Visualization of Knowledge Map based on STACK Answer Data

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Background

❏ Since the process of digitalisation, the use of online systems has covered several fields, including education.

❏ Automatic scoring systems running on LMS can help to give test, including complex mathematical problems with STACK in Moodle.

❏ Depending on the correct or incorrect answers to questions on the online test, it would be more useful if one could view the parts of the course content that have been mastered and those that have not yet been mastered.

❏ We aim to visualise the knowledge elements of the knowledge map that are acquired or unacquired based on the results of online tests.

❑ To **provide a type of feedback** which is more understandable and contains more information with the simplest form, and it should be easily **used in LMS** (Moodle in this research) above.

❑ Using **knowledge map** to display the course structure and link the test with it.

❑ The feedback give information about **the knowledge points** one needs to solve this problem and his **acquisition level of the whole course**.

❑ Apply this system into a real course data.

Learning Management System(LMS)

Hill, Phil. "State of Higher Ed LMS Market for US and Canada: Year-End 2020 Edition." (2021).
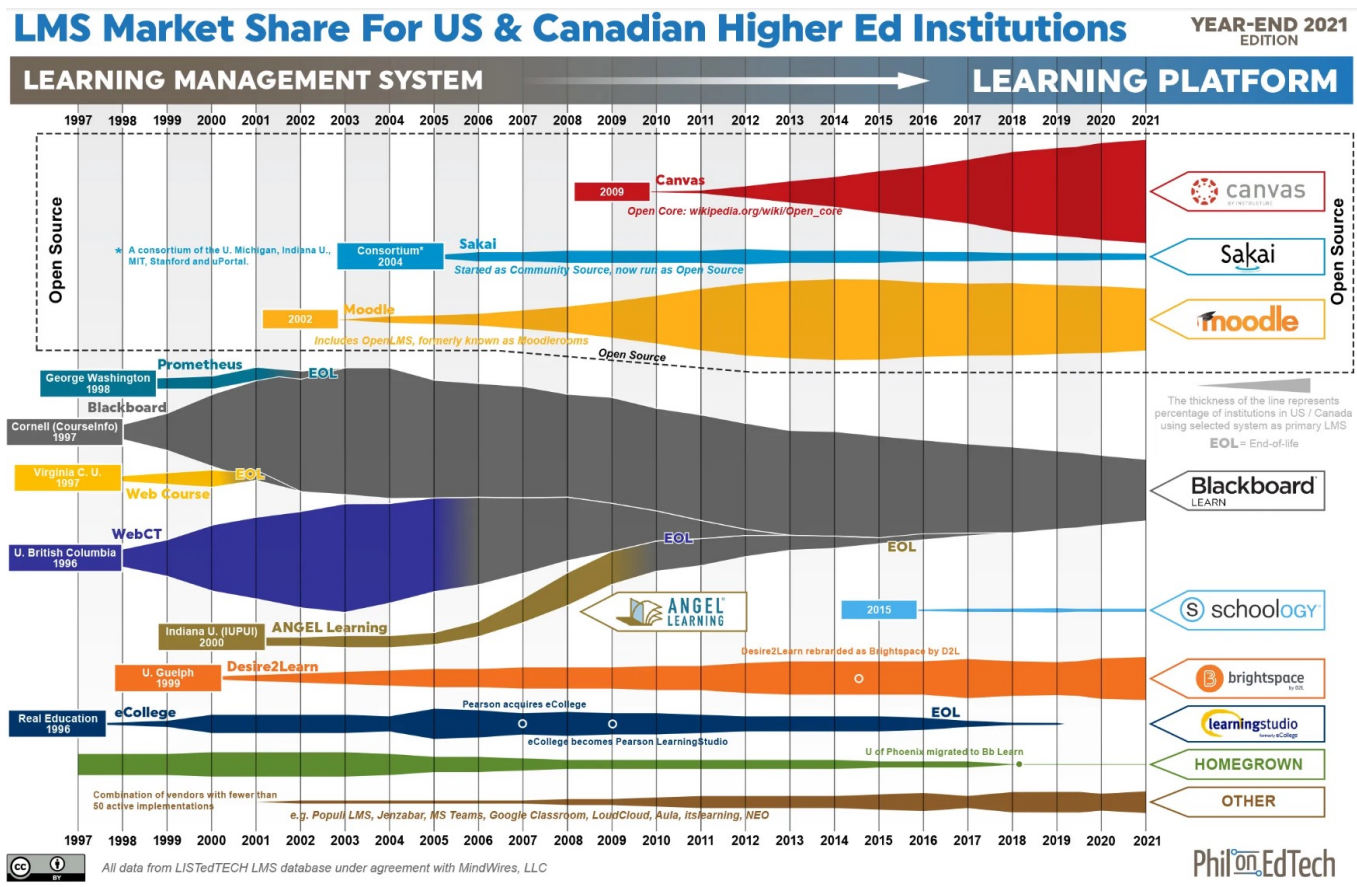
- Moodle has always taken up a sizable portion of the whole market since the fifth year after it was developed.

- Moodle is an **open-source** LMS developed by PHP.

- With Moodle, a teacher can give contents, put online tests, and manage the students in his courses and a student can read the contents opened by the teacher, take tests and manage all his learning resources to have his self-study experience.

STACK

- STACK is an **online assessment system for mathematics**, developed by Chris Sangwin and his group, designed to enable students to **answer questions with a mathematical expression**, such as a polynomial.

- STACK runs on Moodle as a **question type** plugin.

