Development of Concept Inventories fitting Japanese High School Physics I

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Abstract. We have been developing concept inventories fitting to the standard curricula for Japanese high school physics. A "trial" version of the test has already been completed. As a preliminary study, we have administered the test to 2559 Japanese high school students under pre-instructional conditions and analyzed obtained answers statistically. The results suggest that some test items need to be improved. In this talk, we will show an overview of a project on this development and test-data analyses.

1 Introduction

Concept Inventories (CIs) play a crucial role to evaluate students' understandings and effectiveness of physics instruction. Even in Japanese high schools, CIs, especially FCI[1,2] have been administered to a broad range of students. While the educational value of FCI is well recognized, FCI is originally developed for instruction in universities rather than high schools. Thus, FCI items do not always cover all the contents taught in mechanics classes at Japanese high schools. Additionally, the contexts of some FCI items seem not familiar to Japanese students. We are afraid that such differences reduce the accuracy of FCI as a scope of students' understandings. Therefore our research group PEPPER, which consists of Japanese university and high school physics educators and graduate students, started a project in 2019 to develop CIs adapting to the standard curricula of Japanese high school physics.

There are two courses of physics in the standard Japanese high school curricula. One is Basic Physics (*butsuri kiso*), and the other is Advanced Physics (*butsuri*). Contents taught in each course are shown in Table 1 below. Inspired by FCI, our developing CIs consists of 30 items with 5 choices for both courses, respectively. Some of the items are cited from existing CIs as FCI*, the rest are developed by ourselves. We have already completed a "trial" version. As a preliminary study, we have administered a trial version of CIs to a wide range of Japanese high school students. The number is examinees of Basic and Advanced Physics courses are 1912 and 647, respectively. The goal of the project is to complete the CIs by 2024.

Table 1. Contents and the number of items in CIs for Basic and Advanced Physics

Basic Physics		Advanced Physics	
content	item	content	item
1D Mechanics & Projectile Motion	11	2D Mechanics & Momentum,	7
Energy & Thermal Physics	5, 4	Gravity & Oscillations	2
Waves, especially Acoustics	5	2D Waves and Optics & Thermodynamics	4, 3
Circuits and Radioactive Rays	4, 1	Electromagnetics & Quantum Mechanics	12, 2

* Contexts of items cited from existing CIs will be altered to a more familiar setting with Japanese high school students so that we avoid infringing copyrights.

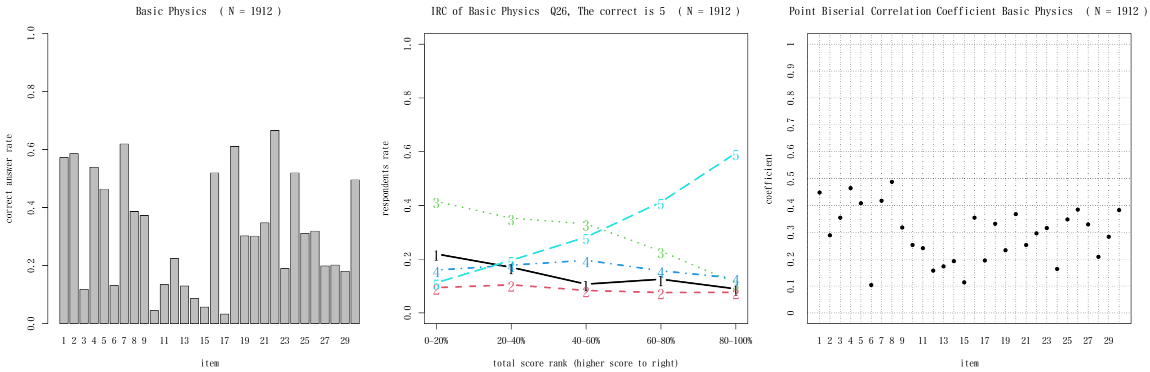

Fig. 1. Examples of analyses. The left panel describes correct answer rates for each item. The center panel shows item response curves describing respondents' rate at each total score rank. Numbers located on each curve indicate choices, respectively. The right panel shows the point biserial correlation coefficients of each item.

2 Statistical and Rasch-Model Analyses

We have analyzed answer data statistically, and some of the results are illustrated in Fig. 1 above. Moreover, we have analyzed the data also in the use of item response theory, especially with the Rasch model. The Rasch model enables each student's latent ability and item difficulty to be estimated as interval scales. Examples of Rasch-model analyses are shown in Fig. 2 below. While person abilities and item difficulties widely distribute, a few of items with infit-*t* statistics over two violates to fit the Rasch model.

Through such analyses, we have found some items in the trial version of CIs to be improved because of too small point biserial correlation coefficient, too large infit-*t* statistics, and so on. Specific examples of those items will be shown in the following presentation by Nishimura. A final judgement of necessity to improve each item will follow posttests and an interview investigation to administer and analyze at the end of this school year.

References

[1] D. Hestenes et al. Phys. Teach. **30** (1992) 141.
[2] R. R. Hake, Am. J. Phys. **66** (1998) 64.
[3] G. A. Morris et al. Am. J. Phys. **80** (2012) 825

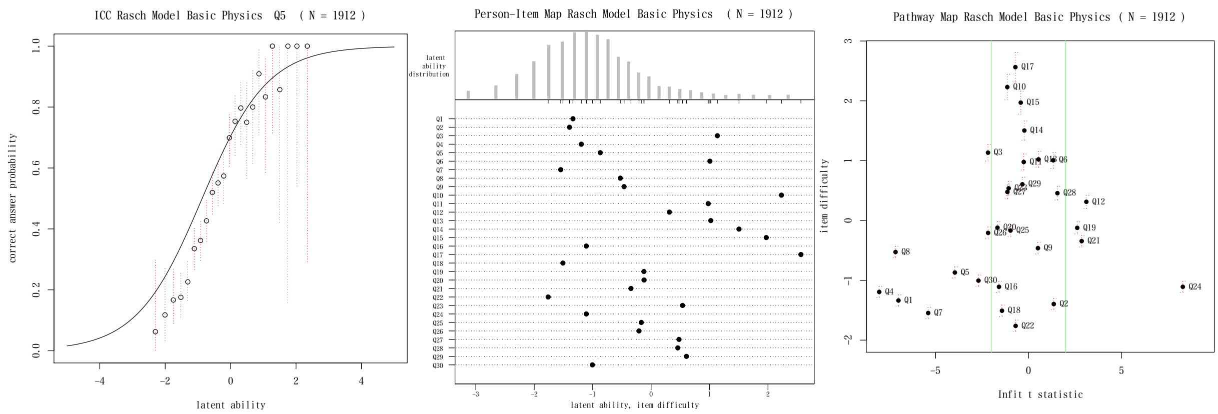

Fig. 2. Illustrations of Rasch-model analyses. The left panel represents an item characteristic curve which shows the theoretical probability that students with a certain latent ability answer correctly for each item. Circular marks around the curve indicate empirical data at each latent ability, respectively. The center panel describes the person-item map, where latent abilities and item difficulties are distributed. The right panel shows the pathway map, where item difficulties of each item are plotted versus their infit-*t* statistics. Infit-*t* statistics larger than two imply that those items may not fit the Rasch model.