International Conference on Physics
In Memoriam Acad. Prof. Matey Mateev

Mathematics and science teachers' concept of critical thinking

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INTRODUCTION

- Education and schools - then, now and in the future

Low-Order Cognitive Skills (LOCS)

Higher-Order Cognitive Skills (HOCS)

The future of education

INTRODUCTION

- Concern about math and science education

- “Inadequacies in precollege math and science education are a chronic and serious threat to our nation’s future”.

Carnegie Commission on Science, Technology and Government

CRITICAL THINKING

- There is no more central issue to education than thinking and reasoning.
- The quest for critical thinking has been at the centre of educational reform for the past 30 years.
- Little progress has been made to achieve this goal.

CRITICAL THINKING

- A question about CT is both very old and very new
- Ancient times
- John Dewey
- Now (Robert Ennis, Richard Paul, John McPeck, …)

CRITICAL THINKING

Definition

CT very simply stated, is the ability to analyze and evaluate information.

CT is purposeful and reflective judgment about what to believe or what to do in response to observations, experience, verbal or written expressions, or arguments.

CRITICAL THINKING

- CT is using thinking processes to actively and skillfully conceptualize, apply, analyze, synthesize or evaluate information gathered from or generated by observation, experience, reflection, reasoning or communication, to reach factual or judgmental conclusions based on sound inferences drawn from unambiguous statements of knowledge or belief.

CRITICAL THINKING

Methodology

Participants

Instrument

Part A (the first six items) consists of six more general questions about subject areas, teachers experience, use of computer, internet and e-mail.

Part B consists of nineteen items which seek from the teachers the opinion about subject they teach, and their opinion about themselves, their thoughts and beliefs.

Part C contains ten Likert-style items in the form of statement.

The last **part D** contains seven open-ended questions which seek opinion from teachers concerning critical thinking, teaching methods and techniques, critical thinking related to practice and teachers' formal and nonformal education.

University „Sts. Cyril and Methodius“
Faculty of Natural Sciences and Mathematics, Skopje, Macedonia

Teacher questionnaire

Dear colleagues,
This questionnaire is anonymous. The information collected here is aimed for research and statistical purposes only. It is prepared for math and science teachers (physics, chemistry and biology).
We will be grateful for sincere answers.

Please fill in the line for questions 1 and 2 and circle one of the answers for questions 3 to 6.

1. By the end of this school year, how many years will you have been teaching altogether?

years _____

2. What subject do you teach? _____

3. What is the highest level of formal education you have completed?
a) Post secondary **b) Bachelor's degree** **c) Master's degree** **d) PhD**

4. Do you have a computer at home? Yes No

5. Do you have an access to Internet at home? Yes No

6. Do you have a valid e-mail? Yes No

Please follow this guide to answer questions 7 and 8

If someone has to describe "an air transport", he or she could do it like this:

quick	✓				slow
safe		✓			dangerous
cheap				✓	expensive

The positions of the ticks between the word pairs shows that you considered it is very quick, slightly more safe than dangerous and quite expensive.

Use this method of ticking to answer questions 7 and 8

7. What is your opinion about the subject that you teach...

I enrolled in university ... it was my choice					I enrolled in university ... for other reasons
I think this is one of students' favorite subjects					I think this is not students' favorite subject
try the teaching process of the…students develop thinking					try the teaching process of the… do not develop thinking
this is an easy subject for most of the students					this is a difficult subject for most of the students
students often ask questions					students sometimes ask questions
the content of the subject is connected to everyday life					the content of the subject is not connected to everyday life
students prefer to work in pairs (groups)					students prefer to work independently
there are a lot of errors in the textbooks					there are not any errors in the textbooks

7. What is your opinion about the subject that you teach...

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8. When it comes to my understandings, thoughts and beliefs I can say that…

I like challenges					I do not like challenges
I like to solve problems, puzzles…					I do not like to solve problems, puzzles…
I make decisions quickly					I think over when I make decisions
I believe in astrology and horoscope					I do not believe in astrology and horoscope
I trust the advertisement (commercial)					I do not trust the advertisement (commercial)
there is life on other planets					there is no life on other planets
I come to conclusions quickly and easily					I come to conclusions cautiously and carefully
UFO are our reality					UFO do not exist
I like and enjoy this job					in general, this job do not satisfy me
I can be easily influenced by authorities					I can not be easily influenced by authorities
I am a conformist					I am not a conformist