- The answer to this question will be **assessed by the scoring system** of STACK called as Potential Response Tree(PRT). A result will be returned, not just correct or incorrect, but may be partially correct.
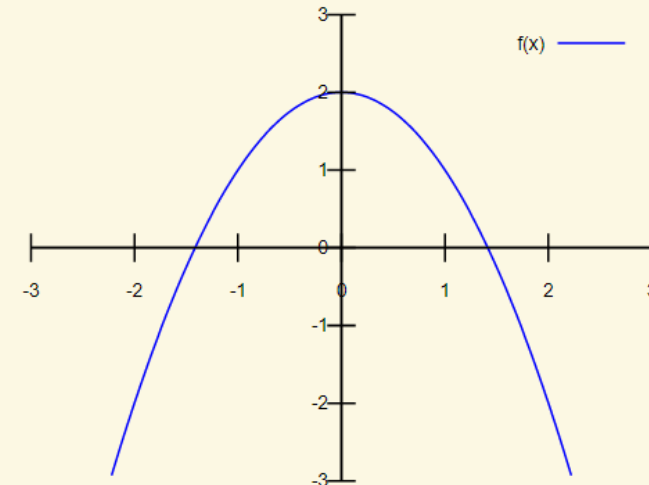
Give an example of a function with y-intercept 2 and x-intercept 1.

$f(x) =$ [2-x^2] $2 - x^2$

Check

🟠 Your answer is partially correct.
Your function does not have x-intercept 1. Instead, it has x-intercept(s) $x = -\sqrt{2}, x = \sqrt{2}$ as shown below.
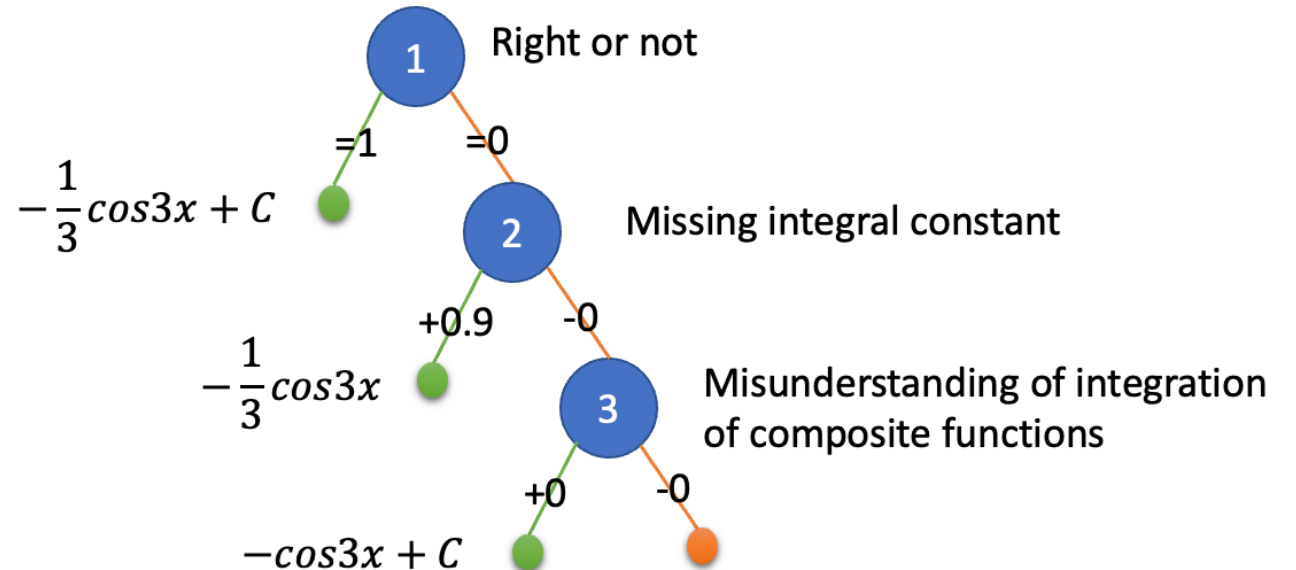

Marks for this submission: 0.50/1.00. This submission attracted a penalty of 0.10.

About STACK, https://stack-assessment.org/About/

Potential Response Tree (PRT)

■ With PRT, a teacher can image what wrong answers may appear for this question and sort them into a tree construction.

■ Plain comment in words is the only feedback a student can receive from the scoring system now.

Question: $\int \sin 3x \, dx$

① Right or not

$-\dfrac{1}{3} \cos 3x + C$ =1 =0

② Missing integral constant

$-\dfrac{1}{3} \cos 3x$ +0.9 -0

③ Misunderstanding of integration of composite functions
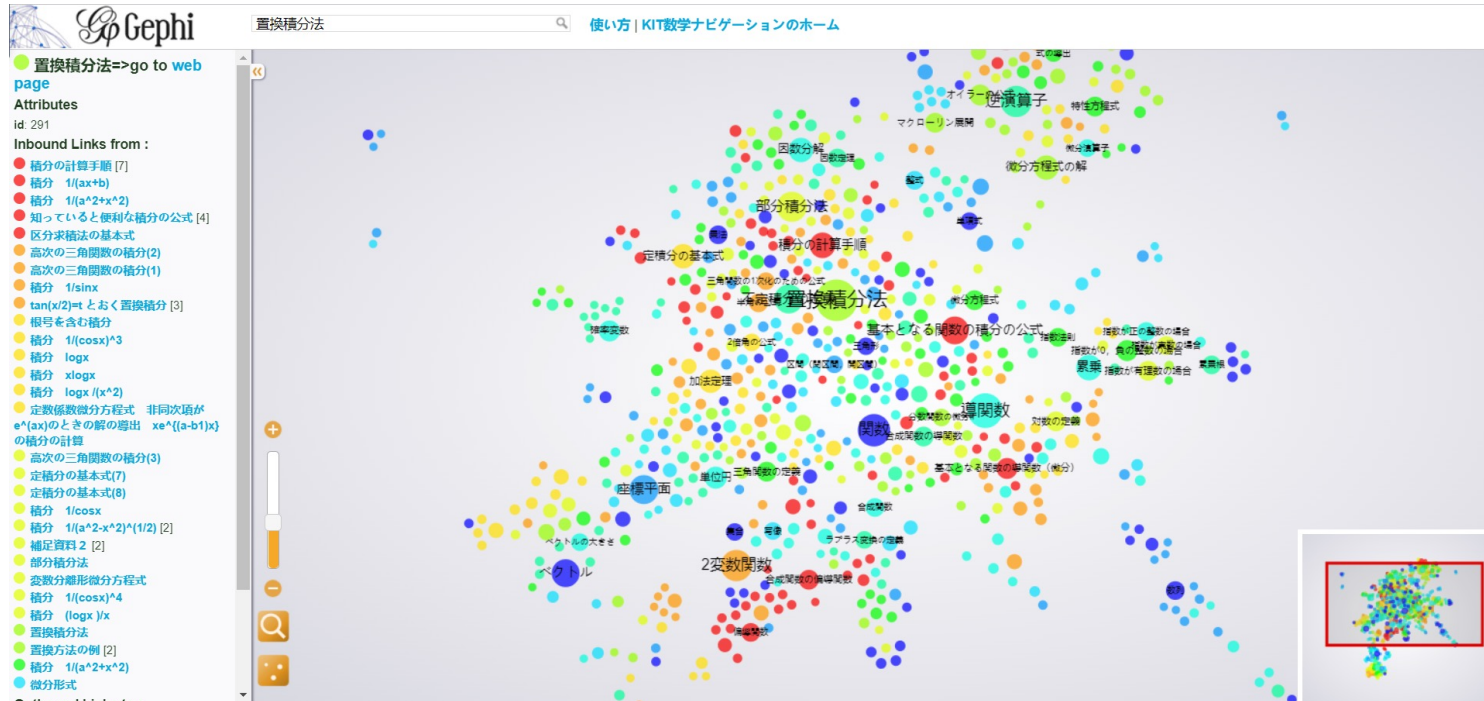
$-\cos 3x + C$ +0 -0

