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Enhancing Hydrologic Modeling Skills of Hydraulic and Water Resources Engineering Students through Interactive Simulation Software: A Case Study at Wolkite University

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Abstract

This research investigates the enhancement of hydrologic modeling skills of hydraulic and water resources engineering (HWRE) students at Wolkite University through the use of interactive simulation software. A total of seventeen students were participated, which comprised two females and fifteen male students. The study also tried to include twelve lecturers, comprising three female and nine male lecturers. Both primary and secondary data were collected to assess skill levels and identify gaps in knowledge.

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Questionnaires were designed for both students and lecturers, focusing on existing competencies, teaching methodologies, and software usage experiences. The researchers conducted targeted training sessions mainly on two key software tools, which are HECH-GEOHMS (Hydraulic Engineering Center for Hydrology-Geospatial Hydrologic Modeling System) and HECH-HMS (Hydrologic Modeling System). The training program comprised hands-on software that allowed students to engage with real-world scenarios, thereby enhancing their understanding of hydrologic processes and modeling techniques. Pre- and post-training assessments demonstrated a significant increase in the students' proficiency in using the software, as well as their confidence in applying hydrologic modeling concepts. Results indicate that students exhibited drastic positive changes in skill levels, with an average improvement of over 80% in their ability to apply hydrologic modeling techniques effectively. The student's improvement in hydrologic modeling skills was also evaluated by exam, desk observations, and project work. This research underscores the importance of interactive learning tools in engineering education and recommends further integration of simulation software into the curriculum. By bridging the gap between theoretical knowledge and practical application, this study contributes to the preparation of future engineers equipped to tackle real-world water resource challenges. Future research can explore long-term impacts on student career readiness and the potential for similar training programs in other engineering disciplines.

Keywords: Hydrologic Modeling; Interactive Simulation Software; HECH-GEOHMS; HECH-HMS; Engineering Education; Skill Enhancement; Water Resources; Action Research; Student Engagement.

1. Introduction

Hydrologic modeling is essential for hydraulic and water resources engineering program, providing essential insights for effective water management and environmental protection. As global water-related challenges intensify exacerbated by climate change, population growth, and urbanization the need for skilled professionals capable of addressing these issues has grown significantly [22]. In Ethiopia, where water resource management is crucial for sustainable development, it is vital that engineering students acquire not only a strong theoretical foundation but also practical skills applicable to real-world scenarios.

At Wolkite University, the curriculum for Hydraulic and Water Resources Engineering students emphasizes theoretical and practical knowledge in hydrology; however, there is a notable gap in the practical application of these concepts. Traditional teaching methods, which primarily rely on lectures and textbook learning, often fail to engage students in the dynamic complexities of hydrological systems [30].This lack of engagement can hinder students' ability to effectively translate theoretical knowledge into practical problem-solving skills, leaving them unprepared for the challenges they will face in their professional careers. To bridge this gap, this action research explores the integration of interactive simulation software as a pedagogical tool to enhance hydrologic modeling skills among students. Interactive simulations offer a unique opportunity for students to engage with hydrological processes in a virtual environment, allowing for experimentation and immediate feedback [15]. Such an approach not only increase active learning but also enhances critical thinking and problem-solving abilities, essential competencies in the field of water resources engineering [6].

1.1. Interactive Simulation Software

The introduction of simulation software targets to provide a hands-on learning experience, helping students to visualize and manipulate hydrological models. This interactive method is expected to increase deeper understanding and retention of complex concepts.

1.2. Importance of Interactive Simulation Software

The integration of interactive simulation software in engineering education has gained attraction due to its ability to enhance student engagement and understanding. Interactive simulations enable students to visualize dynamic processes, manipulate variables, and observe the outcomes in real-time, thereby bridging the gap between theoretical knowledge and practical application [14]. Studies have shown that such tools can significantly enhance learning by increasing active participation and critical thinking [18].

