STEM Education in the Age of Globalization

How to teach science in English

理数系教科研究会
東京私立中学高等学校協会

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Ei-Com
Professional English Training

STEM

- **STEM** = Science, Technology, Engineering, and Mathematics

- **STEM** is important term for:
  - Educational policy
  - Immigration policy

Characteristics of the **English language** and its use in STEM fields

American English

- United States
- US territories
- Canada

- Philippines

British English

- United Kingdom
- Australia
- New Zealand

- Hong Kong
- Singapore

American English

British English

Spelling

analyze, color	analyse, colour

Pronunciation

aluminum, oxygen	aluminium, oxygen

Terminology

scientific notation	standard form

Japanese-English Translations

正確

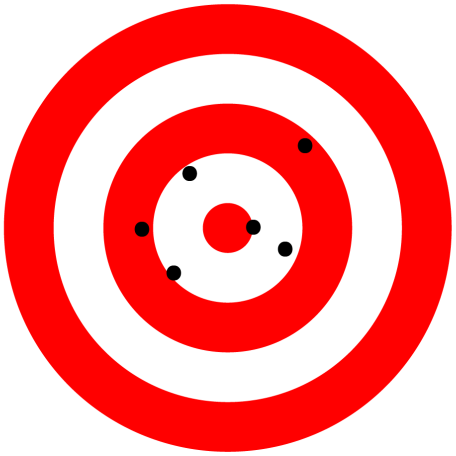
What is the equivalent word in English?

accurate

precise

– WARNING –
These words have *different* meanings when used in discussions about scientific measurements!