Knowledge Map

- The knowledge map here is a knowledge network diagram that represents all knowledge elements to be learned throughout the course and the relationships between these knowledge elements.

- The use of knowledge maps is considered an effective method to check the position of knowledge within the content studied throughout the course.
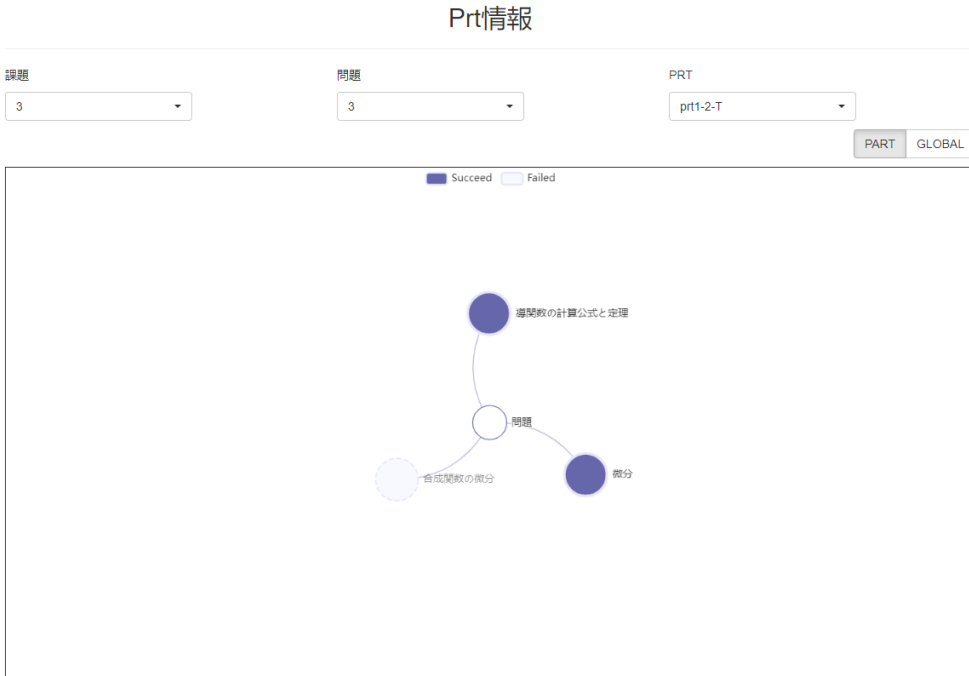
Knowledge Map

中村晃. "KIT 数学ナビゲーション." http://w3e. kanazawa-it. ac. jp/math/

- KIT Mathematics Navigation Site developed by Kanazawa Institute of Technology.

- A simple online course about college mathematics.

- Every node in this map stands for a page of knowledge point, and the link between two nodes represents that the content of one node appears in the other one, which means these two knowledge points have some relationship and should be learnt together.
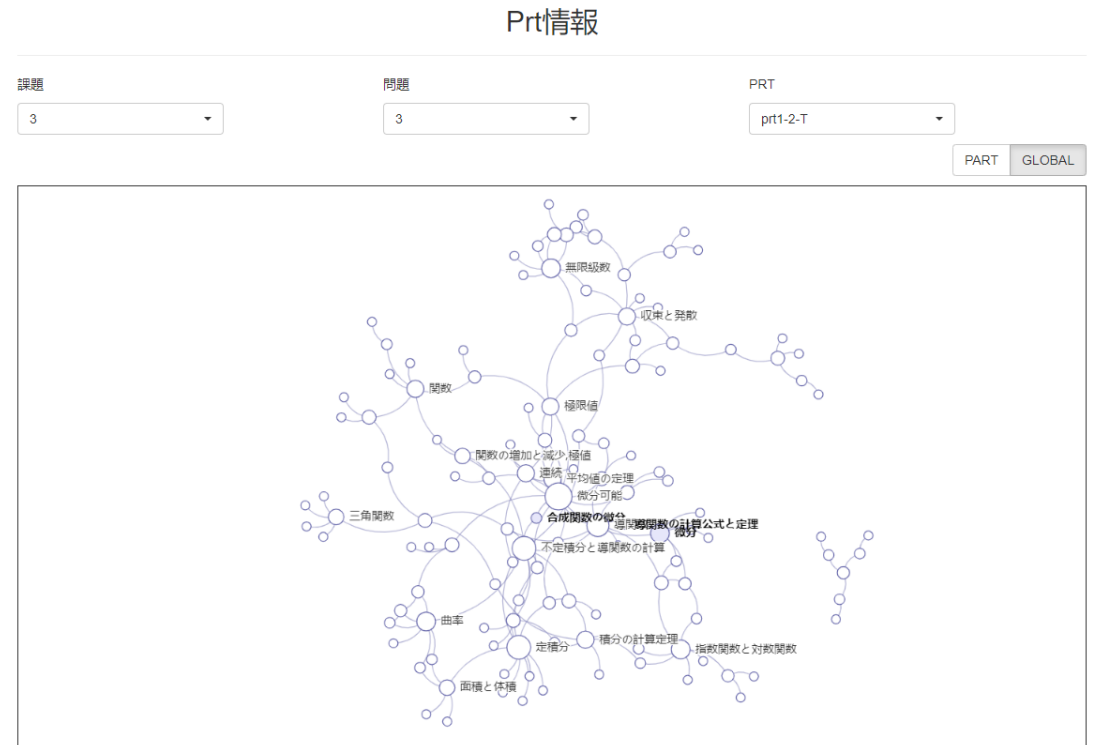
Knowledge Map