1.3. Enhancing Learning through Technology

Numerous studies underline the effectiveness of technology in improving educational outcomes. For instance, **[3]** found that students using computer simulations for chemistry concepts exhibited greater conceptual understanding than those who relied solely on traditional teaching methods. This trend is mirrored in engineering disciplines, where interactive simulations have been shown to enhance students' grasp of complex concepts, particularly in hydraulic and water resources engineering [24]. By providing a hands-on learning experience, interactive simulations can enable students apply theoretical principles to real-world occasion, thereby improving their problem-solving skills [7].

1.4. Studies in Engineering Education

Studies have highlighted the successful implementation of interactive simulations in engineering program [17] . Conducted a study in a civil engineering context, revealing that students who engaged with simulation software demonstrated greater understanding of hydrological modeling concepts compared to their peers who did not utilize such tools. This finding supports the notion that interactive learning environments can significantly contribute to the enhancement of critical skills necessary for future engineers [25].

A study by [20] also emphasized the importance of aligning curriculum goals with the use of interactive technology. Their research indicated that when simulations were integrated thoughtfully into the curriculum, students were better able to connect theoretical knowledge with practical applications, leading to higher levels of retention and understanding.

1.5. Limitations and Considerations

Despite the advantages, the adoption of interactive simulation software in educational settings comes with challenges. Instructors may require training to effectively incorporate these tools into their teaching practices [1]. Technical issues can also arise, potentially disrupting the learning process. It is also essential to ensure that the use of technology aligns with educational objectives to maximize its effectiveness [13]. Research indicates that without proper integration and support, the potential benefits of interactive simulations may not be fully realized [11].

A primary constraint is the sample size, which may be limited due to the availability of students and lectures, potentially affecting the generalizability of the results as only seventeen students and twelve lectures are included in the study. Other limitation was access to the interactive simulation software may vary among students, leading to unequal engagement and learning opportunities. Variability in students' prior knowledge and technical skills can further influence their ability to effectively utilize the software, resulting in divergent learning outcomes. Time constraints also pose a challenge, as limited instructional periods may restrict the depth of training and practice. The success of the study is contingent upon the integration of the simulation into the existing curriculum, which may not always be seamless. The expertise of instructors with the software can vary, impacting the quality of instruction delivered. External factors, such as internet connectivity or hardware limitations, may hinder the practical application of the simulation tools. The assessment methods used to evaluate skill enhancement may not comprehensively capture all dimensions of student learning, and the study primarily focuses on immediate skill acquisition without evaluating long-term retention.

2. Materials and methods

2.1Research Design

To get tangible information regarding how to enhance students' hydrologic modeling skills through interactive simulation software in learning and teaching process, descriptive survey information design were used. A descriptive survey method is one of the commonly used methods of research which is mostly used in almost all science disciplines when one wishes to generate handful and generalized information on a certain issue.

2.2 Sampling Method

Simple random sampling method was used to provide questionnaires to lecturers and all seventeen students were taken to respond questionnaires. Random sampling provides a process in which each subject has an equal and independent chance of being selected.

2.3 Data Collection Method

One is the raw data that will be collected and assessed in order to define the actual causes of problems, which is the basis on which action plans can be developed. Benchmarked data is related information that is often collected in order to provide possible solutions for developing the action plans and making improvements. The researchers can plan to collect benchmarking information on reading while, at the same time, collecting the raw data from the subjects. This process could help the researchers be more efficient in the action research process.

The primary sources of data were obtained from students and investigation direct within practical classroom while the secondary data was obtained from department, library, college of engineering and technology to refer to different documents related to the possible existence of similar works related to this study. The secondary data was also obtained by asking Google and searching different articles available at different journal sites.

Before crossing to discuss pre and post simulation skills of students on the respective software it is quite necessary to describe raw data of students and lecturers who were the participants of the research. Proper arrangements of data and procedures are very crucial for the successful completion of every research. Organizing the number of participants is among different data necessary for the research.

