Simulation Based Learning (SBL): an engineering course on Chao Phraya River’s salinity forecasting by Mathematical Modeling

**Khemisara Kulmart a,** \***,** **Parichat Muensita b**

*a Faculty of Education, Ramkhamhaeng University, https://www.ru.ac.th*

*b Faculty of Engineering, Ramkhamhaeng University,* *https://www.ru.ac.th*

*Bangkok, Thailand*

*Corresponding author: Khemisara Kulmart: Tel. +66642207444; Email: Khemisara.k@* *rumail.ru.ac.th,*

*Parichat Muensita; Email: parichat.m@rumail.ru.ac.th*

***Abstract****.* The objectives of this study were the following: 1.developing a simulation-based learning medium for students practicing and reviewing the knowledge and skills in applying basic mathematics to real-life situations related to CVE4503, a water supply engineering and sanitary system course; 2.providing students with knowledge and familiarity with problem solving processes; and 3.assessing the level of students’ acceptance of learning from both the medium and field trip in the course. Purposely sampled, the sample group and population of this study were 28 third-year undergraduate students majoring in civil engineering, Faculty of Engineering, Ramkhamhaeng University, registered in CVE4503 course, a water supply engineering and sanitary system course, in the first semester of academic year 2022. The sample group consisted of students who were working at the time of study and had direct work experience with water supply engineering and sanitary system. The research tools were mathematical models, exercises, assessment modules, and an innovation acceptance evaluation form. The statistics used were percentage, mean, S.D., and E1/E2.

The simulation medium was 85.71/97.78% effective, much higher than the standard 80/80. The average post-test score was higher than 80%, at 95.36%. The high level of acceptance of the medium was 4.05/5.00. Therefore, the medium was demonstrated to be effective for active learning in future classes.

***Keywords.*** *Simulation Based Learning (SBL), Mathematical Modeling, Active learning.*

1. **Introduction**

Simulation-based learning (SBL) has become an increasingly popular approach in education and training, particularly in fields where real-world experience can be difficult or risky to obtain. By creating virtual environments that mimic real-life situations, simulation-based learning allows learners to practice and develop their skills in a safe and controlled setting. This approach can be used in a variety of settings, from medical and military training to business and leadership development. In this era of rapid technological advancement, simulation-based learning is poised to become an even more integral part of education and training, offering learners the opportunity to gain hands-on experience and develop the skills they need to succeed in their chosen fields. Top papers on SBL are listed in Table 1. Papers on SBL based on mathematical models are listed in Table 2.

|  |
| --- |
| **Table 1.** Top co-cited authors in the field the field of simulation-based learning in management education (author co-citation network of 31,649 authors). [3]    **Table 2.** Co-cited authors in the field of Mathematical Modeling and Simulation in Education |

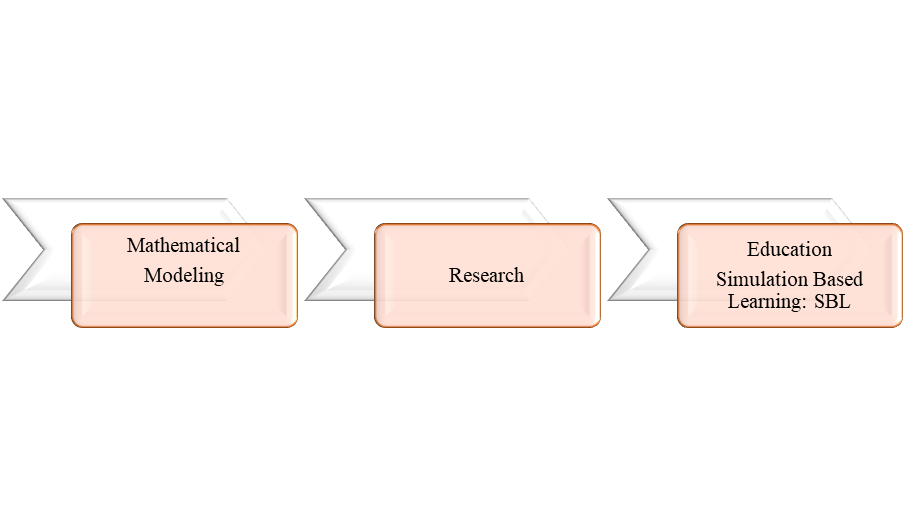
|  |  |  |  |
| --- | --- | --- | --- |
| **Rank** | **Author** | **Country** | **Research Focus** |
| 1 | Zavalani, O., & Kacani, J. | Tirana, Albania | Simulation in Engineering Education/Mathematical Modeling |
| 2 | Arseven, A. | Turkey | Simulation Education/ Mathematical Modeling |
| 3 | Erbas, A. K., Kertil, K. M., Cetinkaya, B., Cakiroglu, E., Alacaci, C., & Bas, S. | Turkey | Mathematics Education/ Mathematical Modeling |
| 4 | J. MIXHELLE CIRILLO, J. PELESKO | Netherlands | Modeling and Simulation Practices in Engineering Education |
| 5 | Cai, J., Cirillo, M., Pelesko J. A. | USA | Mathematical modeling in school education |
| 6 | Nenthian, S. | Thailand | Mathematics Learning with Real-World Problems Based on Mathematical Modeling |