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- The use of knowledge maps is considered an effective method to check the position of knowledge within the content studied throughout the course.

- We aimed to link the online test to the knowledge map and represent the results of the online test and understanding of the course using the knowledge map.

- STACK's PRTs can be used to identify whether the student who answered the question was knowledgeable.

- By visualising the results using a knowledge map, it is expected that it will be possible to graphically grasp the students' own level of mastery of the overall knowledge of the course. It was also possible to quantify their level of mastery.

Prt情報

課題	問題	PRT
3	3	prt1-2-T

PART GLOBAL

Succeed Failed

導関数の計算公式と定理

問題

合成関数の微分 微分

PART GLOBAL

•A white center node called "question", and linked with other nodes.
•Those **mastered nodes in a dark** color and **others in light** color.

•Click [Global] to **switch to whole** knowledge map.
•Specific nodes are in **deep color**, along with **bold label**.

Prt情報

課題	問題	PRT
3	3	prt1-2-T

PART GLOBAL

11

Prototype System
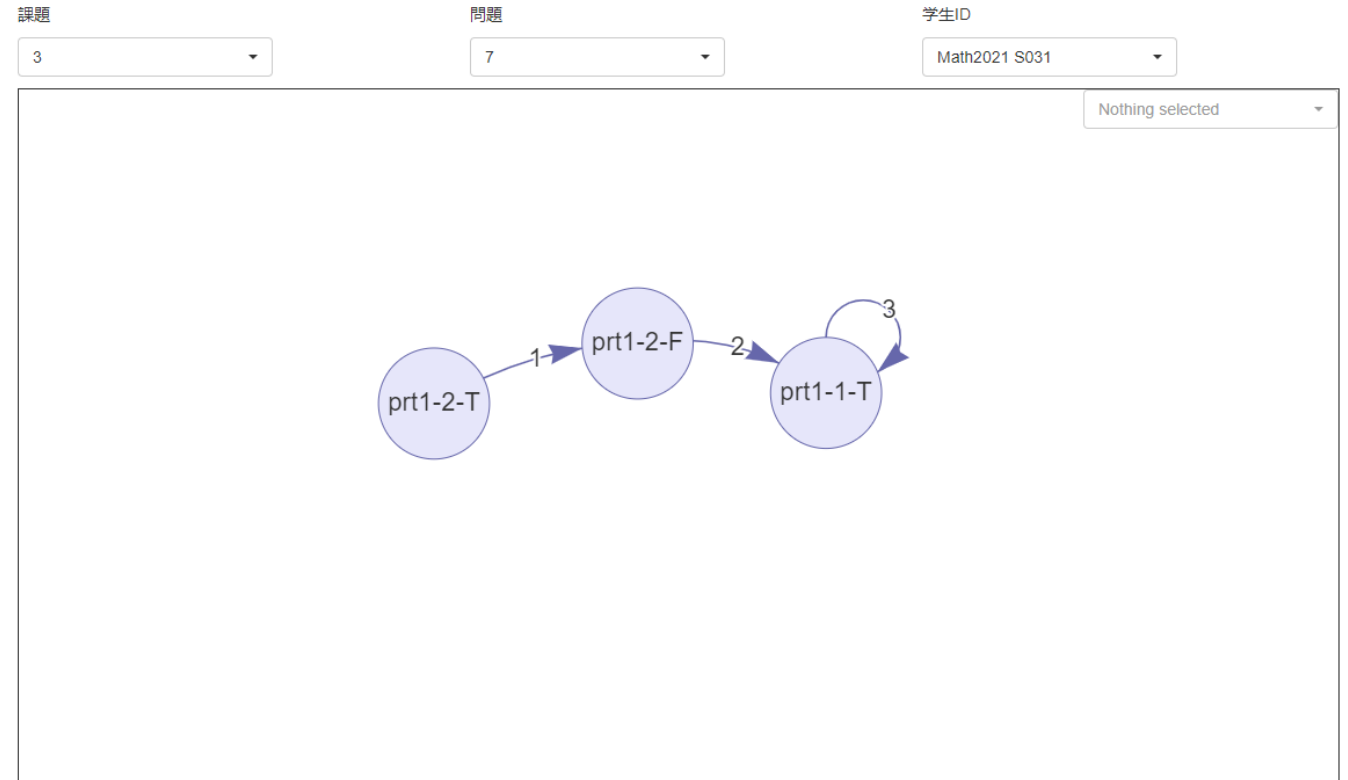
• Draw students' progress of changing answer into directed graph.

• Number above the link represent for the sequence.