High Precision,
High Accuracy



Low Precision,
High Accuracy

High Precision,
Low Accuracy

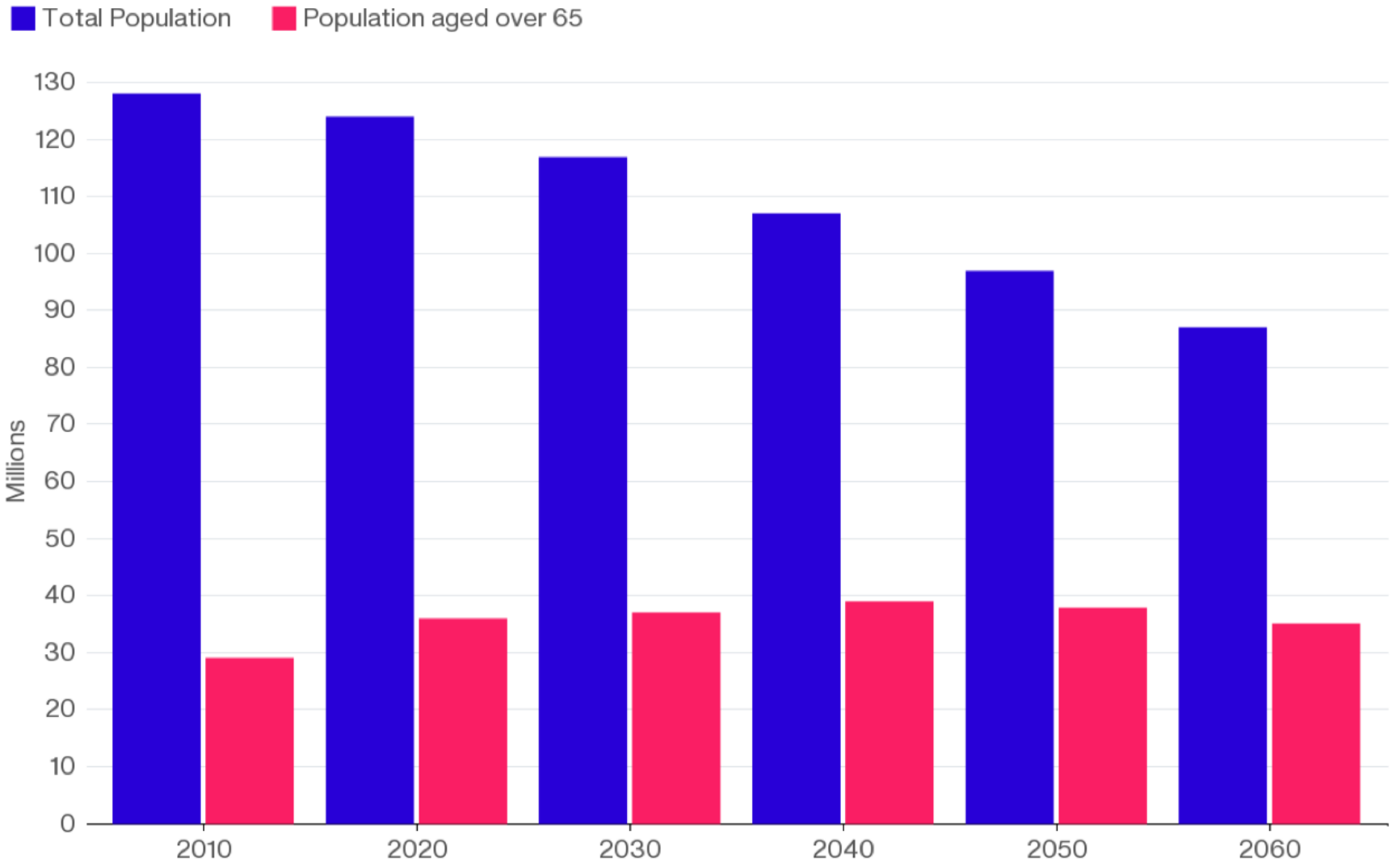
Low Precision,
Low Accuracy

Changes in society

and impacts on education

Japan Faces Demographic Crisis

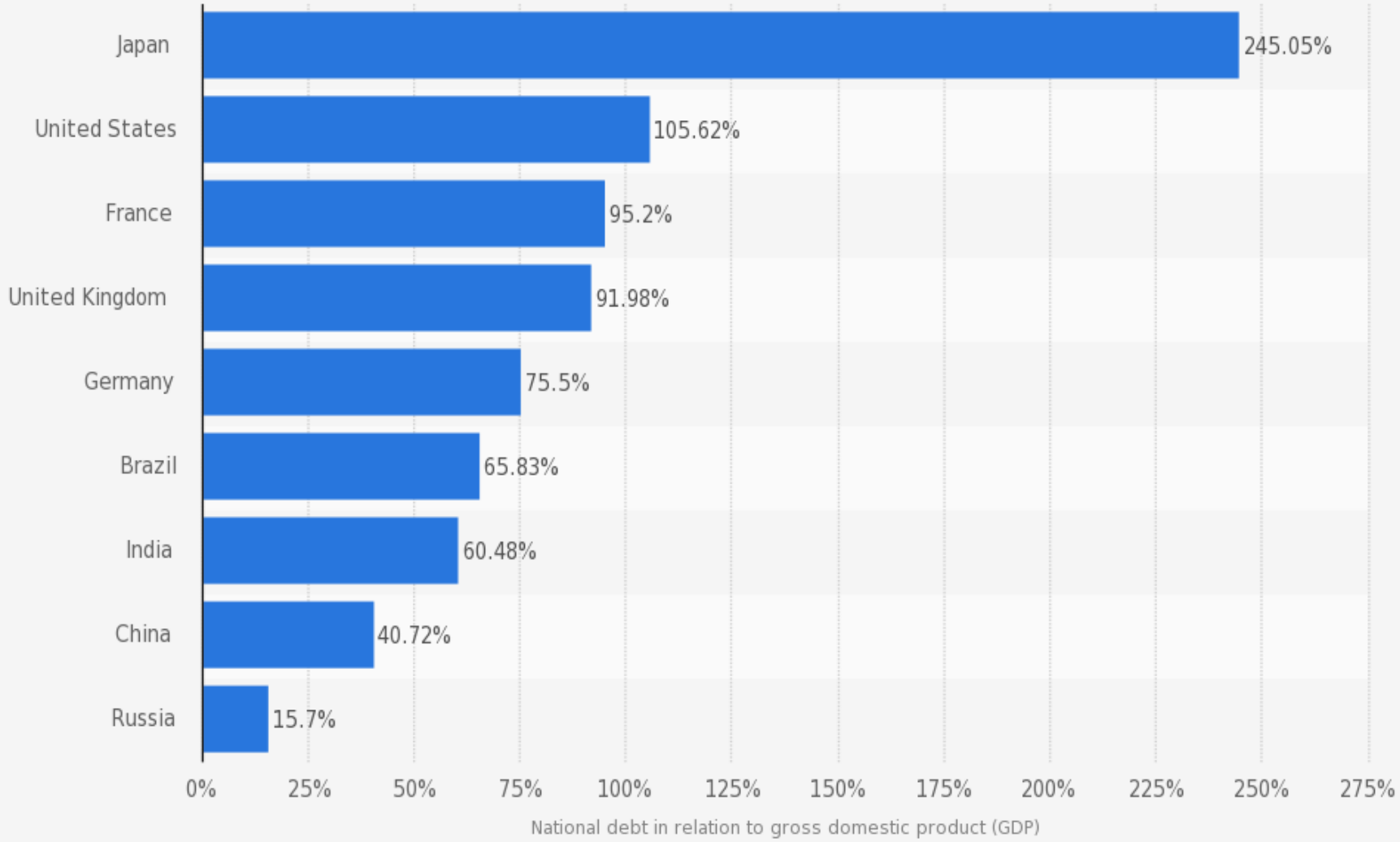
Elderly will make up 40 percent of population



National Institution of Population and Social Security Research

Bloomberg

National debt of important industrial and emerging countries in 2014 in relation to gross domestic product (GDP)