Table 1: Classification of student respondents based on different criteria

Criteria	Category	Number of Respondents	Percent of Respondents
1. Gender	A. Mel B. Female	A=15 B=2	A=88.24 B=11.76
2. Residence Origin	A. Urban B. Rural	A=10 B=7	A=58.82 B=41.18
3. Working Computer ownership status	A. Have personal computer B. Have no personal computer	A=9 B=8	A=52.94 B=47.06
4. Has Schedule for software practices	A. Have Sufficient time for Software practice B. Have no sufficient time for software practice	A=3 B=14	A=17.65 B=82.35

Table 1 above indicates that two students or 11.76 percent of the students are female and 88.24 percent of students are male. The majority of students 58.82 percent are from rural areas, which was a big obstacle for the researchers as they attempted to provide trainings aimed at enhancing their skills. Approximately 52.94 percent of the students have a personal computer, which also contributed to the variations in students' software simulation proficiency. Due to a variety of obligations, including reading for their exit exam to obtain their under graduating credential and conducting graduate research, 82.35 percent of students do not have best enough time for software sessions at home. The goal was to establish a similar learning environment for the students by addressing and arranging data in this manner.

Table 2: General information on lecture respondents

Criteria	Category	Number of Respondents	Percent of Respondents
Gender	A.Male B.Female	A=9 B=3	A=75 B=8.33
Experience	A.Below 5 years B.Between 5 and 8 years C.8 and 12 years	A=1 B=6 C=5	A=8.4 B=50 C=45.46
Qualifications	A. BSc degree B. MSc degree C. PHD holder	A=0 B=10 C=2	A=0 B=83.33 C=16.67

Table 2 above shows that 75 percent of lecturers were men, which is almost nine times the percentage of lecturers who were women. The researchers made an effort to take into account the opinions and recommendations of knowledgeable and experienced lecturers. Three female and nine male lecturers made up the respondents; the majority of them 83.33 percent had an MSc degree, 16.67 percent have a PHD, and no lecturer was found to have a BSc; all of them have an MSc or PHD. Information about lecturer participants was gathered with the intention of gathering critical opinions on how to methodically work on students' simulation skills improvement.

Table 3: Software that students frequently used in their program

Questionnaire	Type of software	Number of Respondents	Percent of Respondents
What types of software have you been using in your program?	A. ArcGIS B. Global Mapper C. HEC-GEOHMS D. HEC-HMS E. Google Earth F. Softonic Software G. Software Informer H. ESRI I. Get Into PC J. ALASKA	A=10 B=3 C=1 D=0 E=3 F=0 G=0 H=0 I=0 J=0	A=58.82 B=25 C=8.33 D=0 E=25 F=0 G=0 H=0 I=0 J=0

The data required for students to download, install, and use software that is essential to their success and the success of this research is displayed in **Table 3** above. The following crucial data was gathered: 58.82 percent of students use ArcGIS software for various objectives, which was crucial to the success of this study. Hydrologic modeling cannot be attempted without GIS. ArcGIS software was used to produce a large number of imputes for both HEC-GEOHMS and HECHMS. The researchers discovered that, prior to this semester; every student had taken ArcGIS software as a course during their first semester of their study. Only one of the seventeen students knew anything about HEC-GEOHMS, which was determined to be important information regarding the degree of work that should be done for students during their initial software training. Prior to the researchers' subsequent training sessions, it was discovered that none of the students knew anything about the HEC-HMS program. The majority of students had no idea how to get software setups from software setup sources such as Softonic, Software Informer, ESRI, and get into PC. Students were also found to be unable to obtain the required DEM, shape data, and other imputes from ALASKA and other raster and vector data sources. In order to conduct the research efficiently, the researchers also had a major task: teaching students how to download various data from ALASKA ESRI and other sources.