9. Tick only one box on each line to show your opinion about the statement.

	Strongly agree	Slightly agree	Slightly disagree	Strongly disagree
1. To think critically means to take negative attitude and to oppose to one's opinion.	☐	☐	☐	☐
2. A literate person means a person who can read, write and perform basic arithmetic operations.	☐	☐	☐	☐
3. The textbooks that I use for teaching my subject are great and I like them.	☐	☐	☐	☐
4. When I ask questions to my students I always take in consideration wait time that students need to think before they answer.	☐	☐	☐	☐
5. I value knowledge rather than students' thinking.	☐	☐	☐	☐
6. Educational system, educational policy and teaching process (generally for all subjects) contribute in the development of student's way of thinking.	☐	☐	☐	☐
7. Most of the teachers encourage students to think.	☐	☐	☐	☐
8. The way how teachers organize and manage the lesson and his/her enthusiasm are more important than the textbook they use.	☐	☐	☐	☐
9. It is obviously that most of the student's study (or study a lot) but think less.	☐	☐	☐	☐
10. I often teach students how to learn and how to think.	☐	☐	☐	☐

10. Which teaching methods and techniques do you use in your teaching process?

11. Can you explain what the term critical thinking means to you?
In a few sentences, please describe the term.

12. Have you ever used any teaching methods that encourage students to think critically?

13. During your formal education, have you ever been taught about critical thinking in any course/subject?
If the answer is Yes, please indicate the course/subject.

14. During your nonformal education, have you ever participate in activities
related to critical thinking? Please indicate some activities.

15. If your answer for the No.12 is Yes, please write some examples from your teaching practice
and experience for which you believe that encourage or develop critical thinking among students.

16. What is your opinion about end of year assessments (tests, exams, project tasks…)
in the sense of extent to which they induce and develop critical thinking?