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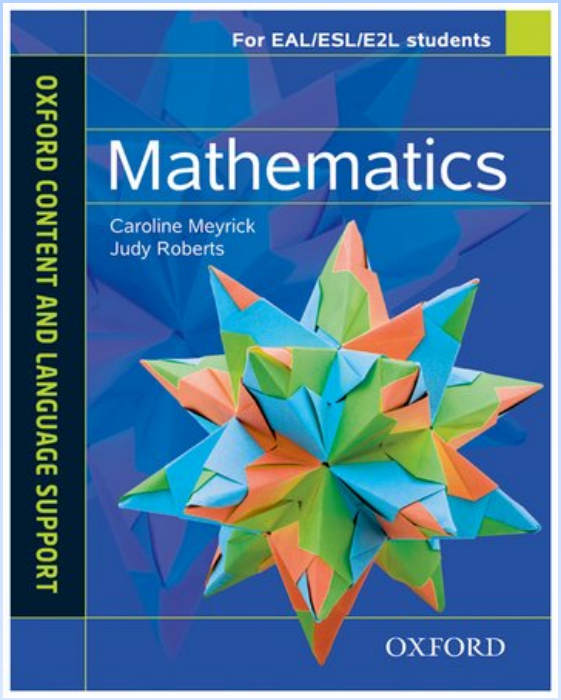
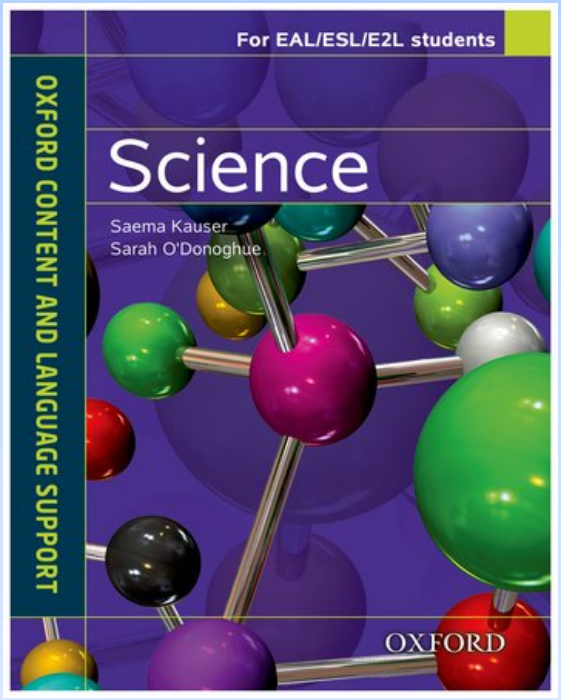
Additional Information:

Worldwide; IMF

Teaching resources

Available textbooks





The Oxford Content and Language Support series

These textbooks are well organized and use simple language, but the scientific content is sometimes overly simplified or incorrect.

Oxford Content and Language Support: Mathematics, page 27

※ Errors are shown in red below.

Facts about planets

The figures are given in standard form to 3 significant figures.

Planet	Distance from the sun	Diameter	Mass
Mercury	5.79×10^7 km	4.88×10^3 km	3.30×10^{23} kg
Venus	1.08×10^8 km	1.21×10^4 km	4.87×10^{24} kg
Earth	1.50×10^8 km	1.28×10^4 km	5.97×10^{24} kg
Mars	2.28×10^8 km	6.79×10^3 km	6.42×10^{23} kg
Jupiter	7.79×10^8 km	1.44×10^5 km	1.90×10^{27} kg
Saturn	1.43×10^9 km	1.20×10^5 km	5.68×10^{26} kg
Uranus	2.87×10^9 km	5.12×10^4 km	8.68×10^{25} kg
Neptune	4.50×10^9 km	4.95×10^4 km	1.02×10^{26} kg
Pluto	5.91×10^9 km	2.27×10^3 km	1.27×10^{22} kg

Pluto is no longer a planet (since its reclassification in 2006).

11 Use the table above to answer these questions. Cross out the wrong word.

more/less massive

a Mercury is ~~heavier/lighter~~ than Mars.

b *Uranus/Pluto* is the planet furthest away from the sun.

c The planet with the *largest/smallest* diameter is Jupiter.

d The planet nearest to the sun is *Venus/Mercury*.

e The distance between Earth and *Mercury/Jupiter* is 6.29×10^8. ← missing units

f The mass of Jupiter is about 300 times greater than that of *Earth/Neptune*.

Available textbooks

The SHIN-CHU-MON series of mathematics textbooks

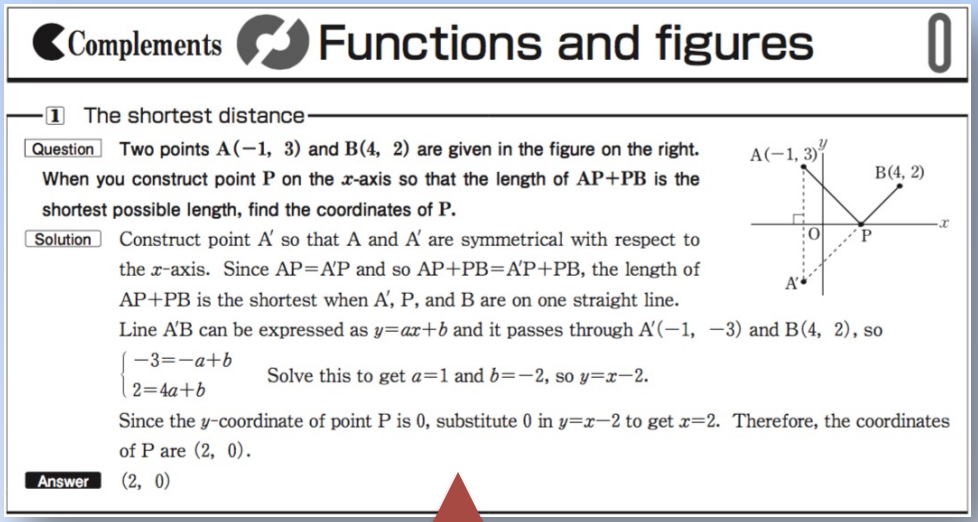
High-quality English translations of the well-known Japanese series of mathematics textbooks for junior high school students.

