Experimentation Comparison in Virtual and Practical Operation
Take Hydraulics Learning for Example

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Abstract: The objective of this research is to examine if practical or virtual operating experimentation can discriminate hydraulics learning. There are several experimental situations, specifically virtual operating experimentation (VoE), practical operating experimentation (PoE), two successive conjunctions of VoE and PoE, and a control situation (i.e., conventional instructing with lack of VoE or PoE). College learners' comprehension of hydraulics notions in the field of force and distance is examined in a pre-post test plan that included 57 members appointed to the control group and 195 members appointed to the four experimental groups. Conceptual exams are dominated to evaluate learners' comprehension throughout instructing. Results revealed that the several experimental situations are similarly efficient in enhancing participants' comprehension of notions in the field of force and distance and better than the control situation; therefore, operation, virtual or practical operation, and not substantiality, at lowest in a condition as the one of the proposed research, is essential in hydraulics learning.

1 INTRODUCTION

Many studies have focused on reform in engineering education in recent years, they were stressed the significance of experimentation in engineering education (Hamalainen, 2008; Liang, 2009; Pennsylvania Department of Education, 2010; Zacharis, 2011). One cause making this a crucial request is quick expansion of virtual operating experimentation (VoE) and its connotations for many fields in engineering. The VoE includes the utilization of virtual equipment and component that appear in virtual circumstance (e.g. computer-based simulation). Many empirical researches indicated the possibility of VoE to promote learners' abilities and comprehension of engineering knowledge during the past decade (Hamalainen, 2008; Zacharis, 2011; Liang, 2010a; Gao, Cai, Zhao, Liu & Xu, 2010). Although these discoveries, many educators have started to sternly ask if experimentation at workshop, as we perceive it by means of the utilization of operational experimentation in automotive troubleshooting (OE_in_AT), namely, application of tangible component, tool and equipment in real world, should be reconstructed to involve VoE (Liang, 2010b; Zacharis, 2011).

Besides the PoE and VoE advocates, there are researchers who advocate associating the utilization of PoE and VoE. Through this mode of experimentation, the advantages of two operations can be acquired (Goldstone & Son, 2005; Winn et al., 2006; Zacharia, 2008). Even though in this condition, substantiality, if it verifies to be a prerequisite for learning, is still a subject because when VoE is applied, the drawbacks (no substantiality) which it delivers is still present, hence, negatively influencing learners' learning. It could be the situation that for several experiments inside the identical circumstance (e.g. identical field and techniques included but different experiment) the substantiality is not always need to show. Yet there is no study in this field so far approving or inquiry such a presumption.

2 LITERATURE REVIEW

The substantiality is the most primary distinction between VoE and PoE, which for VoE supporters, seems not to be a particular necessity for learning, unless the goal technique is sensory-motor. From a theoretic aspect, the supporters in virtual operation demand that the substantiality is a necessity for learning is not educated in any of the present main learning theorems, that is, the learning theorems of

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cognitive and constructivist. The former stresses the requirment for learners to energetically deal with messages and exercise the goal technique (Triona & Klahr, 2003). The latter focuses on the significance of learners playing an energetic character in learning, whereas it does not specially need to practical operation. From a perspective in experimental study, there are a few researches that directly examined the result of substantiality on field learning (Flick, 1993; Triona & Klahr, 2003; Klahr et al., 2007). The findings of these studies reveal which substantiality seems not to be a necessity towards particular learning techniques (Triona & Klahr, 2003) or activities (Klahr et al., 2007). Nevertheless, one can not deduce from these researches if substantiality is a prior necessity for comprehending engineering conceptions.