3. Results and Discussion

3.1 Data Interpretation

The quantitative data was analyzed by using descriptive statistics. It was used to analyze data from the result of the teaching learning process. It was done to compare the students' hydrologic modeling stimulation skill before and after the action or the result of pre-modeling and post-modeling of software. The mean of the pre-modeling and the post modeling skills are calculated with the formulas as follows:

$$X = \frac{\sum_{i=0}^{n} Xi}{N} \quad Y = \frac{\sum_{i=0}^{n} \mathrm{Yi}}{N} \ldots\ldots..(1)$$

X = means of pre-action software running skills

Y = means of post-action software running skills

N = the number of sample taken

[Sumanto, 1995: 210]

3.2 Interpretation of Students Responses

3.2.1 Pre-Assessment Survey

In order to identify what is going to be done for students, it was mandatory to evaluate students' prior knowledge of hydrologic models using different methods such as questionnaires, premier classroom investigations, and interview pre-assessment survey was made.

Table 4: Students' responses on hydrologic modeling skill problems in their program

Questionnaire	Alters for Practice	Number of Respondents	Percent of Respondents
What Challenges have been facing you when you to practice hydrologic modeling software regularly?	A. Absence of hydrologic modeling software setup B. Complexity of the hydrologic modeling software C. Working environment problems	A=6 B=8 C=3	A=50 B=66.67 C=25

According to **Table 4** above, six students or 50 percent of students encountered difficulties of getting software setups for performing hydrologic modeling simulations specially ArcGIS software setup and the compatible setup of HECH-GEOHMS so they could hardly practice hydrologic modeling software simulation. About sixty-seven percent of students were discovered that hydrologic modeling software was too complicated and attempted to simulate on their own. In addition to these, 25 percent of students report difficulties with the computer-based learning environment. For the researchers to complete their objectives, these were some extremely costly issues.

Table 5: Students Response on additional main hydrologic modeling software simulation skill problems

Questionnaire	Challenge	Number of Respondents	Percent of Respondents
What is the main cause for low skills performance in hydrologic modeling software simulation?	A. Presence of improper classroom for software practices B. Lack of software learning interest C. Teachers lower commitments to teach hydrologic modeling software D. Lack of academic leaders supervision on their progress of academic activities	A=9 B=3 C=4 D=2	A=75 B=25 C=33.33 D=16.67

75 percent of students experienced inappropriate classroom setups for software activities, as seen in **Table 5** above. To perform research tasks effectively computer classrooms labs should have complete software, internet access and other accesses for students. Teachers are becoming less committed to teaching hydrologic modeling software as a result of the current teachers' national issues. 33.33 percent of students express dissatisfaction with the hydrologic modeling instruction they receive from concerned teachers due to the teachers' negative remarks.

Table 6: Students response on solutions that can enhance their hydrologic modeling simulating software skills

Questionnaire	Alternative	Number of Respondents	Percent of respondents
What teaching Method do you think that can enhance students' hydrologic modeling software simulation skills?	A. Theoretical teaching method B. Practical simulation through LCD and desktop C. Both combination of A and B	A=22 B=8 C=7	A=16.67 B=66.67 C=58.33

As can be seen from **Table 6** above, 66.67 percent of students thought that receiving practical simulation instruction via desktop or personal computer would improve their modeling skills, and 58.33 percent of students thought that a combination of theoretical lectures and practical simulation lectures would close their skill gaps. Only 16.67 percent of students were found to think that theoretical lectures and then self-home practices could fill in the ability skill gaps in software simulation.

Table 7: Students response show how they have been alleviating hydrologic modeling software skill gaps

Questionnaire	Response	Number of Respondents	Percent of Respondents
In case you get hydrologic modeling software skills in your study program, how have you been responding it?	A. Ask Google and you tube	A=10	A=83.33
	B. Search Articles	B=2	B=16.67
	C. Ask help from concerning lecturers	C=5	C=41.67

Table 7 above told us that ten students or over half percent of students are attempting to address hydrologic modeling skill gaps by consulting Google and YouTube, but it is insufficient information; they need get frequent, structured, and formal lectures on both theory and practice based lectures . The students s' poor levels of guidance and inappropriate usage of technology result in a very low habit of acquiring theoretical and practical information through article researches. Additionally, there is very little probability that the students will attend any of the offered training facilities.

