTIVES: PART I

1. Why is critical thinking the vital connection among developmental courses?

2. What exactly is critical thinking?
OBJECTIVES: PART II

3. What is an argument?

4. How do we identify arguments?

5. How do we identify deductive and inductive arguments?
6. Why is the translation of verbal statements to symbolic statements (and symbolic statements back to verbal statements) a key aspect of critical thinking in developmental mathematics, reading, and writing?

Example: “If I am not hungry, then I am tired.” translates to “\sim H \rightarrow T.”
OBJECTIVES: PART IV

7. How do we analyze reasoning and evaluate that reasoning according to the intellectual standards of

(i) validity and soundness for deductive arguments, and
(ii) strength and cogency for inductive arguments?
PROPOSAL: To improve the theory and practice of developmental education at all levels by highlighting the common ground of developmental courses: critical thinking.

1) All cats have four legs.
2) I have four legs.
3) Thus, I am a cat.

Critical Thinking
Developmental students have problems recognizing premises and conclusions within passages. This may reveal the logical connections and arguments in reading.

Developmental students have problems recognizing the logical connections and arguments. This may clarify meaning in reading, writing, and mathematics.

Developmental students have problems choosing statements carefully and making proper inferences. This is imperative for justifying a thesis in expository writing or a solution in a math problem.

Developmental students have problems showing why something is the case. This is important in connecting the-dots (evaluating the reasoning and information involved) and developing critical thinking skills.
OBJECTIVES: PART I

1. Why is critical thinking the vital connection among developmental courses?

2. What exactly is critical thinking?
Why is critical thinking the vital connection among developmental courses?

- Every developmental course has its logical structure and so can be understood through logic—reasoning, thinking, argument, or proof.

- Critical Thinking enables learners to face challenges within and across subjects by learning how to formulate and evaluate arguments.
Moreover...

- Critical Thinking also provides a solid foundation for overcoming obstacles to reliable reasoning and clear thinking.

- Accordingly, the goal of teaching is to create a context in which students can think.
What exactly is critical thinking?

• **Critical thinking** is a purposeful mental activity that takes something apart, via **analysis**, and **evaluates** it on the basis of an intellectual standard (Mayfield).

• In this discussion that “something” is an **argument**.
3. What is an argument?

4. How do we identify arguments?

5. How do we identify deductive and inductive arguments?
What is an argument?

• Logic is the study of arguments.
• An argument is a sequence of statements (claims): a set of premises and a conclusion.
• A statement (claim) is a declarative sentence that is either true or false, but not both.
1) All cats have four legs.
2) I have four legs.

3) Thus, I am a cat.

- **Conclusion** is the statement that one is trying to establish by offering the argument.
- **Premises** are also statements, but are intended to **prove** or at least provide **some evidence** for the conclusion.
How do we identify arguments?

1. Premise Indicators: Words used for **giving reasons**: For, Since, Because, Assuming that, Seeing that, Granted that, This is true because, The reason is that, In view of the fact that, ...etc.

2. Conclusion Indicators: Words used for **adding up consequences**: So, Thus, Therefore, Hence, Then, Accordingly, Consequently, This being so, It follows that, ...etc. (Nolt).
Students who don’t come to class are thus depriving themselves of the learning process. This is true because coming to class is an essential part of learning the subject matter.

1) Coming to class is an essential part of learning the subject matter.

2) Thus, students who don’t come to class are depriving themselves of the learning process.
How do we identify deductive and inductive arguments?

Look for how the premises logically support the conclusion:

1. In **deductive** arguments, the premises are intended to **prove** the conclusion and so the conclusion follows with certainty.

2. In **inductive** arguments, the premises are intended to provide some (strong or weak) **evidence** for the conclusion and so the conclusion follows with some uncertainty.
DEDUCTION: Look for how the premises logically support the conclusion (example)

Deductive Argument:
1) \( x \) is greater than \( y \).
2) \( y \) is greater than \( z \).
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3) Thus, \( x \) is greater than \( z \). (Where \( x \), \( y \), and \( z \) are real numbers)

The conclusion follows with certainty because if each premise used to demonstrate the conclusion is true, then the conclusion also must be true. So, truth is preserved.

We will call arguments that satisfy this condition, VALID arguments.
**INDUCTION:** Look for how the premises logically support the conclusion (example)

**Inductive Argument:**

1) **90%** of smokers get lung cancer.
2) John is a smoker.

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3) Thus, John will **probably** get lung cancer.

The conclusion follows with some **uncertainty** because even if the premises were true, the conclusion could still be false (some people smoke all their lives and don’t get the disease). So, truth may not be preserved.
Unlike the previous Inductive Argument that only called for few premises, in the example below we have n premises (as many as you want to list).

1) Smoking gives person #1 lung cancer.
2) Smoking gives person #2 lung cancer.
3) Smoking gives person #3 lung cancer.
i) …Etc.
n) Smoking gives person #n lung cancer.