In this study, an SBL course was developed and taught to bachelor’s degree engineering students. The course was a water supply engineering and sanitary system course. In the course, students learned about mathematical models and used a model to simulate and predict salinity level in Chao Phraya River, Thailand. Records of actual salinity level during 01/07/2020 to 03/06/2022 were used in the simulation. Given a future time period in the records, the model could output a predicted salinity level during that period, so the students could check whether their predictions matched the actual levels recorded. They also performed field work with real equipment to get a feel of the real situation. Their learning outcomes and their satisfaction with the course were evaluated. Our contributions include

• An effective SBL instruction medium for water supply engineering and sanitary system course.

• Students’ actively and effectively gaining knowledge and skills in applying mathematics to the real-world.

1. **Conceptual Background**

 The thinking behind this study was to bring applied mathematics in the mathematics research literature to the students to get them familiar with the applications of mathematical modeling. Students were inspired to do research into applications of mathematical modeling. The sequence of learning was, first, to get the students to become familiar with several mathematical models in the literature. Then, let them investigate how to apply one of those models to real-world situations, as shown in Fig. 3. The diagram in the figure summarizes, at the conceptual level, the process of our SBL.

Review the literature (mathematical models) -> investigate the possibility (research into applications) -> Apply to the real-world situation (the end of SBL)

**Turning Research into Teaching and learning**

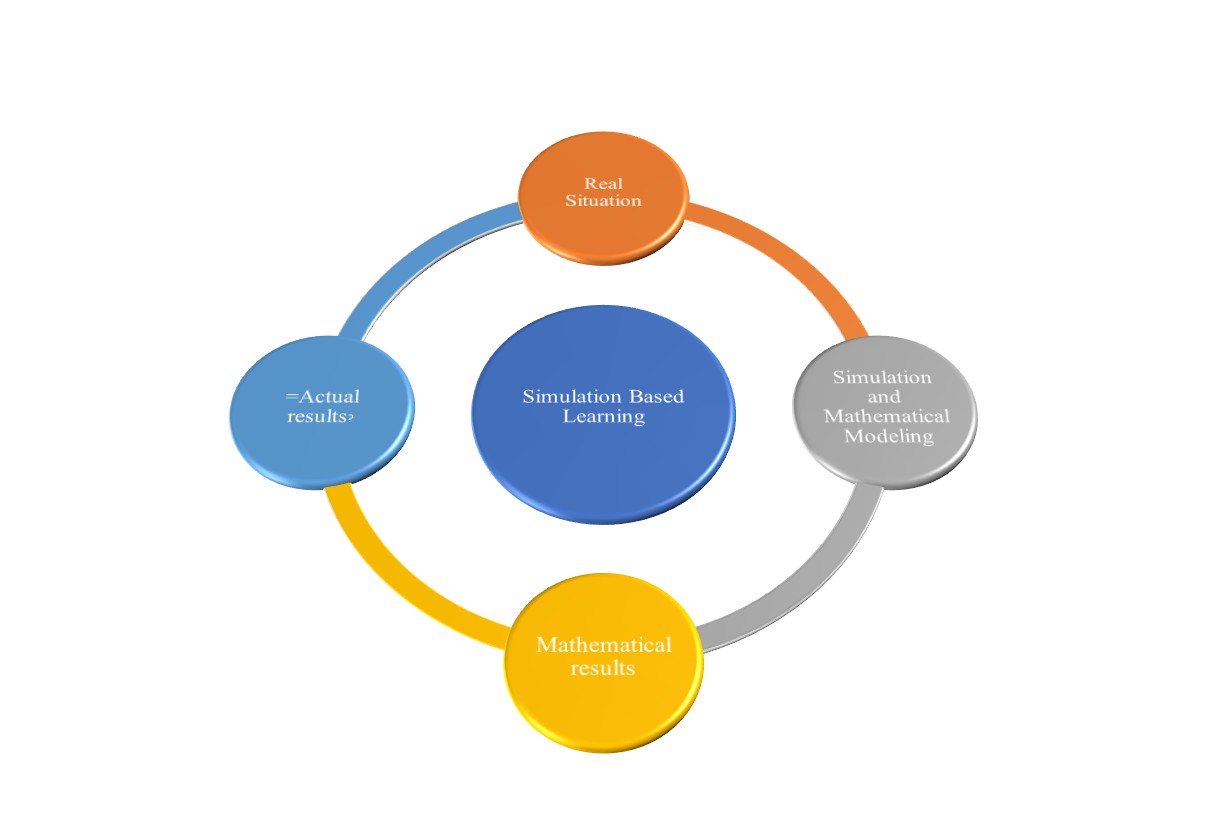
**Fig. 1.** Mathematical and Simulation basic concepts of Research for Education: MSRE