On the other hand, VoE involves operation of component and equipment that is essential for learning, but the essence of operation is rather virtual than practical. Nevertheless, handling virtual operation does not make over the substance of operation by itself (Triona & Klahr, 2003); virtual operation is still a procedure, as with regard to practical operation, which takes purposeful interactions with component and equipment in a skillful way. Learners can still plan, manipulate, or handle the "identical" component and equipment, as in practical operation. The only distinction is that with regard to PoE these purposeful interactions are executed by learner's hand (e.g., through holding and lifting), but with regard to VoE they are executed by virtual ways (through clicking and dragging by a keyboard or mouse of computer). Therefore, because of the lack of substantiality (real and active contacting), virtual operation also disagrees from practical operation in the kind of motion techniques that are utilized in the operation period. Nevertheless, VoE supporters stress that suchlike a perceived import is unlikely to be especially essential towards learning (Triona & Klahr, 2003). Going back the instance of elevating a lift piston with a sample of hydraulic oil, when applying a VoE, as with regard to PoE, the student even has the possibility to trace the identical operational procedures in conveying the lift piston at the targeted distance (takes the lift piston on the lift side of automobile hydraulic lift, setup a digital laser tape measure on the base of lift piston in automobile hydraulic lift, then input the force on another side of automobile hydraulic lift for a definite time), and to obtain the identical response that correlates to the goal of the learning activity, which this situation is to achieve a definite distance (reading from the digital laser tape measure). As a matter of course, VoE and PoE do not offer the student the identical whole response. In truth, although you confine the usability of VoE in offering extra response to the one offered by the digital laser tape measure (e.g., response that is notional in essence, for instance, hydraulic oil particle progress), you must not exclude the practical perspective from PoE that offers touch perceived import when operating the components of the experiment (e.g., a sensation of hydraulic oil pressure is at the starting of the experiment). However, for the targets of the experimental activity of our instance, such a perceived import of tactile sense seems not to be essential for how to press hydraulic oil and gauge its distance.

3 HYPOTHESES OF RESEARCH

Presented the above mentioned different disputes of VoE and PoE supporters and the absence of an accordant theorem on substantiality and its relationships to hydraulics learning, comparing hypotheses about the result of substantiality are systematized. Regarding the first research issue, it is supposed that the PoE only, but not the VoE only, situation will promote learners' comprehension of *F&D* (Force and Distance) concepts as contrasted to the control situation (Hypothesis 1a). In comparison, in the light of VoE supporters, both VoE and PoE will promote learners' comprehension of *F&D* concepts as contrasted to the control situation (Hypothesis 1b). With regard to the second research issue, the PoE supporters dispute that substantiality is essential in hydraulics learning and, hence the students in the PoE only situation will have preferable comprehension of *F&D* concepts than those in the VoE only situation (Hypothesis 2a). Besides, if substantiality is not essential in hydraulics learning, then there will be different between the results of VoE and PoE on the comprehension of *F&D* concepts (Hypothesis 2b).

With regard to the third research issue, from the PoE supporters' aspect, the PoE only situation will promote learners' understanding of *F&D* concepts over the situation of fractional disclosure to substantiality with VoE subsequent PoE; furthermore, both of them will have a more powerful result than the situation of fractional disclosure to substantiality with PoE subsequent VoE and the control situation; eventually, the situation of fractional disclosure to substantiality with PoE subsequent VoE and the control situation will not vary between them (Hypothesis 3a). In comparison, if substantiality is not essential for learning hydraulics, in that case whole four experimental situations will be identically efficient and more profitable than the control situation for enhancing learners' comprehension of *F&D* concepts (Hypothesis 3b). Concerning the fourth research issue, it is assumed that the situation of fractional disclosure to substantiality with VoE subsequent PoE will enhance learners' comprehension of *F&D* concepts more the situation of PoE subsequent VoE (Hypothesis 4a). The opposite assumption is that the two sequences will not vary in their results on learners' comprehension of *F&D* concepts (Hypothesis 4b).

4 RESEARCH METHOD

4.1 Participants

There are 252 participants, undergraduate members (70 female, 182 male, ***M*** = 20.4 years, ***SD*** = 0.72), enrolled in a course of introductory hydraulics at a college in this research, purposed to service car company engineers. This research is arranged in three consecutive semesters. The 57 members are assigned to the control group (CG, S_{cg}) in the first semester, even though, for the others (195 students), data are gathered in subsequently two successive semesters. Especially, 124 members are divided into two groups randomly, that is, Participants are applied VoE only in the experimental group I (EG_I, S_{eg}_I; 65 members) and participants are applied PoE only in the experimental group II (EG_II, S_{eg}_II; 59 members) in the first semester period, and 71 members are divided into two groups randomly, that is, participants are applied both VoE and PoE with PoE subsequent the application of VoE in the experimental group III (EG_III, S_{eg}_III; 36 members) and participants are applied both VoE and PoE with VoE subsequent the application of PoE in the experimental group IV (EG_IV, S_{eg}_IV; 35 members) in the second semester period (as shown in Figure 1). The units involved to the control situation quote the identical topics and conceptions as in the experimental situations.