Thus, smoking probably causes lung cancer in all people.

The conclusion follows with some uncertainty because even if each premise of the sequence of statements used to demonstrate the conclusion were true, the conclusion could still be false. So, truth may not be preserved.

But, as the observed number of cases of people who smoke and get lung cancer increases, the argument gets stronger; as the observed number of cases decreases, the argument gets weaker.
6. Why is the translation of verbal statements to symbolic statements (and symbolic statements back to verbal statements) a key aspect of critical thinking in developmental mathematics, reading, and writing?

Example: “If I am not hungry, then I am tired.” translates to “~H → T.”
Why is translation a key aspect of critical thinking?

• **Translation** of a **verbal** statement to a **symbolic** statement helps one to examine the structure of the declarative sentence (analysis) to reveal logical connections.

• And, recognizing logical connections may clarify meaning in reading, writing, and mathematics.
Moreover...

• Translation of verbal statements to symbolic statements helps one to examine the structure of an argument (a sequence of statements) in detail (analysis).

• Symbolizing this structure can show how premises and a conclusion are related in valid, or invalid, argument forms (evaluation).
To symbolize a statement we need:

- A **statement indicator**, an uppercase letter, used to symbolize a simple statement (e.g., “H” used to indicate “I am hungry”).

- A **connective indicator** (e.g., “&” used to indicate “and”) used with statement indicators to symbolize a complex statement. **Connectives** are words like AND, OR, NOT, and IF-THEN.
For instance, given the following conditions:

• Let the statement indicator $H$ substitute I am hungry.
• Let the statement indicator $T$ substitute I am tired.
• Let connective indicator $\&$ substitute the connective AND.
• Let connective indicator $\lor$ substitute the connective OR.
• Let connective indicator $\neg$ substitute the connective NOT.
• Let connective indicator $\rightarrow$ substitute the connective IF-THEN.
Practice translating the following statements:

1. I am hungry. **ANSWER:** H
2. I am not hungry. **ANSWER:** ~H
3. I am both hungry and tired. **ANSWER:** H & T
4. I am hungry or I am tired. **ANSWER:** H v T
5. If I am not hungry, then I am tired. **ANSWER:** ~H → T
6. ~T → ~H

**ANSWER:** If I am not tired, then I am not hungry.
Practice translating the following arguments:

**EXERCISE #1:**
1) If I am hungry, then I am tired.
2) I am hungry.
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3) Thus, I am tired.

**ANSWER:**
1) H → T.
2) H.
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3) Thus, T.

**Modus Ponens:**
1) If p, then q.
2) p.
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3) Thus, q.

**Note:** Use lower case letters when designating the basic form of the valid deduction.
EXERCISE #2:

1) If I am hungry, then I am tired.
2) I am not tired.

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3) Thus, I am not hungry.

Note: Use lower case letters when designating the basic form of the valid deduction.

ANSWER:
1) H → T.
2) ~ T.

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3) Thus, ~ H.

Modus Tollens:
1) If p, then q.
2) Not q.

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3) Thus, not p.
7. How do we analyze reasoning and evaluate that reasoning according to the intellectual standards of (i) validity and soundness for deductive arguments, and (ii) strength and cogency for inductive arguments?
ANALYSIS: Examine the structure of the argument in detail and symbolize this structure or component parts.

Consider the following deductive argument.

1) All people grow old.
2) Mary is a person.

3) Thus, Mary grows old.
The key to translating *All people grow old* in the argument above is to interpret the universal statement as the conditional statement *If it is a person, then it grows old* (for every member of its subject class: people).

• Again, let the connective indicator $\rightarrow$ substitute the connective *IF-THEN*. Interpreting $P$ (for *it is a person*) and $O$ (for *it grows old*) as statement indicators, *If $P$, then $O$* is finally translated as $P \rightarrow O$.

• The symbolized argument is as follows.

1) $P \rightarrow O$
2) $P$

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3) Thus, $O$
EVALUATION: Is the deductive argument valid? Is it sound (= valid + true premises)?

- This argument about people growing old is a valid deductive argument because it has the following underlying valid argument form we studied.
  
  **Modus Ponens:**
  1) If p, then q.
  2) p.
  
  ________________
  3) Thus, q.

- Moreover, it is also a sound deductive argument because it has true premises.
Consider the following deductive argument.

1) All cats have four legs.
2) I have four legs.
3) Thus, I am a cat.
ANALYSIS: Examine the structure of the argument in detail.

- The key to translating *All cats have four legs* in the argument above is to interpret the universal statement as the conditional statement *If it is a cat, then it has four legs* (for every member of its subject class: *cats*).
1) If it is a cat, then it has four legs. (Assume this is a true premise)

2) It has four legs. (Assume this is a true premise)

3) Thus, it is a cat. (A false conclusion)

What is wrong with this argument?
EVALUATION: Is the deductive argument valid? Is it sound (= valid + true premises)?

• The little dog is guilty of using his reasoning and the information involved to derive something false from something true.