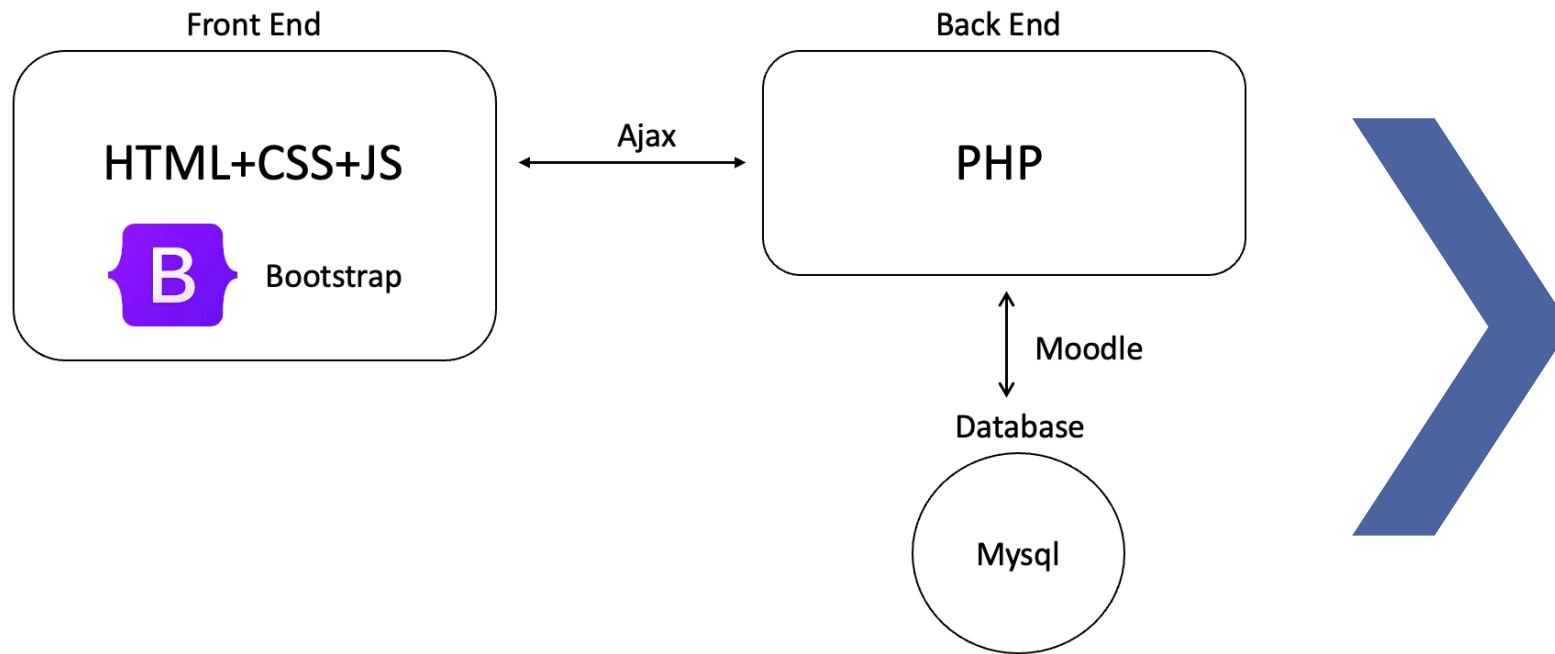• Click the nodes or dropdown box will show corresponded knowledge construction.

System Introduction

Introduction about the system we developed for Moodle, including the development environment, install, and demonstration.

Development Environment

Front End

HTML+CSS+JS

B Bootstrap

Ajax

Back End

PHP

Moodle

Database

Mysql

- The front end is developed with HTML+CSS+JavaScript using the Bootstrap framework while the back end is developed with PHP.

- Ajax is used to transfer data between the front and back end.

- The database of Moodle is MySQL, which can only be accessed by the functions provided by Moodle.

Install

1. To install the blocks into your Moodle site, firstly you need to download the block files from Github in which the source code are opened to the public.
2. Then place these 2 folders under the directory "moodle/blocks/".
3. Finally, reload the site and login as the admin or the teacher to add the blocks.

📁 stackkm	update 12.27
📁 stackkm_stu	checked ver.
📄 README.md	Update README.md

README.md

moodle_block_knowledgemap

A block plugin for Moodle to visualize the question data of STACK

https://github.com/Freyja-Leky/moodle_block_knowledgemap

System Demonstration

We applied this plugin onto a real online course data to check its performance and the prospects to continue the development. Now we will introduce this plugin with this course.

Defining Knowledge Map

- The entrance of the block plugin will perform differently depending on whether there is a knowledge map prepared for this course. If there is no map prepared, the entrance will be displayed like the part in the red box in the Figure with a single link to set the knowledge map.

Defining Knowledge Map

- The setting knowledge map page will be performed like the Figure. Through the navigation bar, one can go back to the course page or jump to the setting questions page.
- Easiest way to show knowledge map is to upload Excel file that define knowledge map.
- Knowledge map can also be defined by adding nodes and edges information.

Defining Knowledge Map

- Example of Excel file for defining Knowledge Map.

	A	B	C	D
1	Name	Field		
2	関数と変動	Function		
3	関数	Function		
4	区間	Function		
5	逆関数	Function		
6	合成関数	Function		
7	座標	Function		
8	極座標	Function		
9	極限値	Function		
10	数列の極限値	Function		
11	収束と発散	Function		
12	収束定理	Function		
13	収束半径	Function		
14	はさみうちの定理	Function		
15	コーシーの収束判定定理	Function		
16	関数の極限値	Function		
17	極限値存在定理	Function		
18	変数	Function		
19	導関数	Derivative		
20	微分係数	Derivative		

Nodes · Links

	A	B	C	D
1	Source	Target		
2	関数と変動	関数		
3	関数と変動	極限値		
4	関数	区間		
5	極限値	数列の極限値		
6	極限値	関数の極限値		
7	数列の極限値	収束と発散		
8	関数の極限値	極限値存在定理		
9	関数の極限値	コーシーの収束判定定理		
10	関数の極限値	収束定理		
11	関数	逆関数		
12	関数と変動	変数		
13	関数	合成関数		
14	関数	座標		
15	座標	極座標		
16	収束と発散	収束定理		
17	収束と発散	収束半径		
18	収束と発散	コーシーの収束判定定理		
19	収束と発散	はさみうちの定理		
20	極限値	連続		

Nodes · Links

Defining Knowledge Map

- The setting knowledge map page will be performed like the Figure. Through the navigation bar, one can go back to the course page or jump to the setting questions page.
- Easiest way to show knowledge map is to upload Excel file that define knowledge map.
- Knowledge map can also be defined by adding nodes and edges information.