3.3 Interpretation of Lectures Responses

Table 8: Lecturers response on hydrologic modeling software skill necessary in their course

Questionnaire		Software	Number of Respondents	Percent of Respondents
On which hydrologic modeling software students show low Knowledge and skill but it's very important?	A.	HECH-GEOHMS	A=1	A=8.33
	B.	HECH-HMS	B=4	B=33.33
	C.	SWAT	C=3	C=25
	D.	HECH-GEORAS	D=1	D=8.33
	E.	HECH-RAS	E=2	E=16.67
	F.	WATER-GEMS	F=1	F=8.33

Table 8 above shows that four lecturers or 33.33 percent of the lecturers thought that HECH-HMS software was highly important and should be provided to fifth-year students studying hydraulics and water resources engineering. Additionally, 8.33 percent of instructors demonstrated that since HECH-GEOHMS software's output is used as input for HECH-HMS software, it should be taught as part of the practical hydrologic modeling course content before HECH-HMS software. SWAT software also should be taught as part of the hydrologic modeling course, according to a small percentage of the instructors. Of the twelve lecturers, 8.33 percent agreed that the WATER-GEMS software is highly significant and should be given to students before they enter their fifth year. They also suggested that the students attend the course when they enter their fourth year. After the students have received the aforementioned software, it is finally determined that both HECH-GEOHMS and HECH-HMS are required and ought to be given trainings for this 1st round of training.

Table 9: Lecturers response on why students show low hydrologic modeling software simulation skill

Questionnaire	Constraints	Number of Respondents	Percent of Respondents
Why do students show low hydrologic modeling software simulation skill problems mostly in their class?	A. Absence of Hydrologic Modeling Software Setups	A=4	A=33.33
	B. Lack of students interest to practice	B=2	B=16.67
	C. Complexity of software for both students and instructors	C=6	C=50

According to **Table 9** above, six instructors or half percent of the instructor respondents stated that the complexity of the software for both students and the instructor was the main cause of the low hydrologic modeling software simulation skill issues that were observed in their class. Additionally, 33.33 percent of the respondents said that the lack of hydrologic modeling software setups and the difficulty of installing them were the main causes of the low hydrologic modeling software simulation skill issues that were observed in their class. Absence of regular trainings for students and improper arrangement of classrooms for practices were also covered equal portions of problems for students to become more effective. Other economic constrains for practices was also found to be another cause of problem for student's success of software simulation skill.

Table 10: Lecturers response on other issues why students show low hydrologic modeling skills

Questionnaire	Constraint	Number of Respondents	Percent of Respondents
Why do students show low hydrologic modeling software simulation skill problems mostly in HWRE program?	A. Lack of tangible and target full connection between software, instructors and students B. Lack of Resources for students and instructors to practice software in the respective years of class levels C. Presence of time constraints	A=5 B=6 C=1	A=41.67 B=50 C=8.33

It is evident from **Table 10** above that half percent (50%) or six lecturers said that the main reason for inadequate skill performance in hydrologic modeling software simulation was a lack of resources for instructors and students to practice software in the corresponding years of class levels. According to five lecturers or 41.67 percent of total lecturers, students' low skill performance efficiency is caused by a lack of a precise and palpable relationship between students, teachers, and software. Another factor contributing to decreased software simulation skill capabilities was discovered to be the existence of time restrictions for both teachers and learners.

4. Planning of Action Strategies

After deep study was taken place to identity the prominent problems cases and what solves them for proceeding skill improvement works different action plans and strategies were targeted. Depending on the discovery of the research, different actions were taken place based on the constraints stages and types of factors faced in improving hydrologic modeling simulation skills of hydraulic and water resources engineering fifth year students of Wolkite University.