Available textbooks

The SHIN-CHU-MON, Mathematics for 8th Grade

English edition, page 152.

Japanese edition, page 152.



Complements Functions and figures 0

1 The shortest distance

Question Two points A(−1, 3) and B(4, 2) are given in the figure on the right. When you construct point P on the x-axis so that the length of AP+PB is the shortest possible length, find the coordinates of P.

Solution Construct point A′ so that A and A′ are symmetrical with respect to the x-axis. Since AP=A′P and so AP+PB=A′P+PB, the length of AP+PB is the shortest when A′, P, and B are on one straight line.

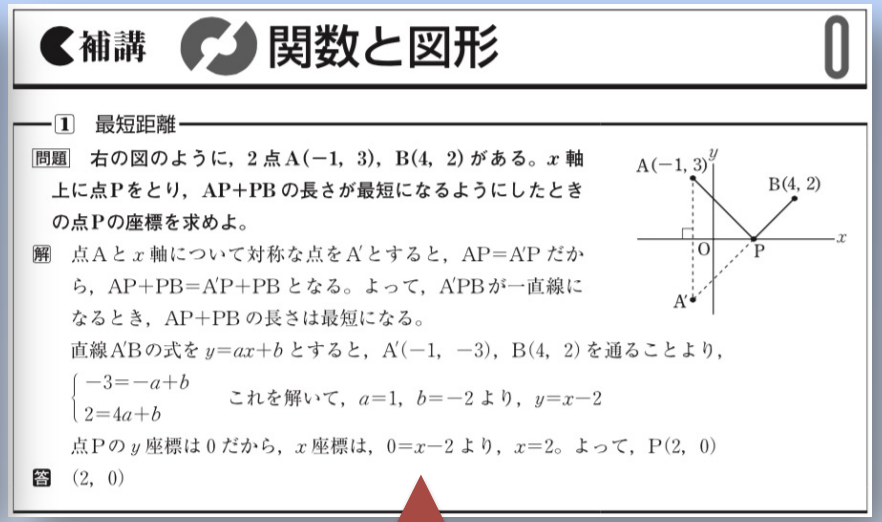
Line A′B can be expressed as $y=ax+b$ and it passes through A′(−1, −3) and B(4, 2), so

$$\begin{cases} -3=-a+b \\ 2=4a+b \end{cases}$$

Solve this to get $a=1$ and $b=-2$, so $y=x-2$.

Since the y-coordinate of point P is 0, substitute 0 in $y=x-2$ to get $x=2$. Therefore, the coordinates of P are (2, 0).

Answer (2, 0)



補講 関数と図形 0

1 最短距離

問題 右の図のように，2点A(−1, 3)，B(4, 2)がある。x軸上に点Pをとり，AP+PBの長さが最短になるようにしたときの点Pの座標を求めよ。

解 点Aとx軸について対称な点をA′とすると，AP=A′Pだから，AP+PB=A′P+PBとなる。よって，A′PBが一直線になるとき，AP+PBの長さは最短になる。

直線A′Bの式を$y=ax+b$とすると，A′(−1, −3)，B(4, 2)を通ることより，

$$\begin{cases} -3=-a+b \\ 2=4a+b \end{cases}$$

これを解いて，$a=1$，$b=-2$より，$y=x-2$

点Pのy座標は0だから，x座標は，$0=x-2$より，$x=2$。よって，P(2, 0)

答 (2, 0)

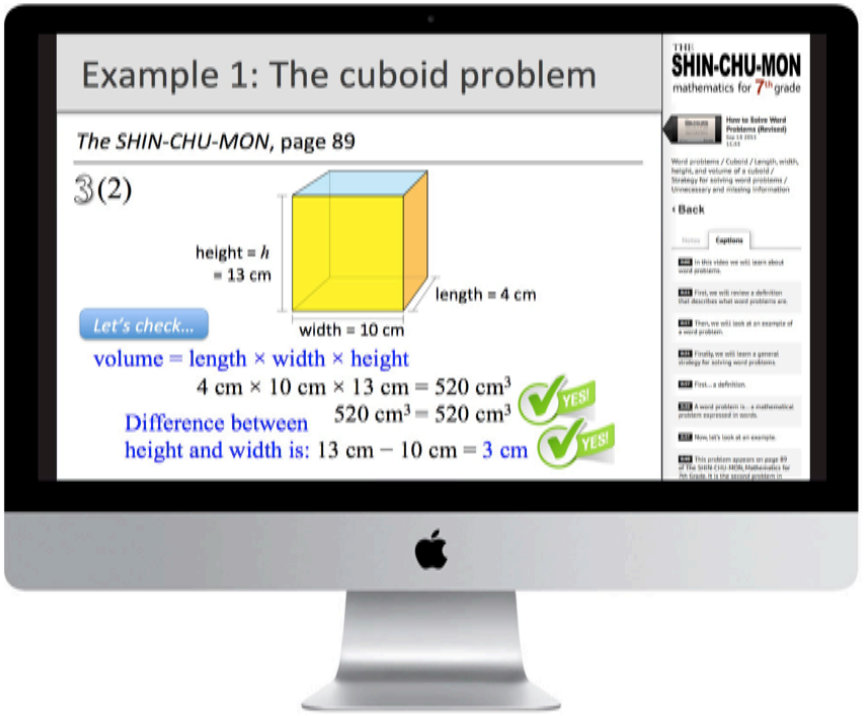
Content on each page of the English edition matches that on the corresponding page of the Japanese edition.

