Exploration on the Effect of Web 2.0-Embedded Scaffoldings to Conceptual Consistency on Force

Sotero O. Malayao Jr, and Vincent Dores N. Tagupa

Abstract— There had been many studies about the multi-representational learning of students. These studies helped us understand how multiple representations can induce understanding on certain concepts to students. Some of these studies are focused on Physics, particularly on the concepts of force. Over the years, students' understanding on force concepts was measured through tests such as the Force Concept Inventory. From this, Nieminen, Savinainen, and Viiri developed a new multiple-choice questionnaire which became known as the R-FCI or the Representational Variant of Force Concept Inventory. In this paper, the R-FCI is used to measure the consistency of the students on the force concepts. Lumping together in this study were ICT integration, scaffolding, student-centered mode of learning, and independent inquiry. Utilizing a modified quasi-experimental design, 3 comparable physics 1 classes were utilized. One class served as treatment (X_t), another as positive control (X_{co+}), and the last one as negative control (X_{co-}). Both X_t and X_{co+}received all the treatments from scaffolded lectures, hands-on investigation on DIY apparatus, group exploration on PhET simulations covering forces, and social interaction by online comment on submitted webquest activities. The X_{co-}however received only the usual classroom lecture mode and was not exposed to webquests and PhET simulations. These three classes took the R-FCI. Results showed that the study can only afford to conclude the significant effect of scaffoldings on raw scores. The scaffolded or treated classes, both X_t and X_{co+}, had no significant difference between them but had a significant difference with the unscaffolded or untreated class, X_{co-}.

Index Terms— FCI, Force, Multi-representational Learning, R-FCI, Representational Consistency, Scaffoldings

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1 INTRODUCTION

One typical study that used the Force Concept Inventory tool concluded that there is something to be scrutinized in the present physics curriculum because of the poor results of students in the inventory test even though the test consisted only of the basic concepts of Physics [1]. This study somehow tries to provide hints as to how the programme should be improved.

In learning, it is important that students must fully understand the concept being taught. In order to grasp the idea, they must have the opportunity for a deeper understanding. It was found out that a representationally-rich instructional environment has an impact on student performance and their consistency of opinions on the representations which they think are correct, and that multiple representations help develop a multifaceted scientific knowledge to learners [2], [3]. "Public presentation, examination and critique of the models is the *key* to consolidating understanding [4]."

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Ainsworth states that there should be scaffolding if multiple external representations are used to build deeper understanding [5]. Kohl and Finkelstein says that "Student representational competence is tied to both micro- and macrolevel features of the task and environment [6]."

Because of this, many applicable strategies, which can be used as assessment, are emerging from different countries. One of these is intensive scaffolding using PhET simulations which provide "animated, interactive, and game-like environments" where students explore and learn [7]. Simulations are an effective substitute for real lab equipments in the right conditions [8] and are "useful tools for a variety of contexts that can promote student learning [9]." Through PhET simulations students can gain an in-depth understanding of Physics concepts because a single simulation can embody proficient models more clearly than other materials through unambiguous representations [10], [11].

1.1. Rationale of R-FCI

From the 1995 version of the FCI [13], nine items were taken as basis for the R-FCI. These are item numbers 1, 4, 13, 17, 22, 24, 26, 28, and 30. These were redesigned with multiple representations which lead to the construction of isomorphic variants, and retention of the concept and context of the items. Each original FCI item was accompanied by two new isomorphic variants in different representations. A set of three isomorphic

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items, including the original verbal alternative, is termed *theme*[13]. A theme is named according to its original item number in the FCI such as these: T1, T4, T13, T17, T22, T24, T26, T28, and T30.

The R-FCI contained twenty-seven (27) items corresponding to *the* nine (9) themes. The following are the table (by Nieminen, Savinainen, and Viiri) of the criteria for the correct explanation in a given theme. These breakdown of the themes are based on the meta-analysis of Nieminen, Savinainen, and Viiri on the existing literatures on FCI from Europe and US. From these themes, the R-FCI were crafted in such a manner that trend of consistency can be captured by way of the graphical representations and by way of scientific homogeneity of reasoning.

Theme	Criteria for the correct explanation in a given theme
T1	Acceleration due to gravity is independent of the mass or weightof an object. Hence, both objects have the same acceleration.
T4	Forces arising from the same interaction have equal magnitudes and opposite directions OR mentioning Newton's third law.
T13	Gravitational force is the only force acting OR there is no "hit force" after the hit.
T17	The net force acting on the elevator is zero Newton's first lawOR the object has no acceleration so the net force is zero "Newton's second law".
T22	The net force is not zero so the rocket is accelerating. "Newton's second law".
T24	No forces are acting on the rocket. Hence, it has a constant velocity. "Newton's first law".
T26	A constant netforce causes constant acceleration OR A non-zero net force causes an acceleration.
T28	Forces arising from the same interaction have equal magnitudes and opposite directions OR mentioning Newton's third law.
T30	Gravitational force and air-resistance are acting. There is no "hit force."