TestCourse

Course   Knowledge Map   Question PRT Setting

Function   Derivative   Indefinite Integral   integrals   Exponential and Logarithmic   Trigonometric
Rational   Definite Integral   Mean Value Theorem   Taylor Theorem   Increase Decrease and Extremum
Integral Expansion   Area and Volume   Plane Curve   Series   Differential Equation

関数の増加と減少,極値

導関数

不定積分と導関数の計算

微分可能

極限値

連続

平均値の定理

Manage Map by upload files:

| Choose File | No file chosen | Upload |

| Download Map | Save changes |

Add Elements:

Node	Node Name
Field	Field Name
Add Node	

FROM	関数と変動 ⌄
TO	関数と変動 ⌄
Add Edge	

Defining Knowledge Map

- The entrance of the block plugin will perform differently depending on whetherthere is a knowledge map prepared for this course. If there is map prepared, the knowledge map is displayed as in the.

Linking PRT and Knowledge Map

- The most important task of this plugin is to link the defined knowledge map with the information from the PRT results of the online test,

1. Select question's PRT node from the right panel.
2. The nodes or elements in the knowledge map of the course can be selected from the first drop-down box to be added to the map.
3. Further, it can be deleted by the second drop-down box.
4. Set the status of the node, which denotes whether the student has commanded this knowledge element to solve the question, by setting it with "Learnt" or "Failed."
5. The "Learnt" nodes are in a dark purple colour and the "Failed" nodes are in a light colour with dotted outline.

Viewing Knowledge Map

- The knowledge map prepared by the teacher will be displayed in the "Knowledge Map" block and students can view some panels when they click the map.

Viewing Knowledge Map

- The knowledge map prepared by the teacher will be displayed in the center window. Like the knowledge map showed in the teacher side, the category above is clickable to change the visibility, and the whole graph can be zoomed and dragged. Putting mouse onto the nodes and the links can highlight them with their label.

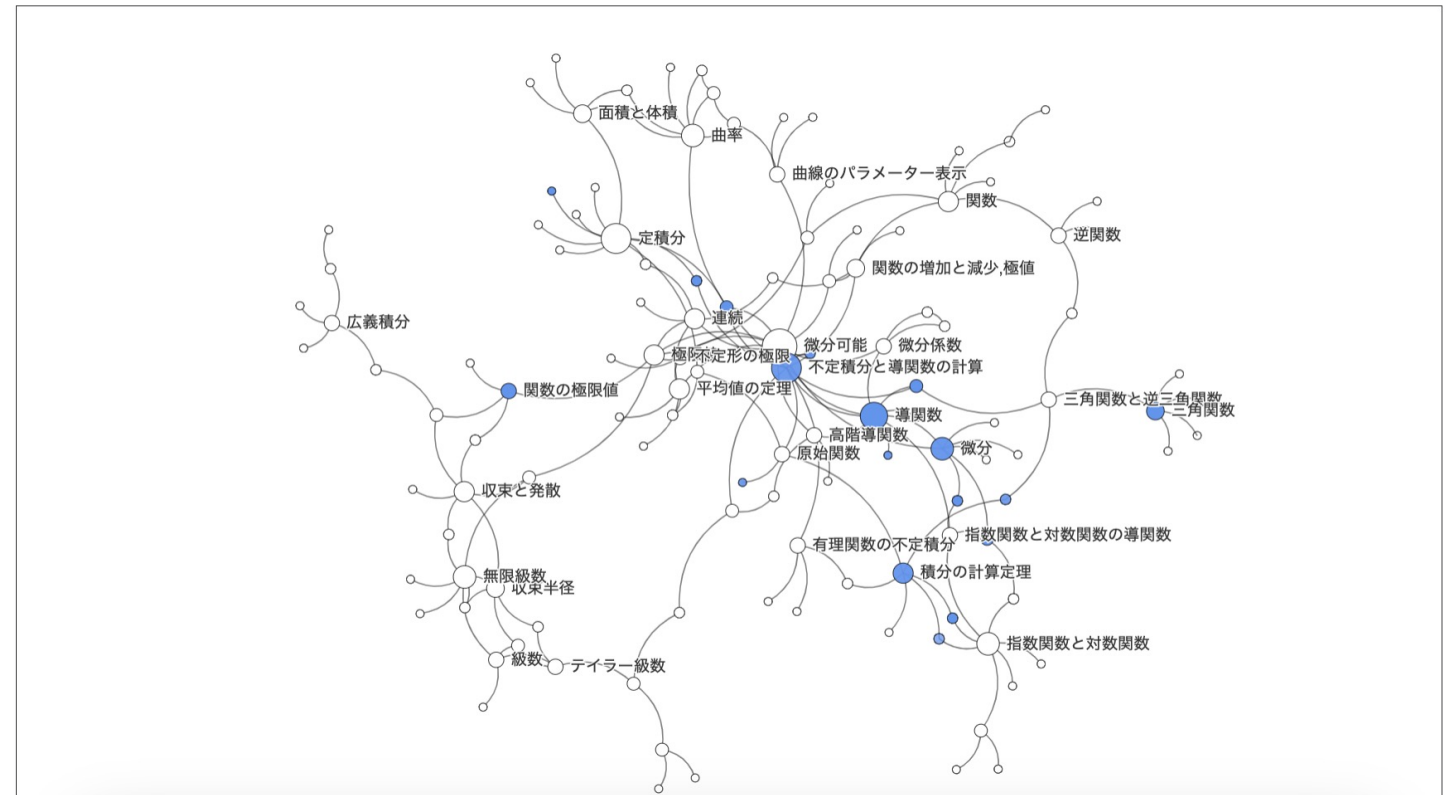# Viewing Leaning Progress

- The learning progress page will present the student's overall mastery level of this course based on all test results.

