The interactive computer simulation and learning activity for facilitating students' conceptual understanding on the buoyant force through the CoSci learning platform

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Abstract. Learning science, especially in the physics field, there are many varieties of invisible and abstract phenomena that are hard and difficult for students to observe and learn. One of the tools that can help students to understand those phenomena in a better way is computer simulations. The computer simulations are usually used in both on-site classroom and on-line learning platforms. Learning in the COVID-19 pandemic era at present, the computer simulations are very important for helping students to understand the physics concept. Interactive computer simulation can be considered as one of the effective methods of facilitating inquiry learning in science, as it allows students to experience the scientific inquiry process and facilitates students to understand an abstract conception and to understand the relationship between variables of invisible phenomena more clearly in reasonable ways. This study aimed to develop the interactive computer simulation and learning activity for enhancing students' conceptual understanding of the buoyant force on the CoSci learning platform. Totally eighteen participants were studied in the twelfth grade in science classrooms of a university-affiliated school project (SCiUS), Khon Kaen University, Thailand, in 2019. The learning activity was developed based on students' alternative concepts and used to facilitate students' conceptual understanding of the buoyant force. There were six basic concepts related to the buoyant force constructed based on the predict-observe-explain strategy (POE) with the interactive computer simulation (i.e., the CoSci learning platform) in the learning activity. The learning activity on the CoSci learning platform consisted of eight pie charts such as 1) main question pie chart, 2) density pie chart, 3) water level pie chart, 4) volume pie chart, 5) mass pie chart, 6) weight pie chart, 7) submerged depth pie chart, and 8) answer pie chart. There were six interactive computer simulations used in this research including 1) density simulation, 2) water level simulation, 3) volume simulation, 4) mass simulation, 5) submerged depth simulation, and 6) weight simulation. All of these simulations were developed on the CoSci learning platform (https://cosci.tw/). The findings showed that 72% of students performed better in the post-test scores than in the pre-test score in all six basic concepts related to the buoyant force after learning buoyant force on the CoSci platform. Furthermore, the most difficulty in changing misconception in learning of the buoyant force was the concept related to the mass of the object.

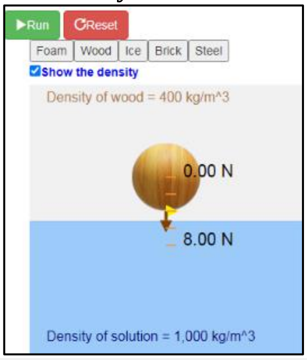
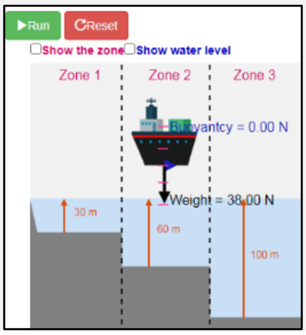
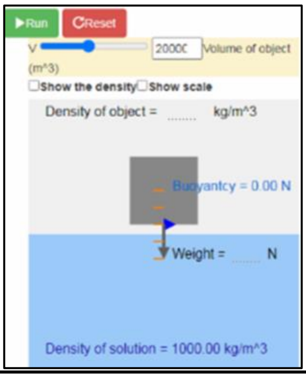
1. Introduction

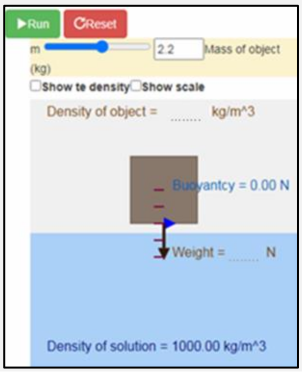
Since late 2019, the COVID-19 pandemic has created the largest disruption of education systems in history, affecting learners in more than 190 countries around the world [1]. As the COVID-19 transmits by person-to-person, many countries launch the policy to close the school, university, and other learning spaces such as a library, and a museum for preventing the COVID-19 pandemic. Responsibility of the distancing policy, online learning has been forced and brought to take action into the educational field. But it does not seem like online learning is only used for preventing the pandemic, because it has its own advantages [2]. However, there are many varieties of online learning platforms available to use. It becomes a challenge for teachers to try to find online learning platforms that suitable for their field. One of the online learning platforms that suitable for learning science is CoSci learning platform (https://www.cosci.tw/, hold a copyright since 2013 by LTLab, NCU, Taiwan). On the CoSci platform, students can learn independently after exploring them on the activities provided during their learning. Learning science, especially in the physics field, there are many varieties of invisible and abstract phenomena that are difficult for students to observe and learn. One of the tools that can help students to understand those phenomena in a better way is computer simulations. The interactive computer simulations, provided in the CoSci platform, may change students' alternative conceptions directly. Students can vary the variables, examine how the variables are changed, and investigate the problem by using interactive computer simulation. There are many benefits for students to learn in the interactive computer simulation, for example, replace such a kind of risk, visualizing an abstract concept, and saving time for conducting experiments [3]. The interactive computer simulation can be considered as one of the effective methods of facilitating inquiry learning in science education, as it allows students to experience the scientific inquiry process [4]. The conception of the buoyant force in previous research was considered that students' conceptual understanding of the buoyant force in Thailand is very low (O-net, 2015). Most students still have alternative conceptions on the buoyant force even they have been taught before [5]. Therefore, this research needed to develop the interactive computer simulation and learning activity for facilitating students' conceptual understanding on the buoyant force concept.