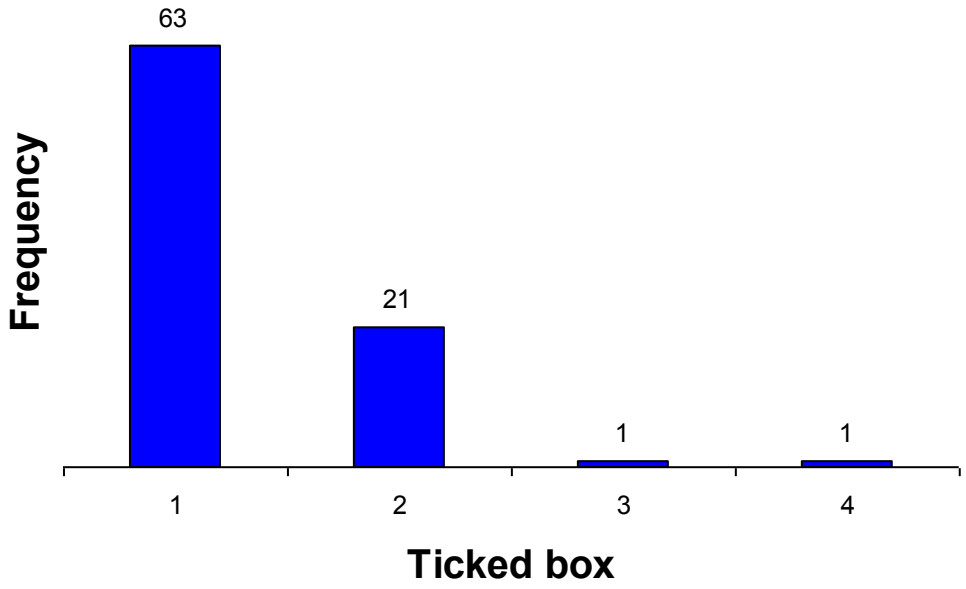
Thank you for your cooperation

RESULTS

Table 1. Characteristics of selected teachers in Macedonian secondary schools

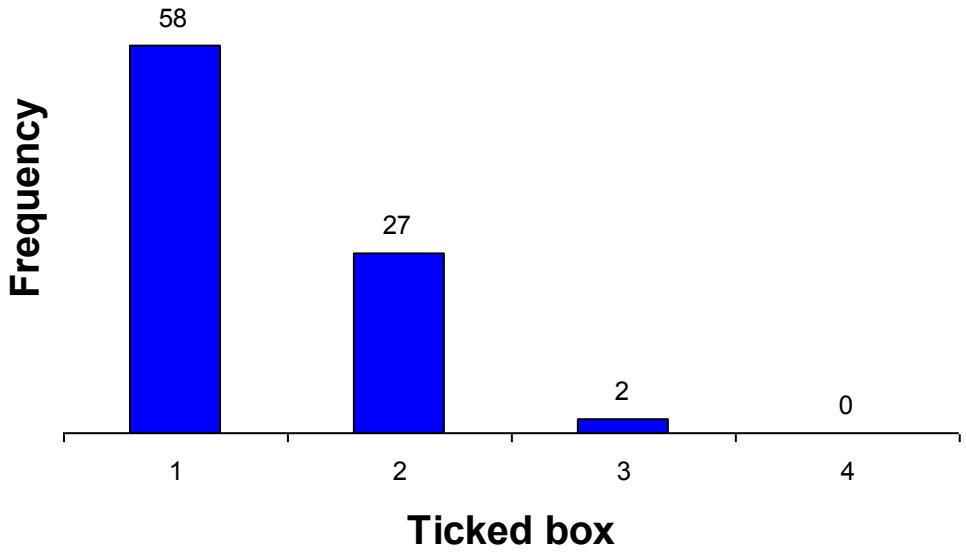
	Number of teachers (N=89)	Teacher experience (years)	Computer Yes/No	Internet access Yes/No	Email Yes/No
Math	27	15			(-2)
Physics	26	20			
Chemistry	18	16		(-1)	(-1)
Biology	18	17	(-1)	(-1)	(-1)