For more information about the SHIN-CHU-MON textbooks, please visit: http://kk-online.jp

Online resources

The SHIN-CHU-MON Video Training Series

The videos review and explain selected content in the English editions of the textbooks using easy-to-understand language, graphics, and animations.



Sample videos are available on:

YouTube

SHIN-CHU-MON 検索

Online resources

TED Ed

https://ed.ted.com/

http://www.ck12.org/

Active learning

methodologies

Flipped Classroom

- Content knowledge is gained at home
- 100% of instructional time is active learning
- More one-on-one teacher/student time
- More academic talk and vocabulary
- Focused on the mastery of content

SOLO Taxomony

Levels of thinking

Not all thinking is the same.

About 80% of what teachers ask (spoken or written) can be answered with lower-order thinking skills:

- by recall or remembering
- by simple handling of a restricted set of ideas, data, knowledge

If we can develop students' higher-order thinking skills this will enhance their learning.

What is SOLO?

SOLO is an acronym that stands for…

Structure of **O**bserved **L**earning **O**utcomes

- Developed by Biggs and Collis (1982)
- SOLO is a hierarchical framework that shows increasing quantity and quality of thinking.
- SOLO allows teachers and learners to ask deeper questions that test true understanding.

The 5 levels of the SOLO Taxonomy

- **Prestructural** – students have no idea nor any understanding about the topic.
- **Unistructural** – students have one idea about the topic.
- **Multistructural** – students have a number of ideas about the topic, but no understanding of how those ideas are connected.
- **Relational** – students have several ideas about the topic, and begin to understand how those ideas are related.
- **Extended abstract** – students can make connections beyond the scope of the problem or question,and can generalize or transfer learning to a new situation.

Surface and deep thinking

Unistructural and multistructural questions test students' surface thinking (lower-order thinking skills)

Relational and extended abstract questions test deep thinking (higher-order thinking skills)

Using SOLO allows us to balance the cognitive demand of the questions we ask and to scaffold students into deeper thinking and metacognition

Describing the levels of SOLO

In the diagram below the symbols shown represent:

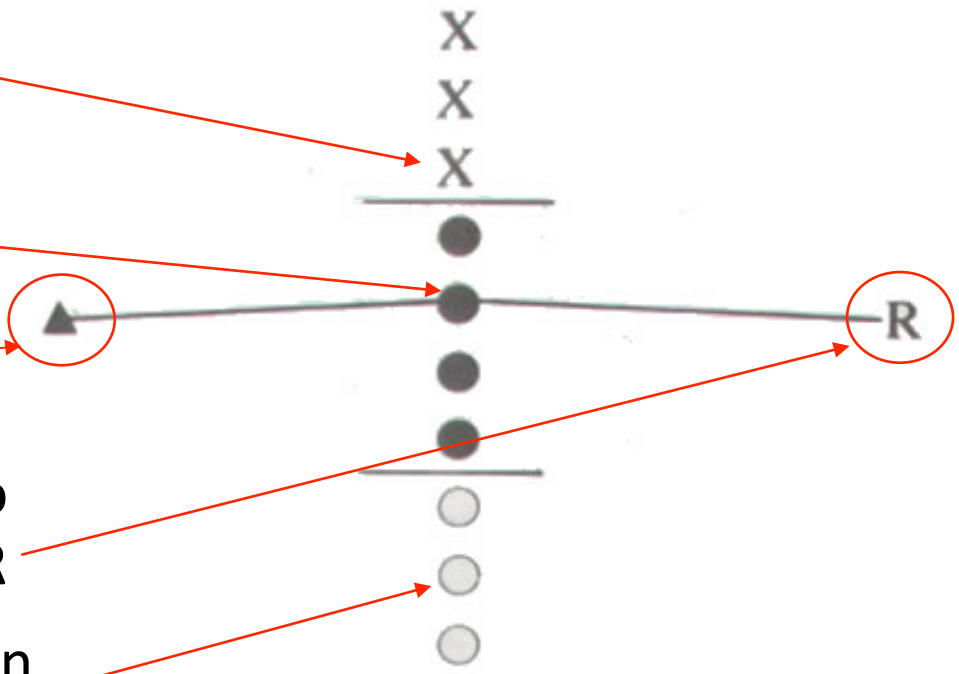
Irrelevant or not given information is shown as – **X**