All participants followed the identical course, introductory hydraulics, and all members had the identical age and educational background. All participants of whole five groups had no taken college layer hydraulics before the research or are joining any other hydraulics course during the research. The exams of this research are finished at a pre-arranged time outside this program.

In one-way ANOVA (a kind of quantitative analysis), it reveals that the achievement scores are not significantly difference among the members in the control group and all experimental groups, as shown in Table 1. Regarding the qualitative analysis, it indicates that the type and character (received in engineering) of learners' conception do not disaccord, across whole of the classifications of notions explored: with regard to distance, $\chi^2(4, n = 252) = 0.42$; as regards changes in distance, $\chi^2(4, n = 252) = 1.76$; concerning force, $\chi^2(4, n = 252) = 0.35$; regarding force transfer, $\chi^2(4, n = 252) = 1.58$; towards viscosity, $\chi^2(4, n = 252) = 1.63$; and for density, $\chi^2(4, n = 252) = 4.92$. Meanwhile, the *p*-value of all above items is greater than 0.05.

Table 1: The results of means and SD in each of the exams.

Group	Exam_1	Exam_2	Exam_3	Exam_4	F&D exam
S_{eg}_I pre-test	20.0 (8.0)	30.2 (7.7)	26.1 (9.0)	23.0 (11.8)	31.1 (9.5)
post-test	72.8 (13.7)	67.0 (6.9)	58.2 (14.6)	80.7 (16.4)	66.9 (12.2)
S_{eg}_II pre-test	23.5 (7.9)	32.5 (6.6)	24.7 (9.4)	29.9 (10.0)	32.6 (10.7)
post-test	73.3 (9.6)	68.3 (8.2)	57.0 (15.9)	81.4 (17.3)	66.4 (13.0)
S_{eg}_III pre-test	22.8 (7.8)	33.4 (6.5)	23.8 (8.8)	29.0 (11.3)	33.0 (14.1)
post-test	77.8 (12.7)	69.1 (10.4)	59.0 (13.2)	78.0 (15.4)	64.4 (15.4)
S_{eg}_IV pre-test	23.4 (5.3)	33.0 (5.3)	25.5 (10.2)	27.6 (9.3)	32.8 (11.1)
post-test	73.1 (11.4)	68.7 (9.0)	59.7 (13.6)	81.0 (12.8)	63.3 (13.6)
S_{cg} pre-test	21.5 (7.5)	31.6 (7.0)	25.4 (8.0)	28.5 (12.4)	32.4 (14.5)
post-test	50.2 (9.5)	52.6 (8.6)	37.9 (10.1)	56.3 (11.8)	46.7 (11.6)

4.2 Experimental Design

Figure 1 illustrated a pre-post test experimental design in this research. A VoE state of high accuracy is employed; it keeps the interactions and properties of the subject field of the research as PoE does. In addition, the identical level of plenty and clarity are achieved in both the VoE and PoE states, and to locate both VoE and PoE inside the identical context of teaching; that is, the identical teaching method, identical instructors, instructing contents (Hydraulics and Pneumatics: A Technician's and Engineer's Guide, Parr, 1999, pp.7-23) and procedures (as assigned by the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course; e.g., learners engage in small teams during the course) are utilized. The adoption of this course is on the basis of the truth that it promotes learners' comprehension of hydraulic concepts over more conventional, inactive ways of teaching (Chanson, 2004; Chua, 2011).

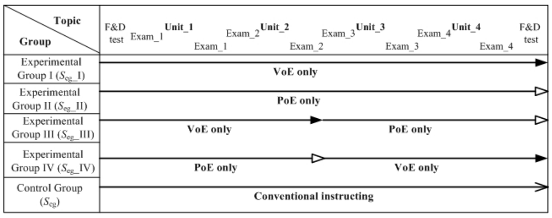

Figure 1: The experimental design of the research.