Item 8.1

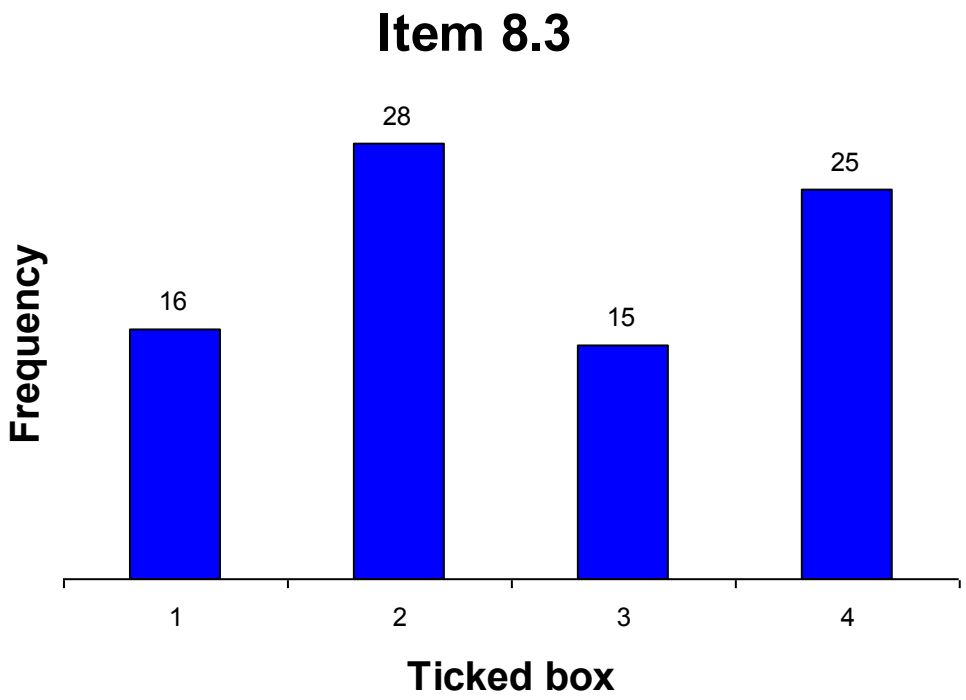


I like challenges ☐ ☐ ☐ ☐ I do not like challenges

Item 8.2



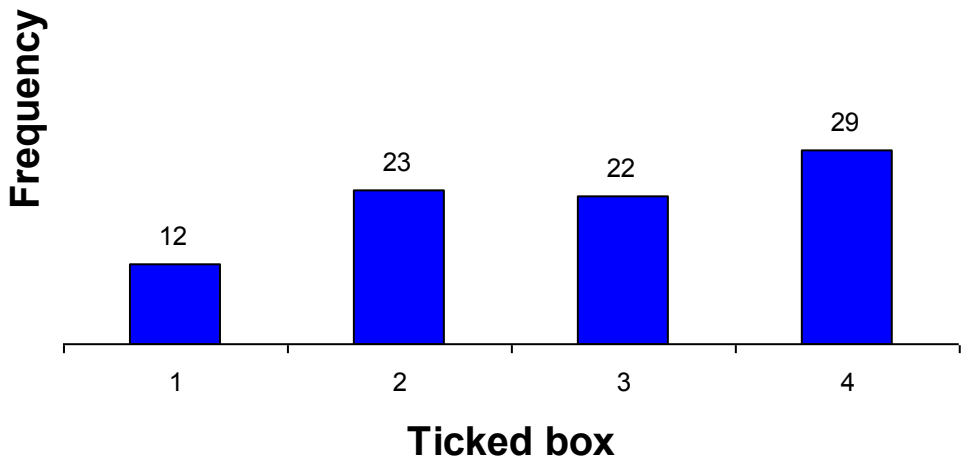
I like to solve problems, puzzles… ☐ ☐ ☐ ☐ I do not like to solve problems, puzzles…



I make decisions quickly

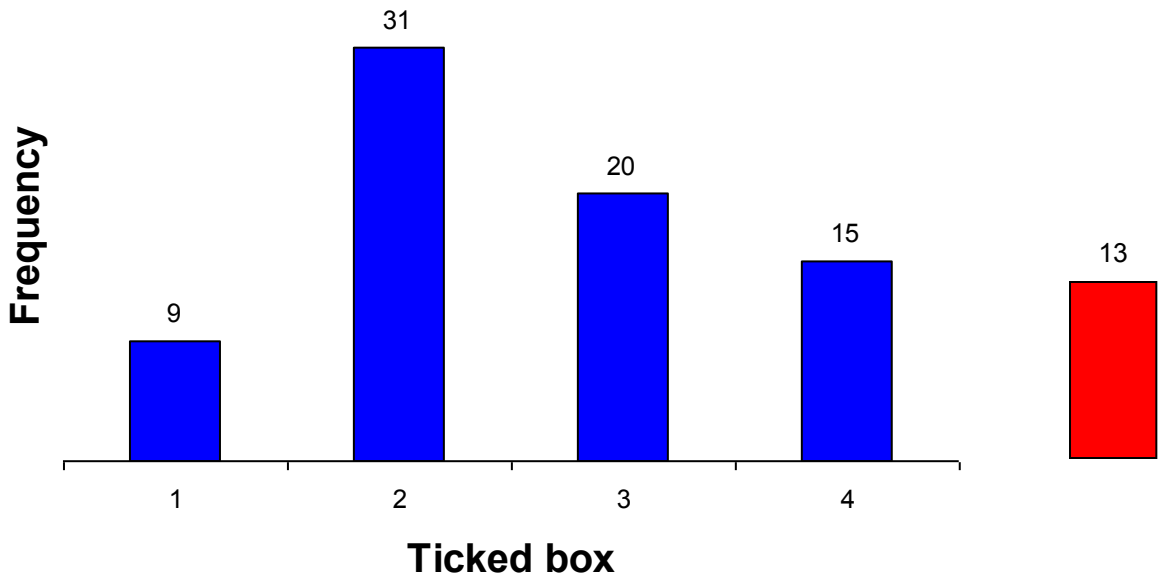
I think over when I make decisions

Item 8.7



I come to conclusions quickly and easily ☐ ☐ ☐ ☐ I come to conclusions cautiously and carefully