Table 11: The strategies taken place in the process of implementation of actions are presented by the table blow

No	Action to be taken	Methods	Time action taken	Participants
	1.Informing the problem and action research	Make aware of the issue to the head of department of hydraulic and water resources engineering ,lecturers and the targeted 5th year HWRE students on the discovery of plan	20-02-2025 GC.	Students,Lecturers,Researchers, Head of the department
		Holding discussion with head of department of HWRE for assignment of the researchers at 5th year HWRE hydrologic modeling course practical session	17-03-2025 GC	Head of department of HWRE and the researchers
	2.Discussion with students	❖ Advising students the advantages of having good hydrologic modeling software simulation skills ❖ Advising the students to have strong commitment to practice hydrologic modeling software	20-03-2025GC.	Students, Researchers
	3.Creating conducive teaching and learning practical classroom atmosphere	❖ Identify the number of desktops that are functional ❖ Assign every student at a single functional desktop ❖ 1st download and Install ArcGIS software version 10.2 for all students by taking long tiresome session plan and give lecture about ArcGIS software	10-04-2025GC.	Students and the Researchers
	4.Give Lecture and guide	❖ Introduction about HECH-GEOHMS software ❖ Teach the compatibility of HECH-GEOHMS software with ArcGIS software ❖ Show and guide how to download and install HEC-GEOHMS software version 10.2 at original website ESRI that is compatible with ArcGIS version 10.2 ❖ Show how HEC-GEOHMS become ArcGIS tool	03-04-2025 GC.	Students and Researchers
	5.Give Lecture and guide	❖ Give Introduction to HEC-HMS software ❖ Guide and show how to download and install HEC-HMS software for all students ❖ Lecture relationship with HECH-GEOHMS software ❖ Lecture HECH-HMS software window components, tool bars and what will be done with each toolbar and window components ❖ Show how to prepare input data and enter data to HECH-HMS	10-04-2025GC	Students and Researchers

According to Table 11 above, deliberated planning of action strategies were taken place to complete the research by alleviating students' skill gap problems. First informing the problem and action research proposal for all students, lecturers and head department of HWRE were taken place before all the actions going to be done for students. Secondly long discussions with students were held to convince the importance of learning hydrologic modeling software. Thirdly creation of conducive teaching and learning practical classroom atmosphere were taken place on the date 10-04-2025 this activity included identify the number of desktops that are functional, assign every student at a single functional desktop, download and install ArcGIS software version 10.2 for all students by taking long tiresome session plan and give lectures about ArcGIS software. At fourth stage lectures and guidance were given for students. The lecturing session included, introduction about HECH-GEOHMS software, teach the compatibility of HECH-GEOHMS software with ArcGIS software, show and guide how to download and install HEC-GEOHMS software version 10.2 at original website ESRI that is compatible with ArcGIS version 10.2, show how HEC-GEOHMS will be become ArcGIS tool. Finally lecturing and guidance of HEC-HMS for students were given on the date 10-04-2025GC.This activity was included giving introduction to HEC-HMS software, guide and show how to download and install HEC-HMS software for all students, lecture the relationship with HECH-GEOHMS software ,lecture HECH-HMS software window components, tool bars and what will be done with each toolbar and window components. Generally the processes of on HEC-HMS installation, data entry, simulation were conducted step by step by giving appropriate time schedule.

5. Execution of Intervention

5.1. Intervention

interactive simulation software in the programs' course at this 2nd semester of 2025 was implementing.

5.2 Implementation of First Action

First the awareness of the issue of action research plan on skill performance improvement of 5th year hydraulic and water resources engineering students towards hydrologic modeling through interactive simulation software was informed to the head of department of hydraulic and water resources engineering and then to the targeted 5th year HWRE students was made on 20-02-2025 .Practical session and tutorial classes time schedules were fixed after permission and cooperation promises obtained from dean of college of engineering and technology after nice and big discussion . The undergraduate 5th HWRE instructors were also cooperated with researchers so as to aware students about the problem and its effect on their future career and in their every model development process in general, and on the students commitments to do practices strongly Particular.

Result of First Action

Following awareness made the head of department and lectures became very kind and positive towards the plan of action implementation on 5th HWRE students' skill performance improvement through interactive simulation software. Specifically the head of the department was very supportive and promised to give material support what his department can.