In the execution of experimental research, it is included the contrast of the result of VoE (i.e., no disclosure to substantiality), PoE (i.e., disclosure to substantiality during the research), two consequent conjunctions of VoE and PoE (i.e., fractional disclosure to substantiality) and conventional teaching (i.e., exclusion of practical and virtual operation of components and equipment) on undergraduate students' comprehension of hydraulics conceptions in the field of *F&D*. In both the experimental and control situations the identical course matter (identical four units from the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course, pp. pp.7-23) was applied. With regard to the control group, the teaching contents are expressed to the participants by discourses that included expositions of the research's experiments. The expositions are constructed by the utilization of films or projected on a screen by the teacher. The experiments involved in all expositions are conducted by PoE. The concept behind the expositions is to meet what the participant's perception in both the experimental and control situations.

4.3 Contents of Instruction

The first four units of the module of Force and Distance (*F&D*) of the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course is employed for the goals of this research. The first unit (Unit_1) generates a manipulative definition for distance, the second unit (Unit_2) investigates distance changes when examples of big-size or small-size piston (i.e., contact area) are used, the third unit (Unit_3) depicts notions regarding force and force deliver in the condition of two pistons of various areas which mutual influence continuously. Meanwhile, this unit discriminates the character of distance and force in dynamic interactions. The last unit (Unit_4) introduces the fluid properties of matter, particularly, viscosity and density. In the four units, the participants are stimulated: (a) making the required psychical commission by conducting them through the procedure of generating a conceptual framework for how distance changes beginning from direct the experience of doing in person that includes applying different size of contact surface, as well as different viscosity of hydraulic oil, and (b) developing the notions essential to depict substance regarding its fluid attributes.

4.4 Activities and Evaluations

The identical conceptual exam (F&D exam) is administered to estimate participants' comprehension of *F&D* concepts concerning distance, changes in distance, force, force transfer, density, and viscosity both before and after this research. In addition, exams specific to each unit of the research are executed before and after introducing each unit (from Exam_1 to 4; see Figure 1), with each exam being same before and after each unit. Each of the exams includes several portions (some that is composed of two sub-portions and every sub-portion has at lowest one question) that inquire open-ended notional problems all of which need to make a description of inference. The *F&D* exam involves six open-ended portions in order to measure all units of the research's course. This exam aims both the particular notions presented in each unit and the correlations of these notions. Each portion of each exam is scored respectively; for exact responses, nevertheless, a total mark is obtained from each test and utilized in the analysis. All exams are calculated and recorded no matter the situation that the participant is arranged. The marking of each portion is executed by means of the application of a marking annotation table that included pre-assign rules (exact answer and exact description), which are applied to mark both whether a member's reply to a question and its followed description are exact. An exact solution to a question is marked with one point, for all exams, and its consistent description in the light of how many of its pre-assign rules (anticipated knowledge required to describe a solution) are matched. Each description rule is marked with different point, across every exam. The maximum score of each question of a portion of an exam differs in accordance with the count of rules utilized for marking its description. Hence, the maximum score of a portion of an exam differs both across the portions of an exam and across the portions of the other exams, unless two portions share the identical amount of description rules. A single total score on an exam is obtained by summing up all the specified score, both those of a solution and a description, of all questions of an exam, and by regulating it to a one hundred-point scale. The range of total mark is limited from 0 to 100 on each exam. Two independent raters marked about twenty percent of the data. The reliability measures (Cohen's kappa coefficient) for marking of the *F&D* exam (pre-post test) and Exam_1, Exam_2, Exam_3, and Exam_4 (pre-post test), are 0.91, 0.92, 0.89, 0.90, and 0.89, separately. The reliability (agreement ratio) of the qualitative data (participants' conceptions) is 0.92. Disagreements are investigated after the analysis of reliability, and are categorized while reciprocal agreement is approached.