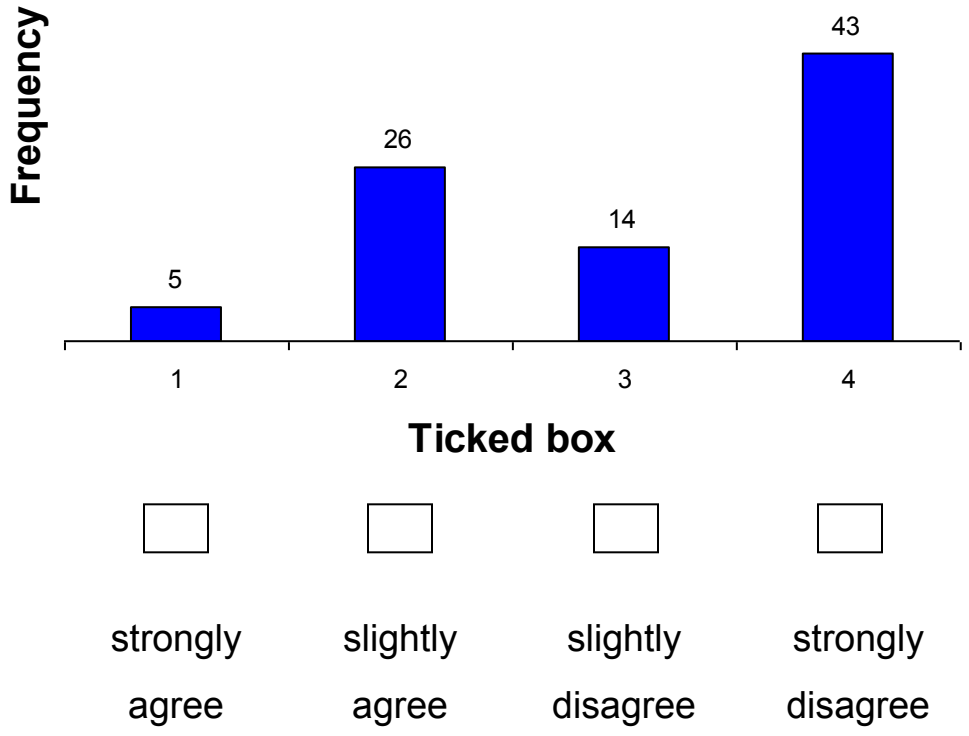
Item 8.11



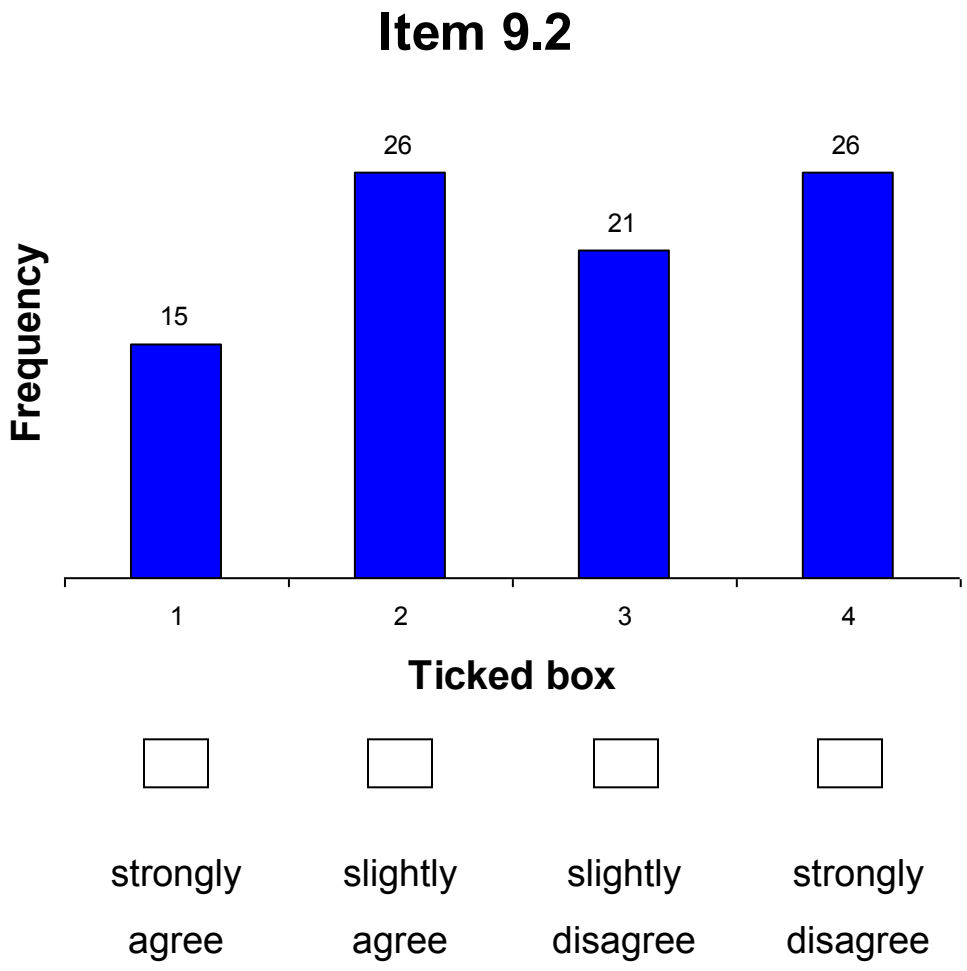
I am a conformist ☐ ☐ ☐ ☐ I am not a conformist

To think critically means to take negative attitude and to oppose to one's opinion.