TABLE 1. Validation criteria of the themes [12]

1.2. Rationale of the Study

The study focuses on the effect of web2.0-embedded scaffoldings to the conceptual consistency on force. It is said to be embedded because the PHET simulations are not taken as standalone component but rather in tandem with non-ICT scaffoldings. Hence, a hybridized mix of ICT and non-ICT contextualized scaffoldings became the backbone of the present study.

The non-ICT scaffoldings had been used for quite a time and the objective of this study is to evaluate any unique characteristics on student conceptual consistency being a function of cognitive processes in a carefully-scaffolded classroom settings.

2 METHODOLOGY

2.1 Subjects and Settings

The respondents (*N*=70) are students of Cristal e-College enrolling in the first semester of SY 2012-2013. The respondents of the study comprised of three *Physics 1* classes, a total ofseventy (N=70) second year maritime college students. One class served as treatment (X_t), another as positive control (X_{co+}), and the last one as negative control (X_{co-}).The *treatment* class (X_t = 23) is taking *BS in Marine Transportation* under the KLINE-MESP Scholarship, and the *positive control* (X_{co+}=23), *BS in Marine Engineering*. under the KLINE-MESP Scholarship The *negative control* (X_{co-}=24), are also taking *BS in Marine Engineering* but under the Veritas Scholarship.

Lumping together in this study were ICT-Integrated scaffolding, student-centered mode of learning, and independent inquiry. Utilizing a modified quasi-experimental design, 3 comparable *Physics 1* classes were utilized. One class served as treatment (X_t), another as positive control (X_{co+}), and the last one as negative control (X_{co-}). Both $X_t$and X_{co+}received all the treatments from ICT-Integrated and non-ICT scaffolded lectures, hands-on investigation on Do-It-Yourself apparatus, group exploration on PhET simulations covering forces, and social interaction by online comment on submitted webquest activities. The period of study covered exactly 18 hours with extra off-school hours for the webquest activities. The X_{co-} ,however received only the usual classroom lecture mode and was not exposed to webquests and PhET simulations environments.

At the end of the observation, the R-FCI was administered to all respondents. This inventory test is a promising tool to study the effect of the representational set-up on students' performance, provided that the context is fixed. It is an adaptable instrument for evaluating the "representational consistency and understanding" of the students on the force concept [12].

2.2 Items and Data Scoring

The items, which are called *themes*, of R-FCI are reflected in Figure 2 with the corresponding items that represent it. Each theme has 3 items. T13 still has 3 items with 4i, 4ii, and 4iii being treated as one. If a sub-item in item number 4 is wrong, then the whole item is wrong.

Themes	Item numbers
T1	1, 10, 19
T4	2, 11, 20
T13	22, 13, 4i, 4ii, 4iii
T17	5, 14, 23
T22	6, 15, 24
T24	7, 16, 25
T26	3, 12, 21
T28	8, 17, 26
T30	9, 18, 27

FIG. 1. Themes and items

Below are the screenshots of the analysis tool that is used to measure the students' conceptual consistency. This analysis tool was the product of the study of Nieminen, Savinainen, and Viiri as they developed the R-FCI.

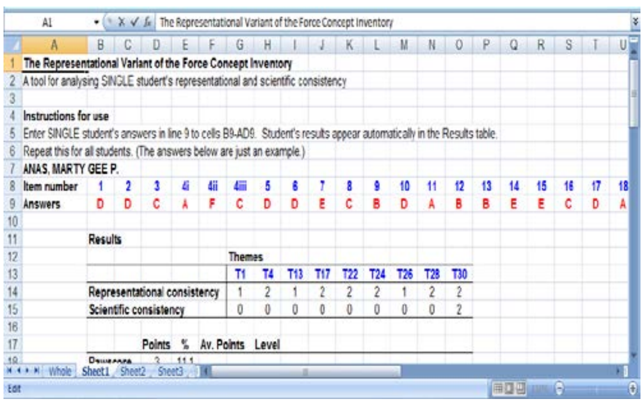

FIG. 2. Cropped Screenshot of the Consistency Analysis Tool

Figure 2 shows the cropped screenshot of the Consistency Analysis Tool spreadsheet. This analysis tool, together with the R-FCI questionnaire itself, was requested from the author of the R-FCI. Such tool was designed to analyze a student's representational and scientific consistency. In order to verify the analysis, calculations for each theme (T) per student, responses will have to be inputted on the spreadsheet and a report will be generated. To compare the results of each student in a particular class and to determine the percentage of the levels of consistency, another sheet which is linked to the single sheets was made (see figure 3).

A student's scientific consistency is based on whether or not "all the answers in a given theme are correct in terms of both physics and representations" [12], while his representational consistency, on whether or not "all the answers in a given theme are consistently correct or consistently incorrect" [12].