4.5 Procedure

In spite of the truth that the data accumulation happened at distinct phases, the processes traced are same at whole times. Firstly, all groups are created after random appointment of the members to a specific situation. Participants in all experimental groups trained in the identical workshop circumstance that administers both traditional equipment and computers organized in the surroundings, whereas members in the control group joined the course in one of the college's curriculum. Secondly, within each situation participants are randomly appointed to sub-teams as proposed through the course of this research (in a number of groups there are 2-students sub-teams due to the entire members in the group is not adequate to become triads). With regard to the control group, members trained in sub-teams of three merely during the solution of course book problems. Thirdly, whole participants are dominated the *F&D* pre-test before getting dealt with the processing of the situation they belong do. Meanwhile, concise descriptions that endeavor to accustom participants with the contents they are on the point of utilizing. Members in the control group are presented to the course book that is arranged for them and the processes that they will trace all over the course. Members in the all experimental group are presented to the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course and both VoE and PoE by an exposition despite their situation. The presentation to the procedures and methods of the Hydraulics and Pneumatics: A Technician's and Engineer's Guide course is very essential since they distinct from those included in the more conventional, inactive modes of instructing that participants have undergone in hydraulics courses in their school years period. In contrast, participants are taken accountable in hydraulics learning and are anticipated to together establish knowledge and generate their comprehension of hydraulics notions by the guidance of a cautiously planned, framed succession of query-oriented experiments.

Finally, conceptual exams are also performed both before and after each unit except the teaching of each unit (see Table 2). There are 18 weeks included in the research period. Participants have three-hour meeting per week. The all groups have the same time schedule on activities (as shown in Table 2). In execution stage, we dominated for any abnormalities between the time schedule on activities athwart whole situations (it is found anywhere else to influence member's learning; note an example Zacharis, 2011), especially amongst the experimental groups thanks to a discrepancy in the probabilities afforded by VoE and PoE for pressing hydraulic oil. For instance, because it takes participants utilizing practical operation more time to carry a lift piston to a definite height through the use of hydraulic oil than the members utilizing VoE, the groups that employed PoE are offered with pre-install substance (such as pre-pressed samples of hydraulic oil) to save time on routine activities.

Table 2: Time-on-activity data in each group.

Activity	**Time**				
	S_{eg}_I	S_{eg}_II	S_{eg}_III	S_{eg}_IV	S_{cg}
	Hours/ Week	Hours/ Week	Hours/ Week	Hours / Week	Hours / Week
F&D exam	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1
Introduction	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1	1.5 / 1
Exam_1	1 / 2	1 / 2	1 / 2	1 / 2	1 / 2
Unit_1	12 / 2-6	12/ 2-6	12/ 2-6	12/ 2-6	12/ 2-6
Exam _1	1 / 6	1 / 6	1 / 6	1 / 6	1 / 6
Exam _2	1 / 6	1 / 6	1 / 6	1 / 6	1 / 6
Unit_2	10/ 7-10	10/ 7-10	10/ 7-10	10/ 7-10	10/ 7-10
Exam _2	1 / 10	1 / 10	1 / 10	1 / 10	1 / 10
Exam _3	1 / 10	1 / 10	1 / 10	1 / 10	1 / 10
Unit_3	10/ 11-14	10/ 11-14	10/ 11-14	10/ 11-14	10/ 11-14
Exam _3	1 / 14	1 / 14	1 / 14	1 / 14	1 / 14
Exam _4	1 / 14	1 / 14	1 / 14	1 / 14	1 / 14
Unit_4	8/ 15-17	8/ 15-17	8/ 15-17	8/ 15-17	8/ 15-17
Exam _4	1 / 17	1 / 17	1 / 17	1 / 17	1 / 17
Pressure exam	1.5/ 18	1.5/ 18	1.5/ 18	1.5 / 18	1.5 / 18
Total	52.5 h	52.5 h	52.5 h	52.5 h	52.5 h