1. **Methodology**

This section describes this study's overall method and then details the evaluation methods. The overall method of the study is summarized in the diagram in Fig. 1.

The simulation-based learning happened in cycles, as shown in Fig. 2 below.

**Fig. 2**. Overall methodology of the study



**Fig. 3**. Simulation-based learning: SBL Cycle

The evaluation methods were an 80/80 learning outcome evaluation and a student’s course satisfaction evaluation. The sample group and population of these evaluations were 28, 3rd-year, water supply engineering and sanitary system students at Ramkhamhaeng University in academic year 2022. The quality of the mathematical models, the exercises, and the pre and post-test were examined and approved by a panel of three experts, obtaining an average Index of consistency: IOC of 0.83, as shown in Table 3. The level of quality of test papers were listed in Table 4. The statistics used were mean, standard deviation, and E1/E2.

**Table 2**. Approvement level of the panel of three experts

|  |  |  |  |
| --- | --- | --- | --- |
| **Statements** | **Mean** |  | **Interpretation** |
| 1. Subject content | 0.81 | 0.18 | Excellent |
| 2. Logical sequence | 0.84 | 0.19 | Excellent |
| 3. Language | 0.67 | 0.00 | Fair |
| 4. Exercise | 1.00 | 0.00 | Excellent |
| Average | 0.83 | 0.11 | Excellent |

**Table 3**. Quality of test papers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Reliability statistics** | **Quality of test papers (Items)** | | | |
|  | **1** | **2** | **3** | **4** |
| Scannell and Tracy, 1975: 223  (Difficulty Index), (p) | 0.61 | 0.73 | 0.65 | 0.53 |
| Scannell and Tracy, 1975: 228 (Discrimination Index), (r) | 0.30 | 0.54 | 0.62 | 0.58 |
| Reliability Statistics (N of Items = 4) | Cronbach’s Alpha coefficient: | | | |
| .702 | | | |

1. **Results and discussion**

The main results are the following. The assigned standard criterion of 80/80 was exceeded by the result, at 85.71/97.78 (see Table 4). The average post-test score was 95.36% (see Table 5). Both demonstrated the effectiveness of the course. The average level of acceptance of the course was high at 4.05 out of 5, demonstrating that the students liked the way the course was taught. On the various aspects of acceptance, ‘interaction and participation’ scored the highest at 4.51 (see Table 6), demonstrating that the students were really interested in learning the course. In addition, the students enjoyed their times together in field trips and discussion sessions. They actively learned the subject in an enjoyable way. In conclusion, the medium was demonstrated to be effective for future classes.

**Table 4.** The efficiency of this SBL.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tool** | **N** | **Mean** |  | **Percentages** |
| Quiz (E1) | 28 | 195.36 | 15.75 | 85.71 |
| Post-Test (E2) | 28 | 75.64 | 7.70 | 97.78 |

**Table 5.** post-test score on field work

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tool** | **N** | **Mean** |  | **Percentages** |
| Post-Test on field work | 28 | 95.36 | 6.37 | 95.36 |

**Table 6.** Students’ satisfaction towards simulation-based learning.

| **Statement** | **Mean** |  | **Interpretation** |
| --- | --- | --- | --- |
| 1.Perceive Usefulness | 4.03 | 6.25 | fair |
| 2.Perceived | 3.98 | 8.07 | fair |
| 3.1 Feedback | 4.19 | 7.77 | fair |
| 3.2 Interaction and participation | 4.51 | 6.38 | Excellent |
| 3.3 Measurement and evaluation | 3.97 | 6.94 | fair |
| 4.Intention to use | 4.03 | 6.63 | fair |
| Average | 4.05 | 7.00 | fair |

1. **Conclusion**

This study was a development and evaluation of a simulation-based learning course for water supply engineering and sanitary system students at Ramkhamhaeng University. The course was well-received and effective, accomplishing a student acceptance level of 4.05 out of 5 and an E1/E2 of 85.71/97.78. The students were actively learning the subject and enjoyed interactions with their classmates. In the future, the author will apply simulation-based learning to other subjects and fields of study.

**Conflicts of Interest**

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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