- Every node in this map has a special transparency depending on mastery level.
- Suppose there are 4 questions related with a knowledge point P, which means one need to master P to solve these questions at least.
- According to the answers submitted by this student, we can know that he correctly understood and used P in 3 questions, but failed in the second question.
- For each answer, if P is seen as learnt in this answer, it will be counted as 1, otherwise 0 for failed. Then the mastery level of this P would be calculated by the formula on the right side.

Answer 1

Learnt

Answer 2

Failed

Learnt

Answer 3

Knowledge Point P
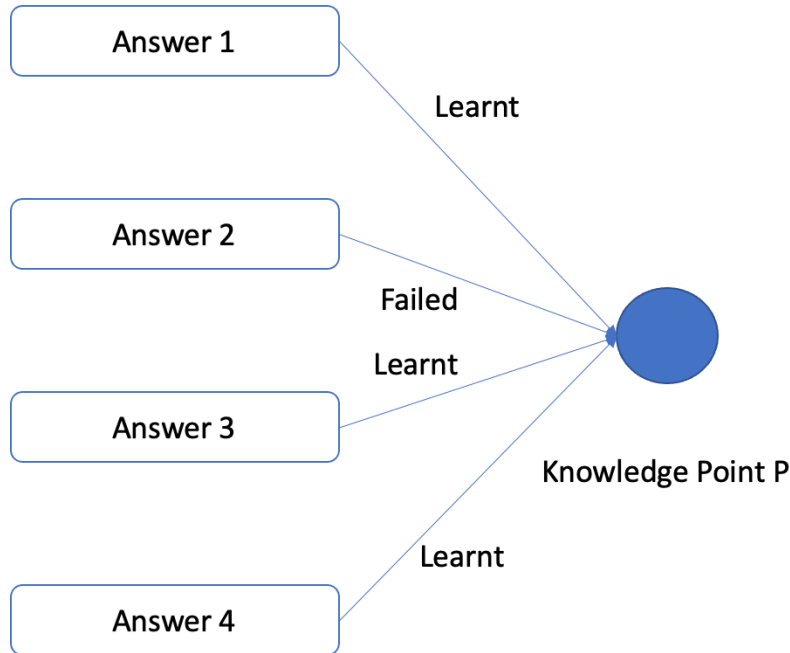
Learnt

Answer 4

Learnt	1
Failed	0

$$Mastery\ Level(P) = \frac{\sum Learnt + \sum Failed}{The\ amount\ of\ answer\ about\ P}$$

Viewing Leaning Progress

- The learning progress page will present the student's overall mastery level of this course based on all test results.
- The progress bar above the map shows the overall mastery level of the whole course. This value can be calculated by the formula below, as the total of all nodes' mastery level.

$$\text{Overall} = \frac{\sum \text{Mastery Level}(P)}{\text{The amount of nodes}}$$