5 RESULTS

5.1 Performance of Exams

The results of means and standard deviations of performance scores are shown in Table 1. Meanwhile, a main result of group for all exams is revealed in the ANCOVA analysis. With regard to Exam_1, $F(1, 246) = 28.5$, partial $\eta^2 = 0.13$, and of post-test 1 points on members' pre-test 1 points, $F(4, 246) = 30.6$, partial $\eta^2 = 0.34$, yet no interplay between group and post-test points. Regarding Exam_2, $F(1, 246) = 34.7$, partial $\eta^2 = 0.12$, and of post-test 2 points on members' pre-test 2 points, $F(4, 246) = 25.6$, partial $\eta^2 = 0.28$, yet no interplay between group and post-test points. Concerning Exam_3, $F(1, 246) = 115.5$, partial $\eta^2 = 0.32$, and of post-test 3 points on members' pre-test 3 points, $F(4, 246) = 49.6$, partial $\eta^2 = 0.45$, yet no interplay between group and post-test points. As for Exam_4, $F(1, 246) = 78.6$, partial $\eta^2 = 0.22$, and of post-test 4 points on members' pre-test 1 points, $F(4, 246) = 28.2$, partial $\eta^2 = 0.30$, yet no interplay between group and post-test points. Eventually, with regard to the *F&D* exam, $F(1, 246) = 121.2$, partial $\eta^2 = 0.28$, and of *F&D* post-test points on members' *F&D* pre-test points, $F(4, 246) = 54.5$, partial $\eta^2 = 0.34$, yet no interplay between group and *F&D* pre-test points. Furthermore, the *p*-value of all above exams in the ANCOVA analysis is less than 0.001.

According to the Bonferroni-adjusted *p*-values for pair-wise comparisons, it implies that members' scores in the four experimental situations cross all tests are significantly higher than those of participants at post-test in the CG. However, it does not show any emergent distinct between the members' scores at post-test of the EGs cross all tests in the analysis of pair-wise comparisons. These results imply that the utilization of VoE only, PoE only, and the two successive conjunctions (PoE subsequent VoE and VoE subsequent PoE) promoted participants' comprehension of the *F&D* concepts over conventional teaching does; furthermore, that whole the experimental situations are similarly efficient in enhancing participants' comprehension of these notions.

5.2 Comprehension in F&D Concepts

In the qualitative analysis, it shows that the mostly equivalent notions are shared across *F&D* concepts studies in all EGs (i.e., distance, changes in distance, force, force transfer, density, and viscosity), as either acceptable notions in hydraulics (ANH) or not acceptable notions in hydraulics (NANH), both before and after the *F&D* exam is performed. The members in CG seem to share the identical ANH and NANH notions with the members in EGs only the research at the pre-test of each unit. In the *F&D* conceptual exam, most of the members of the experimental groups transit from NANH to ANH across the *F&D* concepts searched, after the four units are completed. The members in experimental groups have higher popularity for each ANH and lower popularity for each NANH cross whole post-tests than the CG. The popularity of each ANH and NANH of the members in the CG is discovered to be about the equivalent at the *F&D* pre-post test, as well as at each exam before and after each of the four units. Meanwhile, the equivalent most popularity NANH is shared across all pre-post tests in all groups. Eventually, these results reveal that the utilization of VoE and PoE, only or in successive conjunction, has the equivalent consequence on college participants' comprehension of *F&D* notions, that is to say, on the transformation from NANH to ANH and on the type of notions participants have after the each unit is completed.

6 DISCUSSION

In the proposed research, the objective is to explore whether operation or substantiality (virtual or practical) is essential for learning hydraulics at the college level, and especially in comprehension of hydraulics notions. The results of this research reveal that the utilization of VoE and PoE, either only utilized or in successive conjunction, while inserted in a context alike to the one of this research, can similarly promote members' comprehension of *F&D* concepts and over conventional teaching. These results verify several Hypotheses (from Hypothesis 1b to 4b) that coincide with past researches (Hofstein & Lunetta, 2004; Krivickas & Krivickkas, 2007). Meanwhile, these results also confront the common supposition of the PoE supports that substantiality is a necessity for learning hydraulics. Not one of the prophecies (from Hypothesis 1a to 4a) grounded on this supposition is not confirmed. In comparison, the results indicate that what is essential in learning hydraulics is operation, practical or virtual, instead substantiality, at least inside a context alike to the one of the proposed research. This result, of course, does not offer decisive indication that substantiality, mainly, is not a necessity for each student's comprehension of hydraulics notions, or that the model of working memory depicted above (Millar, 1999) and its result is not cogent in cognitive load and capability.