Given facts, ideas, information are shown by – **black dots**

The student is represented by the **triangle**

The response or given answer to the question is shown by the – **R**

Relevant information not given in the question is shown by – **O**

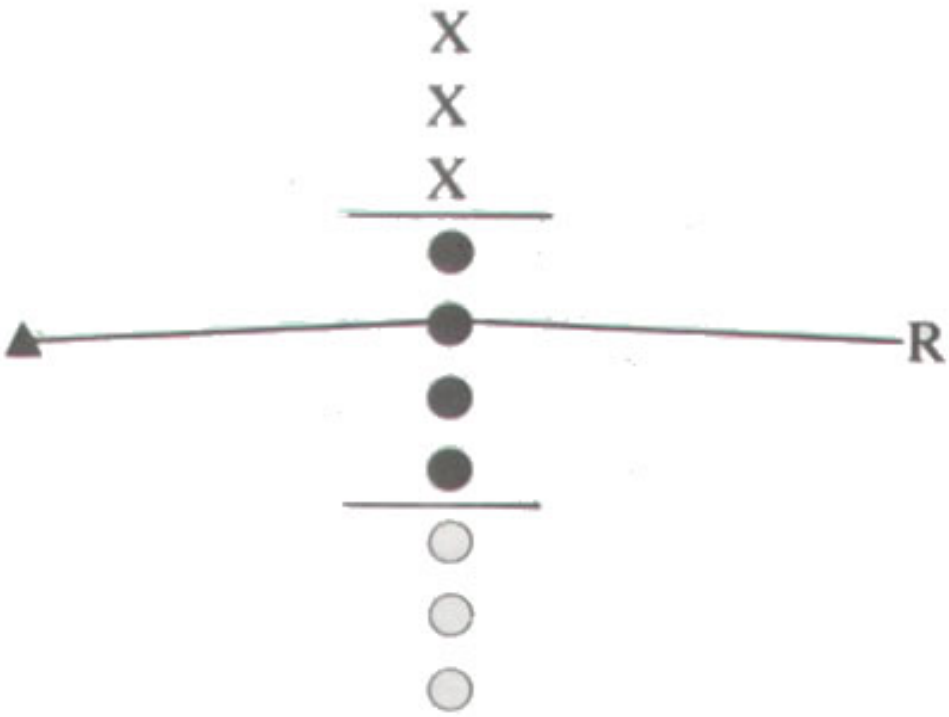


This key is used in each of the following slides

Unistructural questions

To answer the question the student needs:

knowledge or use of **one** piece of given information, fact, or idea, that she can get directly from the problem.



Unistructural question

A year that contains 29 days in February is a _____.

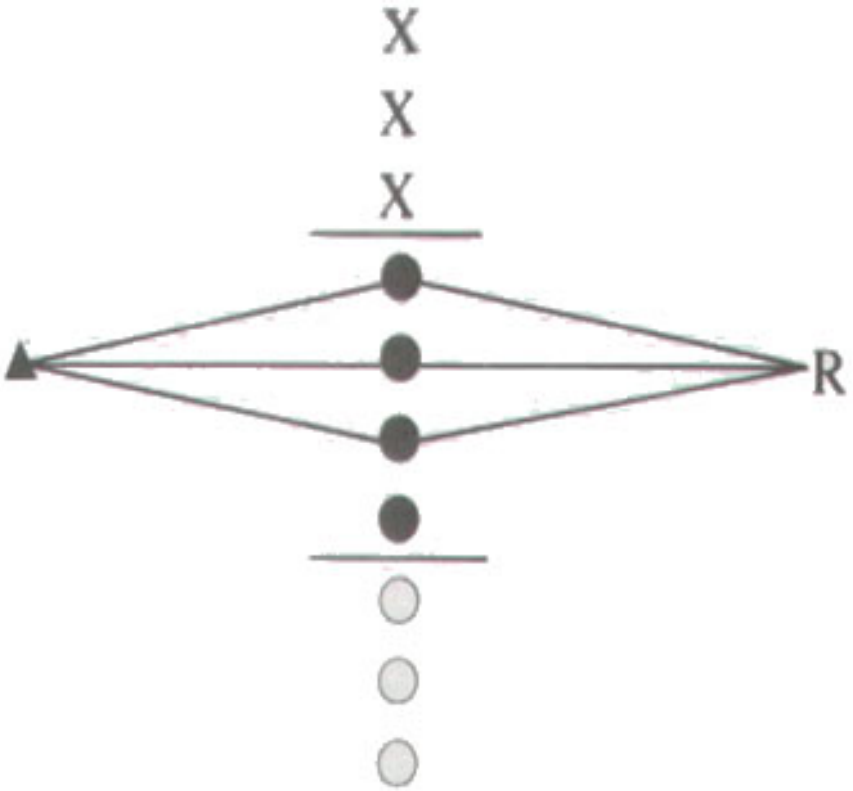
a) frog year
b) jump year
c) leap year
d) long year

Multistructural questions

To answer the question the student needs:

knowledge or use of **more than one** piece of given information, fact, or idea.

However, the ideas are not integrated.



This is fundamentally an unsorted, unorganised **list**.