Item 9.1



A literate person means a person who can read, write and perform basic arithmetic operations .



PISA 2006

Programme for **I**nternational **S**tudent **A**ssessment

- Reading literacy: An individual's capacity to understand, use and reflect on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society.

- Mathematical literacy: An individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.

- Scientific literacy: the ability to use scientific knowledge and processes not only to understand the natural world but to participate in decisions that affect it.

Assessing Scientific, Reading and Mathematical Literacy

A Framework for PISA 2006

Table 2. Number of teachers who did not answer any of the last seven questions

	Item number						
	10	11	12	13	14	15	16
Math	3	8	5	7	5	18	8
Physics	6	10	6	10	10	13	10
Chemistry	3	7	7	7	7	9	5
Biology	3	4	4	5	7	6	5
Total	15	29	22	29	29	46	28

Item 10

Which teaching and learning methods and techniques do you use in your course?	frequency
Lecturing	34
Dialogue	22
Demonstration and hand-on activities	20
Group discussion	18
Individual work	15
Work in a group	12
Use of illustrations	10
Inquiry based learning	7
Experiment	5
Brainstorming	4
Project work	4
Use of internet	4
Self-assessment	3
Analysis and synthesis	3
Debate	3
Problem solving	3
Direct teaching	1
Outdoor lessons	1

Item 10

Teaching methods and techniques that are not mentioned in teachers' answers

Critical reading
Content analysis
Discovery learning
Poster session
Concept mapping
Web quest
Creating problem to solve problem
Reformulating the problem
Role playing
The film as a teaching technique
Science excursion
Quiz
Story telling
Case study
Think-aloud techniques
Verbal reports
Highlighting/note taken

Item 11

Table 3. Critical thinking definers

CT definers mentioned in teachers' answers	frequency
To take negative attitude and to oppose to one's opinion	3
To be able to see his or her own position from others perspectives	2
How to apply knowledge in new situation	2
To use knowledge in real-life situations	2
The way how to overcame some situation or state	2
The things are not the same as they appear	2
To draw conclusion	1
Objective and fair-minded	1
Not to memorize, to analyze in order to make decision	1
My opinion to some aspect	1
Do not agree to one's attitudes	1
To give your opinion	1
Thinking based on arguments and self analysis	1
To give opinion how to work and solve problems	1
To be critique in finding your mistake, errors, omissions, problems and how to solve it	1
Self-control, to think more creatively	1
To think about problem, where is the problem…	1
How to find information, knowledge (critically)	1
Coming to knowledge through Wh questions	1

Item 11

Table 4. Critical thinking definers used by expert

CT definers do not mentioned in teachers' answers	Group
problem solving, drawing conclusions, inductive reasoning hypothesize, convergent thinking, higher order thinking,	Scientific reasoning
deductive reasoning metacognitive skills, Socratic questioning, constructive skepticism, open-minded, rational thinking, evaluating assumptions	Cognitive strategy
adequacy, fairness objective, logical, accuracy, consistency, precision, responsible	Conscientious judgments
decision-making, synthesis relevance, clarity, significance, completeness	Relevance
active participation, self-directed, cooperative learning intellectual challenges, independent thinking, student-centered discovery learning	Intellectual engagement

- Do The Ministry of Education guidelines require math and science teachers to teach CT?

- Physics syllabus, grade 12
  Physics, elective subject
  (math and science group, combination A and B)

- The specific goals of the course are:

-

-

- To develop the skills, including critical thinking skill, and ability for logical end creative thinking.

CONCLUSION

- It is not easy to define CT.
- There is no single definition of CT.
- CT is sensitive to context.

CONCLUSION

- A predisposition toward CT seems to be a characteristic of math and science teachers.
- Math and science teachers is not familiar with the term CT, so they do not have a clear concept of what it means.
- To understand the nature of CT math and science teachers must be asked fundamental questions about the nature of knowledge, the importance of thinking and process of teaching and learning.
- We need to rise awareness of critical thinking among the public, teachers and students.
- Promotion, development and teaching for CT is responsibility to policy-makers, universities, teachers and administrators.

Thank you