Furthermore, the proposed research is to examine whether disclosure to fractional substantiality, namely, whether joining the operation mode (virtual to practical or contrariwise) in the same order of learning activities as in VoE only and in PoE only will have a distinctive result on participants' general comprehension compared to VoE only and PoE only; also, to investigate whether the result is distinct when practical operation succeeds virtual operation and contrariwise. The results show that the two successive conjunctions, in which the operation mode is shifted, do not vary between VoE only and PoE only, thus confirming Hypothesis 3b. The truth that the shift of experimentation can take place without influencing participants' comprehension offers sustain to Triona and Klahr's (2003) address that the perceived import deriving from the accordant operation or motion techniques may not be particularly essential for learning. What seems to be essential is if the important parameters and interactions are kept the "identical" between virtual and practical operation situations. Furthermore, this conclusion has to be further examined, especially if somebody concerns that the motion techniques applied in both operation modes are easy and have already been utilized by the learners before the college. For example, some questions need to be explored, like "Is the shift of the operation mode viable when the motion techniques included in the practical mode are complicated?", or "How earlier background with the virtual or physical operation motion techniques affect the effects of shift of the operation mode?"

Besides, the plan of researches in the future have to permit examining of hypotheses regarding the perceived modes actively utilized in the experimentation period, and how this application of perceived modes influence learners' cognitive load and combination of multi-mode messages. Factors, such as the participants' age or earlier disclosure to PoE by past experiences, also have to be examined. It may be the condition, for instance, that the students of the proposed research who utilize VoE do not require the perceived modes from touch because the messages are already in learners' long-term memory from earlier experiences in learning.

7 CONCLUSIONS

The findings of the proposed research offer messages regarding the possibility and merit of the utilization of VoE and PoE for learning hydraulics, especially of VoE that has been argued as a feasible mode for learning. The data of the proposed research in the quantitative and qualitative analysis indicate that the utilization of VoE enhanced participants' comprehension of hydraulics notions quite good as PoE, with the supply that VoE and PoE are performed inside a circumstance similar to the one of the proposed research. This result sustains the recent studies regarding the corresponding effect of VoE and PoE for enhancing learning in science (Klahr et al., 2007: Triona & Klahr, 2003; Zacharia & Olympiou, 2011). Another finding appear on the qualitative analysis in the proposed research's data that farther sustains the above disputation is that the greater part of the members in whole experimental situations reveal to share the identical notions in NANH, both in the pre-post tests. This result shows that the learning outcomes and the character of learning do not virtually change when PoE is substituted for VoE. This result offers farther mode to the concept that VoE can be utilized (in some circumstances) to offer reliable workshop experiences that are not virtually distinct to the means utilized when applying PoE.

The question is considered that the two experimentation modes should be selected when VoE and PoE provide the same usability for hydraulics learning by experimentation, as in the proposed research. Apparently, any of the VoE and PoE learning circumstances will do. Nevertheless, if an instructor needs to select between VoE and PoE other causes in addition to the usability of each of the two kinds of learning circumstances should be concerned. For instance, conditions of cost-efficiency, convenience, or security can be concerned. Klahr et al. (2007) proposed some of these "exterior" causes that an instructor can pondered. For instance, they disputed that VoE ordinarily occupies less space and takes less effort. Hence, it is easier than PoE in classroom management. They also indicated that they easy reproduction and circulation of VoE as another apparent benefit over practical engineering toolkits.

Despite there are several limitations included in this research, e.g. the time-scheme that was used regarding the data gathered, the findings of the proposed research still offer a number of useful information. Particularly, Results like the ones of this research challenge the already constructed criterions regarding experimentation in the hydraulics classroom, as we undergone it by PoE, in a way that demands a re-specification and reconstructing of experimentation to involve VoE. However, this call for reformation generates the demand for comprehending how PoE and VoE could be merged in instructing and learning action orders for hydraulics. Hence, it is imperative to expand the empirical groundwork by analogous study so as to base the aspects advocated in this research.

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