Learning Completion

14.10%
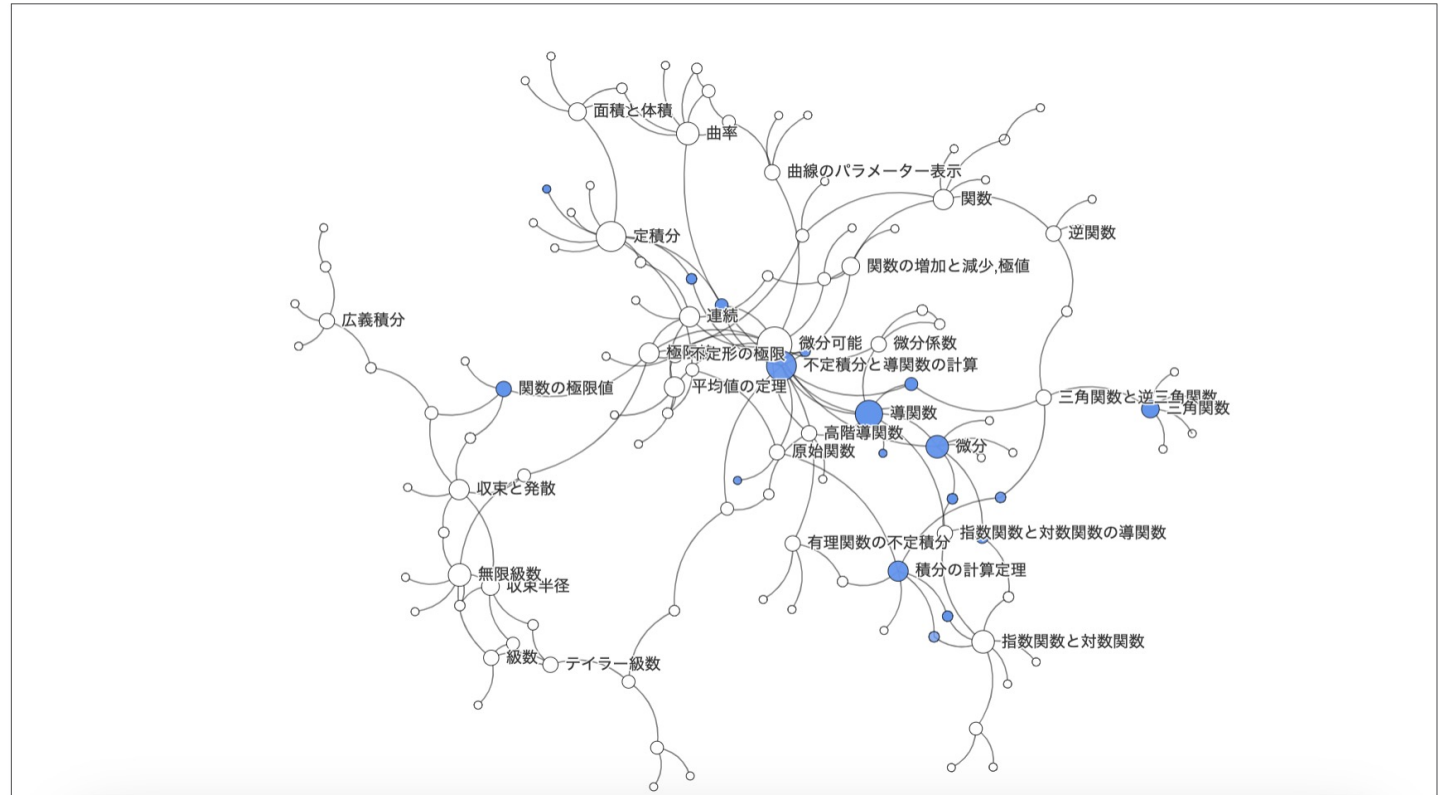
Viewing test Feedback

- In the test feedback page, students can select from the quizzes the teacher gave and confirm the last answer they submitted with the graphic feedback.
- When a student select a quiz, the score of the last attempt he submitted for this quiz, along with the timestamp he finished it, will be shown.

数学入門2021（研究用）

Course   Knowledge Map   Learning Progress   **Test Feedback**
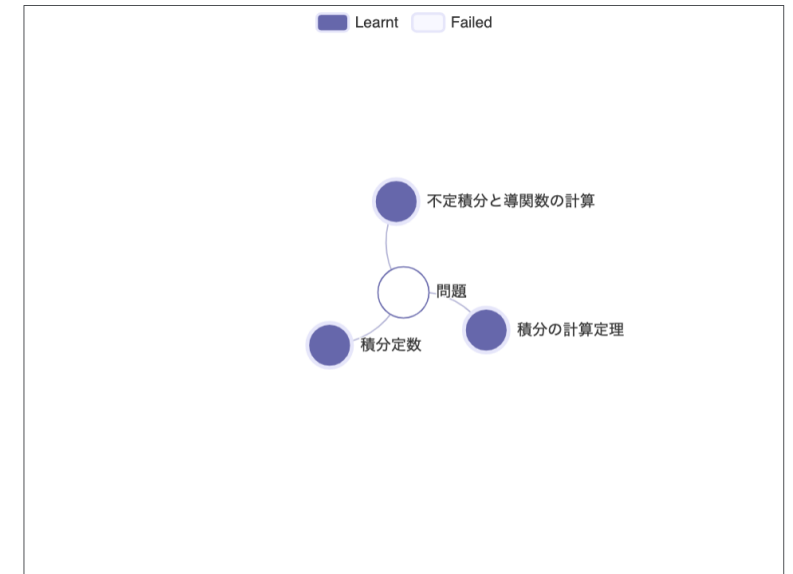
Quiz:

積分の計算 ⌄

Last attempt:

4.10000 / 9.00000

2021-06-20 16:48:43

Question:

(3x+2)^4の積分 ⌄

Your Answer :

1/15*(3*x+2)^5+c

Learnt   Failed

不定積分と導関数の計算

問題

積分定数   積分の計算定理

Viewing test Feedback

- In the test feedback page, students can select from the quizzes the teacher gave and confirm the last answer they submitted with the graphic feedback.
- When a student select a quiz, the score of the last attempt he submitted for this quiz, along with the timestamp he finished it, will be shown.

数学入門2021（研究用）

Course　　Knowledge Map　　Learning Progress　　**Test Feedback**
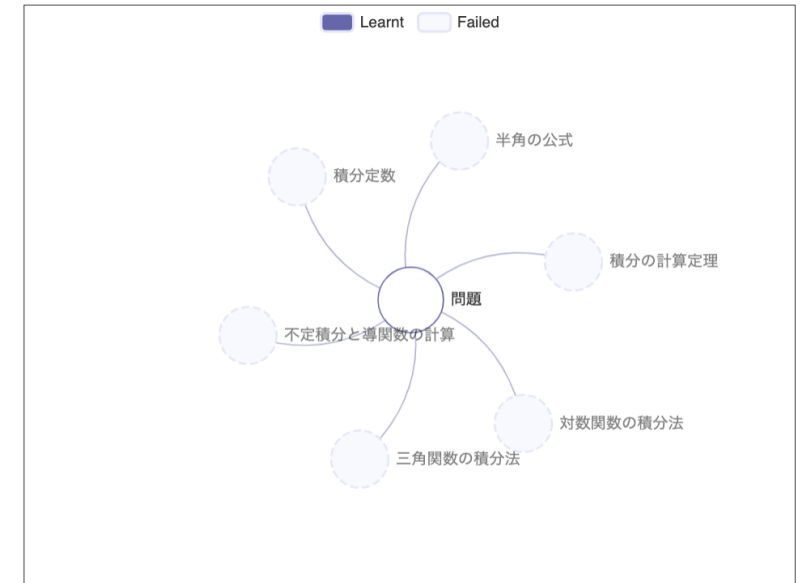
Quiz:

積分の計算 ⌄

Last attempt:

4.10000 / 9.00000

2021-06-20 16:48:43

Question:

1/sin(x)の積分 ⌄

Your Answer :

log(abs(tan(x/2)))+c

Conclusion

This research **developed a visualization plugin** for knowledge map and test feedback running on the online test system Moodle, aiming to **give the learner a more understandable feedback** about the test they take and a more direct recognition of his knowledge acquisition level.

The teacher can **build a visual relationship between the test and the course content**. The student can view the construction of the whole course content, confirm their knowledge acquisition level and view the graphic feedback of the tests they took. This can help to **get a better performance of online courses**.

Future Work

01

Use it to refine the course and test design. it can also help to build a better PRT in order to avoid useless questions or tests focus too much on the same knowledge point.

02

Add extra features into the plugin. The learning progress of every student and their answering progress of every question should be displayed as the new feature for this plugin.