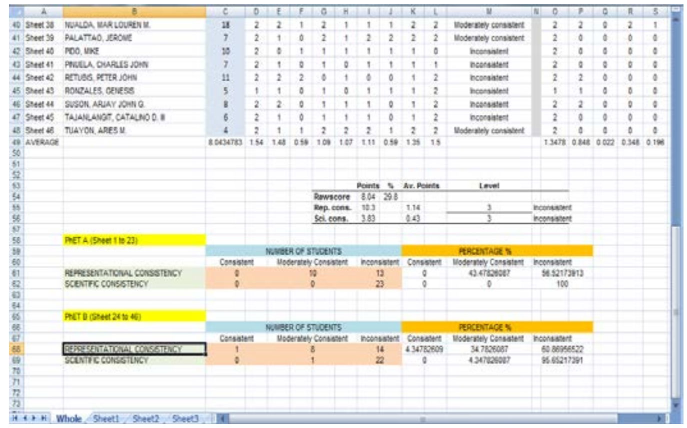

FIG. 3. Cropped Screenshot of the Spreadsheet which Links to the Single Sheets

3 RESULTS AND DISCUSSIONS

In the data analysis, consistency among the three groups is rated as "consistent", "moderately consistent", and "inconsistent".

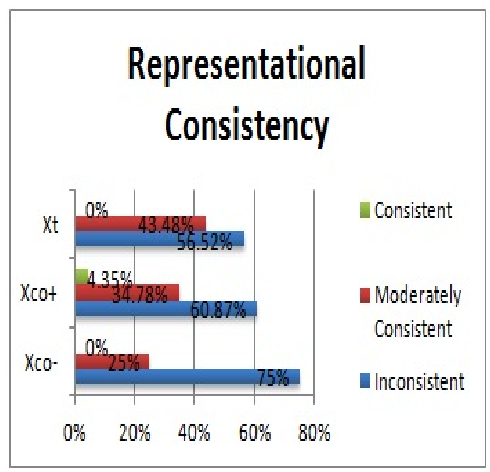

FIG. 4. The Overall Representational Consistency

Figure 4 shows the Overall Representational Consistency of the X_t, X_{co+}, and X_{co-}classes. The negative control (X_{co-}) have the highest inconsistent percentage followed by the positive control (X_{co+}) and lastly by the treatment (X_t). In terms of moderate consistent, treatment (X_t) have the highest percentage followed by positive control(X_{co+}), and lastly by the negative control (X_{co-}). Curiously, the positive control is the only group that exhibited a small degree of consistency.

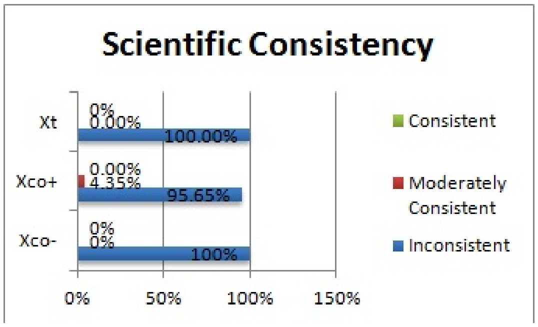

FIG. 5. The Overall Scientific Consistency

Figure 5 shows the Overall Scientific Consistency of the X_t, X_{co+}, and X_{co-} classes. All the groups are scientifically inconsistent and only the positive control exhibited a small degree of moderate consistency. This indicates a dismal picture of the way learning took place in the classroom. It appeared that innovations came up with certain effect but not so sizeable to generate conclusive stand on the efficacy of the innovation

4 Conclusions

The results of the study are indicators of the need for in-depth and detailed investigation of the student cognitive system regarding force.

That student cognition is generally inconsistent in terms of representation indicates that the perceptual processing did not reach the level of homogeneity based on the series of representations depicting the concept of force. Although there are some degree of shift to the middle as shown by the remarkable percentage of moderately consistent responses. A caveat, though, this inconsistency in representational aspect simply indicates that the answers are neither consistently correct nor consistently incorrect in terms of representation.

The highly inconsistent result in terms of representation is re-echoed in the inconsistent scientific aspect.

That student cognition is almost fully inconsistent is alarmingly important. First, the respondents are group of scholars and have upper level IQ and high degree of scholastic engagement. Despite this commonality of the respondents, the scientific consistency is albeit not evident. This indicates that aside from non-conformance of cognition to representational homogeneity, a much deeper construct is also not homogeneous.

Further, the presence of moderately consistent proportion of respondents in representaion aspect can be posited to be accrued as; (1) inherent characteristics of respondents as part of their high school learning they loosely termed as ‘stock knowledge”, (2) the low level effect of the scaffolding effort. The possibility of low level effect of scaffolding is due to the fact that respondents with no treatment have the highest inconsistent proportion and lowest moderately consistent proportion.

So far, no studies directly linked representational consistency and scientific consistency, however, this study showed the parallel presence of this two inconsistencies to the respondents. It indicated, however, that the respondents took certain amount of mental processing on the graphcal representations to somehow make meaning of the material. However, the meaning generated from the representation did not match a scientific consistency as offshoot of higher order thinking skill and dependent on the language structure the way the material was constructed.

The study opened a new avenue of inquiry into the concept of force in the context of student cognitive system. So far, the study echoes the findings of the researches in mechanics that misconceptions are highly persistent and resistant to extinction and impinges on learning. However, there is also the positive aspect of better avenues of looking into these deep-seated system of beliefs through ICT enriched modalities and environment.

The study might have produced non-clarifying stance on the nature of learner’s cognition but it does opened a wider avenues for exploration.

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