2. Methodology

The purposes of this study were to develop the interactive computer simulation and learning activity for facilitating students' conceptual understanding on the buoyant force concept. There were eighteen students of twelfth-grade from a university-affiliated school project (SCiUS), Khon Kaen University participated in this study. They were selected because they have already learned the buoyant force concept since they were in ninth-grade. None of the participants used the CoSci learning platform before this study. To examine students' conceptual understanding before and after they learned the buoyant force through the interactive computer simulation and learning activity, the conceptual test was revised from the prior study was used as pre-test and post-test in this study [5]. The conceptual test is a two-tier multiple choice, consisted of eight items which are related to the concept of buoyant force including density (ρ), mass (m), weight (W), submerged depth (h), volume (V), water level (L). After students finished the pre-test, they learned the activity provided on CoSci learning platform which is the problem related to the buoyant force in 100 minutes or until he or she finished learning. An activity consisted of eight pie charts included 1) main question pie chart, to ask students to solve the problem of buoyant force., 2) density pie chart, 3) water level pie chart, 4) volume pie chart, 5) mass pie chart, 6) weight pie chart, 7) depth pie chart, and 8) answers pie chart for answering the question posted on a main question pie chart. Pie chart number 2) to 7) were created from students' alternative conception of buoyant force. The POE teaching strategy was adapted in pie chart number 2) to 7) for also changing students' alternative conceptions of buoyant force. Interactive computer simulations used in this study were also developed from students' misconceptions on the buoyant force. There were six interactive computer simulations used in this research including 1) density simulation, 2) water level simulation, 3) volume simulation, 4) mass simulation, 5) submerged depth simulation, and 6) weight simulation. All of these simulations were developed on the CoSci learning platform (https://cosci.tw/). We created new interactive computer simulation which are 1) density simulation, 2) water level simulation, 3) volume simulation, and 4) mass simulation. The simulations of submerged depth and weight were revised from the previous simulations, created by Ming-Hua Chang, which were available on the CoSci learning platform. The details of each simulation are described as followed in table 1.

Table 1. Description of interactive computer simulation.

Simulations and Interface	Goals	Descriptions
Density simulation 	To help students to understand the effect of density on floating and sinking in the solution.	This simulation simulates the floating and sinking of different materials of an object which has a different density. There are five kinds of object available for students to choose by clicking consists of foam, wood, ice, brick, and steel. The simulation's interface comprises an object and a fixed density solution.
Water level simulation 	To enhance students' understanding on water level effect to the buoyant force.	This simulation simulates a cargo ship that floating in different level of water. The simulation's interface consists of a cargo ship and a zone of water. There are three zones of different levels of water including zone1: 30 meters depth, zone2: 60 meters depth, and zone3: 100 meters depth.
Volume simulation 	To enhance students' understanding about the effect of volume of object on buoyant force.	This simulation simulates dropping an object into the solution when it was fixed mass. In this simulation, students can vary the volume of an object from 12,000 m^3 up to 30,000 m^3. The colour and size of an object will be changed while the volume is varied for representing a fixed mass object when the volume is changing.

Simulations and Interface	Goals	Descriptions
Mass simulation 	To enhance students' understanding about the effect of mass of object on buoyant force	This simulation simulates dropping an object into the solution, but it was fixed volume of an object. In this simulation, students can vary the mass of an object from 1.2 kg up to 3 kg. Only the colour of an object will be changed while the mass is varied for representing a fixed volume object when the mass is changing.
Weight simulation 	For enhancing the understanding of the impact of weight on the buoyant force.	This simulation simulates the sinking of a boat when adding more weight into it. To run the simulation, students need to drag the elephant, the monk, or tanks into the boat.
Submerged depth simulation 	To enhance student to understand the effect of weight on the buoyant force after an object fully submerged in the water.	To run the simulation, students need to drag the elephant, the monk, or tanks into the boat. The weight simulation will stop when the boat completely submerged under the water while the boat of submerged depth simulation will not stop.

