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

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ABSTACT: 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-} .

Keywords: Multi-representational Learning, FCI, R-FCI, Representational Consistency, Force

Received: 5 September 2013, Revised 12 October 2013, Accepted 18 October 2013

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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

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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]."

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 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

Theme	Criteria for the correct explanation in a given theme
T1	Acceleration due to gravity is independent of the mass or weight of 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 " <i>hit force</i> " after the hit.
T17	The net force acting on the elevator is zero Newton's first law OR the object has no acceleration so the net force is zero " <i>Newton's second law</i> ".
T22	The net force is not zero so the rocket is accelerating. " <i>Newton's second law</i> ".
T24	No forces are acting on the rocket. Hence, it has a constant velocity. "Newton's first law".
T26	A constant net force causes constant acceleration OR A nonzero 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

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.

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 stand-alone 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 1.

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 of seventy (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*,

), 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, Data Scoring, and Scaffoldings

2.2.a R-FCI

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

Figure 2. 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.

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Figure 3 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 4).

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", while his representational consistency, on whether or not "all the answers in a given theme are onsistently correct or consistently incorrect [12]".

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3																					-
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6	Repeat this for	all stud	lents.	(The an	swers be	low a	re just	an exa	mple.)				1.00								
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8	item number	1	2	3	4i	4ii	4iii	5	6	.7	8	9	10	11	12	13	14	15	16	17	18
9	Answers	D	D	C	A	F	C	D	D	E	C	В	D	A	в	в	E	E	C	D	A
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Figure 3. Cropped Screenshot of the Consistency Analysis Tool

2.2.b Scaffoldings

The whole proceeding of the research was characterized by a series of scaffoldings utilizing web 2.0 tools and were all enmeshed in the web resources. The scaffolds were presented on the table below

Web Resources	Specific utility	Url address
PHET Simulations	Energy skate park, forces and motion, projectile motion	http://phet.colorado.edu/en/ simulations/category/new
Facebook	Used as virtual classroom platform	
Readability test	Readability index and grade level using flesch-kincaid	http://www.online-utility.org/
Plagscan		http://www.plagscan.com/

PHET simulations provided rich resources for the concept of force. Some of the resources were listed in the table above and the concepts covered are overarching with other simulations. Subjects belonging to the treatment X_t and positive control X_{co+} were exposed to this web resource while the negative control X_{co+} were not. The template utilized in the PHET activities were taken

from the resources submitted by the users of PHET and given modifications. The main function of PHET was for concept exposition and utilized as parallel modality for the actual lesson cycle and as standalone package for student independent investigation.

The social networking site of Facebook (FB) was utilized as virtual classroom platform since the school has no strong IT backbone. The treatment X_t and positive control X_{co+} were made to join the FB group as the virtual classes.



Figure 4. Cropped Screenshot of the Spreadsheet which Links to the Single Sheets

The Facebook becomes the virtual classroom through the group assigned for the treatment and positive control. When used as virtual classroom, the proceedings did not require actual classroom presence. Students were given the lee way to station at the library, lawn or dormitory during the virtual classroom meetings. In some cases, the virtual classroom meetings took place at extra time beyond the regular class hours.

As on-line submission venue, student outputs were posted on the wall of the group and is open for viewing by other students of the same class. This made the students critical and cautious on their postings. Thus they made use of another web resources to check the quality of their narratives as well as self monitor for the basic errors resulting to plagiarism.

Part of the utility of the FB group was to facilitate student exercise of proactive critiquing called "*critical friend*" by posting a comment on the posting of their classmate. In the process, students were made to elevate their cognitive processing to higher order thinking in order to come up with relevant question and at the same time a launch point for improvement of the posted works.

Readability test and Plagscan were utilized by the treatment and positive control group to enhance the quality of their write-ups and monitor plagiarism in their essays. Students were given exercises wherein they were able to use the both readability test and plagscan. However, on the evaluation aspect, they were given topic during the test and they were made to subject the work of other groups to readability test and plagscan and they reported the output to the class.

3. Result and Discussion

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

•	Utility of Facebook
Virtual Classroom	Used as virtual classroom for simultaneous execution of tasks using web resources for a limited window period.
On-line submission	Student outputs in terms of powerpoint, movies, and detailed outlines were submitted on the message board of the FB group
Exercise of critical friend	Students were required to critique the postings in the mode consistent to being " <i>critical friend</i> " as espoused by INTEL Teach.

Figure 5 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.



Figure 5. The Overall Representational Consistency



Figure 6. The Overall Scientific Consistency

Figure 6 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.

In terms of sentence quality, the table is shown below.

The grade quality of sentence as summarized in the table above. It indicated that in general, the students under treatment and positive control are well within their age bracket in terms of readability ease and grade level. This points to the very good language facility of these respondents. However for students in the negative control, the grade level reading ease complexity of words, and number of words per sentence were way lower compared to those that received treatment.

Descriptive	Value for X_t and X_{co+}	Value for X _{co-}
Grade level	11-13	9-11
Easily understood between ages	16-19	12-14
Flesch Kincaid reading ease	50- 65	70-85
Percent of complex words	15.50 %	10%
Average words per sentence	14-19	9-12

4. Conclusion and Discussion

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 representation 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 conflicting outcome however was represented by better sentence quality of the treatment and positive control group compared to the negative treatment. This possibly points out that the whole scaffolded activities improved the written language facility of the respondents but it did not engender a consistency in terms of concept formation.

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