Multistructural question

Which of the following years contained 29 days in February?

a) 1200

b) 1600

c) 1850

d) 1900

To successfully answer this question the student must know two things:

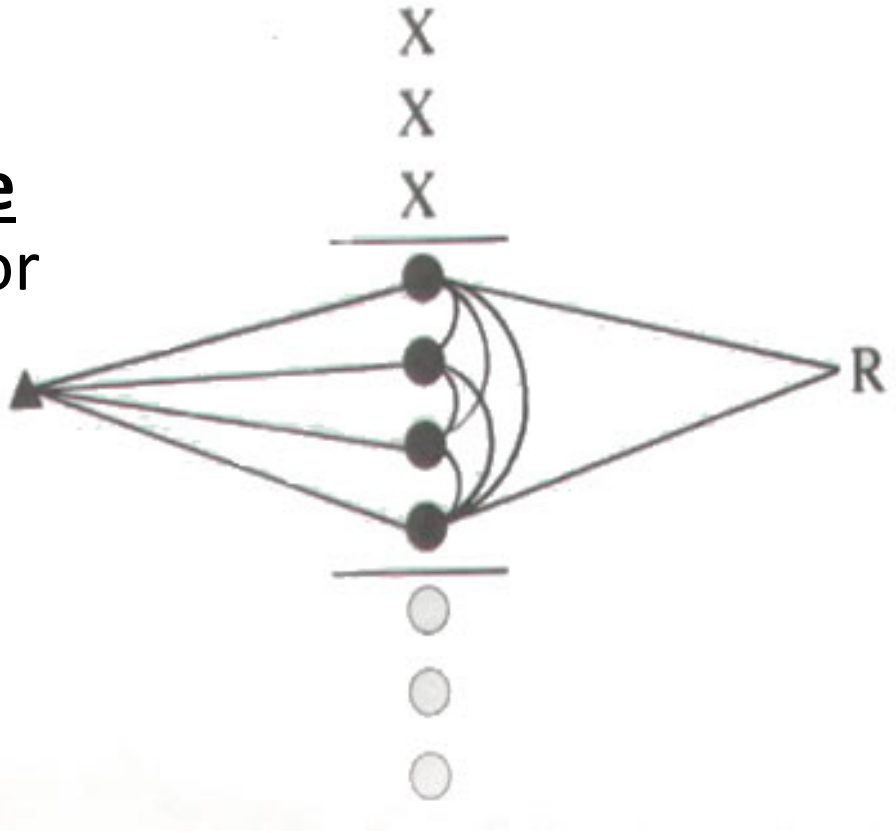
1. The algorithm for determining leap years
2. The history of that algorithm (i.e., when it was initiated).

Relational questions

To answer the question the student needs:

to ***integrate*** **more than one** piece of information, fact, or idea.

At least two separate ideas are required, that working together, will solve the problem.



Relational question

Describe the relationship between the earth's movement and the algorithm used to calculate leap years.

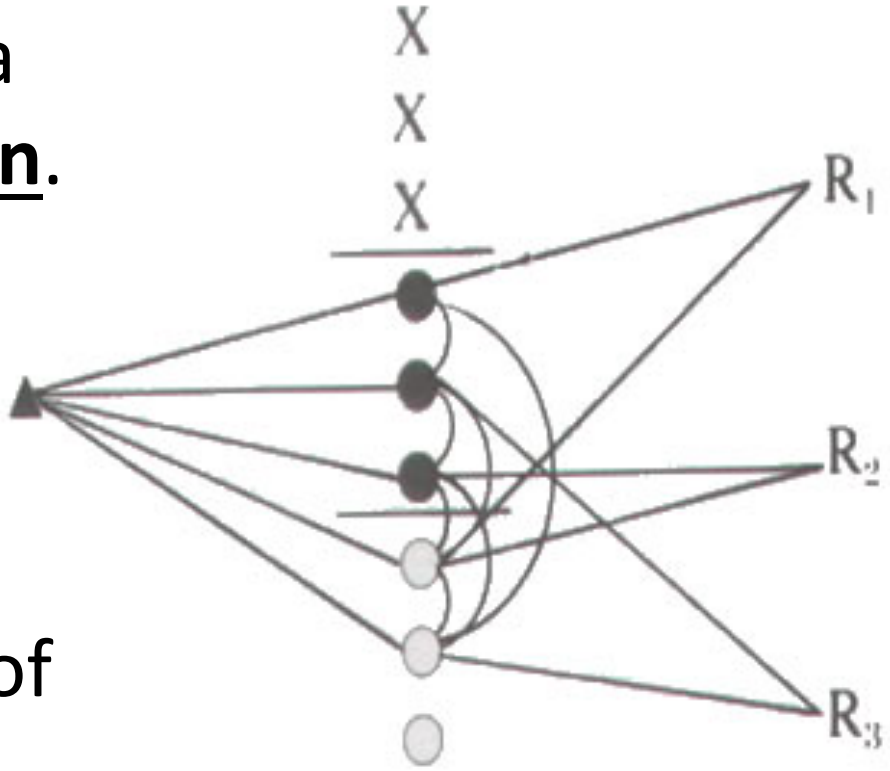
To successfully answer this question the student must know two things:

1. The algorithm for determining leap years
2. The relation between the Earth's rotational movement and its movement around the sun.

AND the student must understand the relationship between these two things.

Extended abstract questions

These questions involve a higher level of **abstraction**. They require the student to go beyond the given information, knowledge, or ideas and to deduce a more general rule or proof that applies to all cases.