The students' responses, behavior, and using time would be recorded in CoSci system while students were using the CoSci learning platform. The post-test was provided to students after they finished learning immediately. To achieve the aim of this study, as shown in table 2, students' responses of the pre-test and the post-test would be scored according to the following criteria by Costu [6]. The conceptual test score of the pre-test and the post-test were analyzed by using the Wilcoxon paired test ranks between pre-test and post-test scores.

Table 2. The criteria for evaluation of student responses to the conceptual test.

Understanding level	Score	Tier 1: Answer (multiple choice)	Tier 2: Reason (multiple choice)
Scientific understanding (SU)	3	True	True
Partial understanding (PU)	2	True False	No response True
Specific misconception (SM)	1	True	False
No understanding (NU)	0	False False No response	False No response No response

3. Research findings

This study examined the impact of the interactive computer simulation toward students' concept on the buoyant force to see students' conceptual understanding after they learned the buoyant force concept on CoSci learning platform which was provided in this study. The finding shows that the post-test score was significantly higher than the pre-test score ($p < 0.01$) as shown in table 3. There was 72% of students had a progression after they learned buoyant force concept on CoSci learning platform.

Table 3. Shows the Wilcoxon test ranks between pre-test and post-test score.

Posttest - Pretest	N	Mean Rank	Sum of Ranks	Z	Asymp. Sig. (2-tailed)
Negative Ranks	0	0.00	0.00	-3.266	0.001 *
Positive Ranks	13	7.00	91.00		
Ties	5				
Total	18				

Note: The pre-test and post-test score were graded following the criteria shown in table 2.

As mentioned above, the conceptual test consisted of eight items of basic concepts related to the buoyant force. The scores of each item in pre-test and post-test were analyzed by using the Wilcoxon paired test ranks to examine students' basic concepts related to the buoyant force more deeply. The finding shows that the percentages of students who were successful in learning the buoyant force (SU level) in each item were as follows: 1) item 1 related to submerged depth concept which there was 100% of students who were in SU level, 2) item 2 related to water level concept which there was 100% of students who were in SU level, 3) item 3 related to density concept which there was 94% of students who were in SU level, 4) item 4 related to volume concept which there was 100% of students who were in SU level, 5) item 5 related to mass concept which there was 72% of students who were in SU level, 6) item 6 related to weight concept which there was 89% of students who were in SU level, 7) item 7 related to submerged depth concept which there was 94% of students who were in SU level, and 8) item 8 related to density concept which there was 100% of students who were in SU level. Most of the students had difficulty with item 5, which was related to the mass concept. Significant difference ($p < 0.01$) was found between the pre-test and the post-test score of this item, while the others had no difference. The number of students who performed unsuccess in the pre-test and post-test of each concept is shown in figure 1.

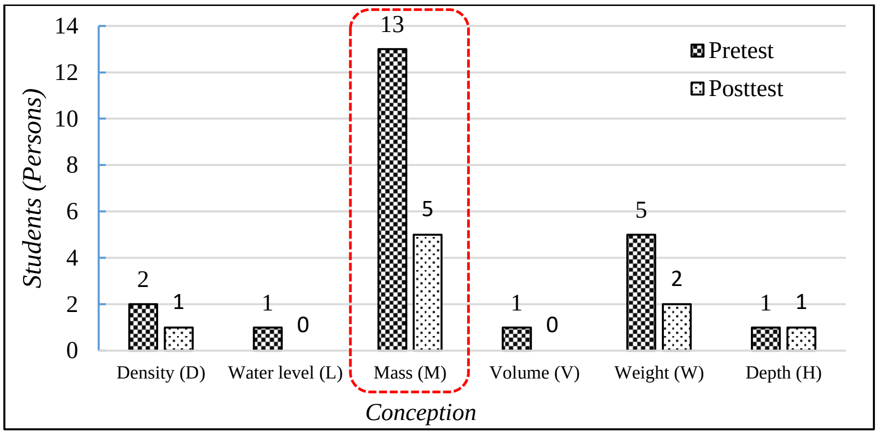


Figure 1. Students who performed unsuccess in each concept.

4. Conclusion and discussion

The interactive computer simulation can use to facilitate students' learning process and to enhance students' conceptual understanding on the concept of buoyant force. Because while students were learning on the CoSci, they were enhanced to observe phenomenon by using the computer simulation carefully. We found that most students predicted the result incorrectly. However, after students used the computer simulation with the guided question carefully and clearly, they could correct the target conception of the activity and they could explain the situation correctly.

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