• Since this argument has true premises and a false conclusion, it is an invalid deductive argument.

• Symbolized, the argument reveals its invalid form....
ANALYSIS: Symbolize the structure or component parts.

• Again, let the connective indicator $\rightarrow$ substitute the connective **IF-THEN**. Interpreting $C$ (for *it is a cat*) and $F$ (for *it has four legs*) as statement indicators, *If C, then F* is finally translated as $C \rightarrow F$.

• The symbolized argument is as follows.

  1) $C \rightarrow F$
  2) $F$
  3) Thus, $C$
Generally speaking, arguments that share the same INVALID deductive form below commit the fallacy of **AFFIRMING THE CONSEQUENT**.

<table>
<thead>
<tr>
<th>Affirming the Consequent:</th>
<th>1) C $\rightarrow$ F</th>
<th>1) S $\rightarrow$ G</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) p $\rightarrow$ q</td>
<td>2) F</td>
<td>2) G</td>
</tr>
<tr>
<td>2) q</td>
<td>3) Thus, C</td>
<td>3) Thus, S</td>
</tr>
<tr>
<td>--------------------------</td>
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<td>---------------------</td>
</tr>
</tbody>
</table>

Interpret **S** (for I study) and **G** (for I get good grades) as statement indicators above.
1) Legalized marijuana eliminates criminal profiteering.
2) Criminal profiteering is bad.
3) Legalized marijuana eliminates many health dangers by controlling quality.
4) Eliminating health dangers is good.
5) Legalized marijuana permits its medical use.
6) The medical use of marijuana is good.
7) Thus, marijuana should be legalized.
**EVALUATION:** Is the inductive argument strong? Is it cogent (= strong + true premises)?

The conclusion that marijuana should be legalized follows with some uncertainty because even if each premise of the sequence of statements used to demonstrate the conclusion were true, the conclusion could still be false.

But, as the number of relevant reasons/premises about the legality of marijuana increases, the argument gets **stronger**, as the number decreases, the argument above for the conclusion that marijuana should be legalized gets **weaker**. **Cogency** here would require a strong argument with true premises.
Consider the following math problem found in a basic Algebra course: “Given that two more than a number is ten, find the number (i.e., find $X$).”

- **Analysis**, here, requires that we translate an open statement to its corresponding open algebraic expression.
- **Two more than a number is ten** translates to $X + 2 = 10$.
- Accordingly, given that $X + 2 = 10$, we must show or prove what $X$ is (Let $X$ be a real number).
Further analysis requires that we put the argument in natural order (put the premises first and draw the conclusion at the end):

1) \( X + 2 = 10 \) .................Given.
2) \( (X + 2) - 2 = (10) - 2 \) ....Go to Premise #1, Subtract 2.
3) Therefore, \( X = 8 \) ........Go to Premise #2, Simplify.

We can use open statements as if they were statements, given additional information. For instance, the open statement \( X + 2 = 10 \) may simply be given as true.
EVALUATION: Is the deductive argument valid? Is it sound (= valid + true premises)?

Evaluating this algebraic argument requires that we ask: Is this deductive argument valid? Is it the case that if each premise of the sequence of statements used to demonstrate the conclusion is true, then its conclusion cannot be false? Is it the case that the conclusion also must be true, so, truth is preserved?
On the basis of this sequence of statements, then, the conclusion $X = 8$ cannot be false. The conclusion that $X = 8$ must also be true. So, the deductive argument is valid.
So if the critical thinker asks “Why is the solution the number eight?”, then one may respond—on the basis of logical reasoning—because …

- Given that $X + 2 = 10$, we still maintain the equality by subtracting the same amount from both sides of the equation so that $(X + 2) - 2 = (10) - 2$.
- And by simplifying, we conclude that $X = 8$.

But is the deductive argument sound?
A \textit{how} question asks—\textit{how} do you do the problem? But, the aim of critical thinking is \textbf{not} to have the learner ask the teacher to merely show the class \textit{how to solve the problem}—to just show the class \textit{how to plug-in the values} to solve for instances (i.e., examples) of the problem. Showing \textit{why} something is the case allows the student to connect-the-dots (\textit{evaluate the reasoning and information involved}) and develop critical thinking skills. And in this sense, there certainly is more to teaching than simply giving-out instructions or recipes that show \textit{how} to do a problem.
CONCLUSION:

✓ Recognizing premises and conclusions within passages may reveal the logical connections and arguments in reading.

✓ Recognizing the logical connections and arguments may clarify meaning in reading, writing, and math.

✓ Choosing statements carefully and making proper inferences is imperative for justifying a thesis in expository writing or a solution in a math problem.

✓ Showing why something is the case allows the student to connect-the-dots (evaluate the reasoning and information involved) and develop critical thinking skills.
WHAT NEXT?


- Mayfield, M. (2001). Thinking for yourself: Developing critical thinking skills through reading and writing (pp. 4-6). USA: Thomson Learning, Inc.