Extended abstract question

Planet X rotates about its axis 823.451 times during each full revolution around its host star. The leader of the alien race living on Planet X asks you to create a leap year algorithm that will ensure that the calendar used on Planet X will not drift more than one day during each 10,000-year period.

Create the algorithm.

How to create "deeper" questions

Take a **unistructural** question
- ask for a list of 2 or more things

→ **multistructural** question

Put the list of things into the question
- ask what they have in common

→ **relational** question

Ask what class of event, situation, or rule applies.
- generate list of possible wrong answers to go with correct answer to create a multi-choice question

→ **extended abstract** question

Algebra: Number Patterns

Given:

Houses	1	2	3
Sticks	5	9	___

- How many sticks are needed for 3 houses? (unistructural)
- How many sticks are there for 5 houses? (multistructural)
- If 52 houses require 209 sticks, how many sticks do you need to be able to make 53 houses? (relational)
- Make up a rule to count how many sticks are needed for any number of houses. (extended abstract)

Group Work:

Use the SOLO Taxomony to describe various levels of understanding of an important scientific concept

Task 1:

In your scientific area, select a unistructural question and then transform it into a…

- Multistructural question
- Relational question
- Extended abstract question

Some things to think about

Response versus requirement

- A question must be phrased in such a way as to gain the type of response required.

Deep thinking and difficulty

- Questions that are hard and require long responses do not necessarily require students to think deeply

Deep thinking and learning

- Deep thinking can be a given if it becomes a learned response
- Today's extended abstract question can become tomorrow's relational question

In summary…

- SOLO is a true hierarchic taxonomy – increasing in quantity and quality of thought
- SOLO is a powerful tool in differentiating curriculum and providing cognitive challenge
- SOLO allows teachers and learners to ask deeper questions without creating new ones
- SOLO is a powerful metacognitive tool

References

- Hattie, J.A.C., & Brown, G.T.L. (2004, September). *Cognitive processes in asTTle: The SOLO taxonomy*. asTTle Technical Report #43, University of Auckland/Ministry of Education.

- Biggs, J.B. (1999). *Teaching for Quality Learning at University*. Buckingham: SRHE/Open University Press.

- Biggs, J.B., & Collis, K.F. (1982). *Evaluating the Quality of Learning: the SOLO taxonomy* New York: Academic Press.

International opportunities
for students to conduct and present research

https://www.googlesciencefair.com/en/

BREAKTHROUGH JUNIOR CHALLENGE

https://breakthroughjuniorchallenge.org/

Comments from students who have participated in English immersion lessons

(planned and presented by Ei-Com, LLP)

Mr. Shaw, thank you for your class!
It's the first time to take a math class in English.
First, I worried about this class. Because I had never learned a subject in English, and I'm not good at listening and speaking English. But your English is easy for me to understand. So, I could understand both today's math class and English!
I enjoyed your class. You used icecream flavor to collect date and make graphs. If I thought only me, I would make only one pattern of graph shape. But I saw many shapes of graphs, I could swell my images.
I think, this plan is very very good for everyone. We can practice to speak and listen English!
Thanks to your class and this plan, I really want to take every subjects in English. Thank you very much

Thank you very much for doing a lecture for us today. I used to go to an international school when I was younger, and I used to learn math in English, so it made me remind those days. It was really fun and it made me more interested in that part of math, even though I have hated it as a subject.

I usually hate math when I study it in classes in school, but in English, it seemed really enjoyable. I really would like to study other subjects again in English, so that I can enjoy myself using English as well as other subjects.

In the world now, I often hear the word "globalization". In order to contribute in part of the "globalization", we must be able to say our opinions clearly in English or other foreign languages. Today, I felt that I couldn't raise up my hand to answer, even though I know the answer. I don't want to be shy anymore. So I will always remember this word, "Don't be afraid of mistakes." Thank you very much again.

I really enjoyed your lecture of data.
Before the class, I was so worried about whether I could understand your lecture because I'm not good at math.
But it was very fun.
The data that we analyzed in class are about our height and favorite ice cream. They were quite familiar with us.
You told us that English is always written in horizontal and so it is easier to show the horizontal graph than vertical graph.
Since Japanese is written also horizontal and vertical, I think it is more useful than English when we make a graph.
What interest me most is that the letter which is most used When write something. In English, the letter "e" is most used. I think it is natural result, because "e" is vowel.
In fact, I have already used "e" over 60 times in this report
Well, How do you think in Japanese?
I counted 1000 letters in criticism which is written in Japanese. In consequence, the letter "し" (shi) is most used Fancy that! "し" is not vowel.
I probe deeper into the probrem. Then I found the reason.
It is characteristic of Japanese words to resemble to the synonym in their sound. The criticism that I read is about welfare state. So, there are many technical terms.
Therefore, "し" is more used than nomal.
Counting letters were very hard. But I'm happy to know those things. I think that chapter of data is much difficult. But it is important to think it closely.
And the most important thing is not to afraid of making mistakes. I'm sure to keep this in my mind.
I'm very greatful to you for taking the trouble to come all this way. I'll never forget your class!

Ei-Com, LLP wishes to thank the Math and Science Teachers' Study Group of the Tokyo Association of Private Junior and Senior High Schools for organizing this event.

If you have any questions or comments about the information presented in these slides, please send an email to:

support@ei-com.net

Thank you very much!