5.3 Implementation of Second Action

The researchers invited the students for computer practical class session on the date 20-03-2025GC. On this day the researchers appeared to the class and observed the arrangements of desktop computers, checked how many computers are functional and assigned every student on a single computer. During this day, the students were concerned in the class room how learning will be proceed because some software work in ArcGIS as toolbar and ArcGIS installation was quite difficult for them. In addition to that the compatibility of ArcGIS was also another challenge. On this day, the researchers before ending the class, taught students about the compatibility of ArcGIS with other software. The researcher delivered ArcGIS version 10.2 setup to all students together with the compatible HEC-GEOHMS version 10.2 setup. The researchers added that the importance of learning in a deep interest. After advising, the researchers agreed with the student to have another practical class on the same date 20-03-2025GC. The students were agreed to come and promised to tell students not to absent and perform activities they missed in that day class.

The Results of 2nd Action

After the researchers taught the students about how to work and run other software on ArcGIS software, fixed none functional desktops, arranged classroom in good manner to conduct practical trainings, delivered all files that are necessary inputs for software, the student became egger to do activities. The students promised to come to next class on the time.

5.4 Implementation of 3rd Action

Because the installation of ArcGIS at all students' desktop computer was very tedious and time talking it was done on another full day's program.HEC-GEOHMS software that is compatible with ArcGIS software installation was also done on the same day when installation of ArcGIS was done.

5.5 Implementation of 4th Action

The practical class was held on 03-04-2025 GC. On that day, the researchers taught well about the competent toolbars of HEC-GEOHMS and showed how to connect it with ArcGIS and showed practical simulations how to model watershed using this software. Questions were raised to students to discuss together in order to make them aware about the software. On that day almost all students were came to the class on time. When the students tried the questions, the researchers motivated them by saying very good, Excellent, keep up it. In addition, gave moral reward. During that time, most students became more active and gave more attention to the teaching learning process than the former class days. But not all students gave more attention; still there ware little confusion on students, because of the presence of complexity of software and lengthy processes. The researchers before ending the class, agreed about to have another practical class on, 10-04-2025GC.On the other practical class day , on 10-04-2025GC, the researchers tried to handle each and every challenge that the students couldn't solve and gave hands on all computers to run the software successfully by processing and importing inputs. The researchers prepared themselves more than the previous other days to teach, by supporting students with technical issues. During that day the researchers invited the less active students and gave advice in peaceful way by saying that they are mature, and to achieve their objectives not to be let and to practice hard. Moreover, continued the practical teaching learning process rather than theoretical. During that day all of the student came to the class and tried to dig out what were best. On the same date 10-04-2025GC after repeated lecturing and practical guidance serious measurements were taken on all students in order to know how many of them understand the HECH-GEOHMS and can run independently.

Figure 1: Activity one shown to Students how to Export Gilgel Abay shape from Large Admin

The Gilgel Abay watershed shape file, which is the Abay basin sub-watershed when exported from the largest Ethiopian administrative map, is shown in **figure 1** above. Figure 1 used to extract to figure 2. Figure two shows how to extract a smaller DEM from the larger DEM using shape file. It served as the foundation for acquiring other raster shape files.

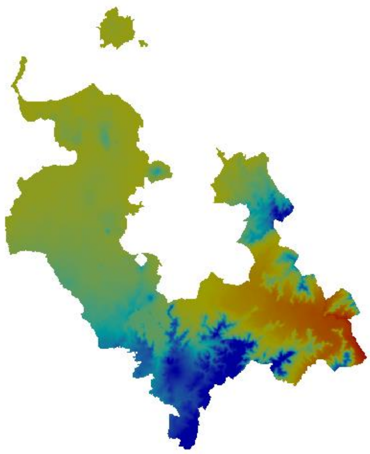


Figure 2: Activity Two shown to Students how to extract Gilgel Abay DEM from Large DEM

Raster **figure 2** above is the DEM that was taken from the biggest DEM utilizing figure one above. It was utilized to process further HEC-GEOHMS software preprocesses, as shown in blown figure three. The out puts for delineation using the HEC-GEOHMS software are displayed blow figure three from fill up to the last adjoining hydrologic processes.

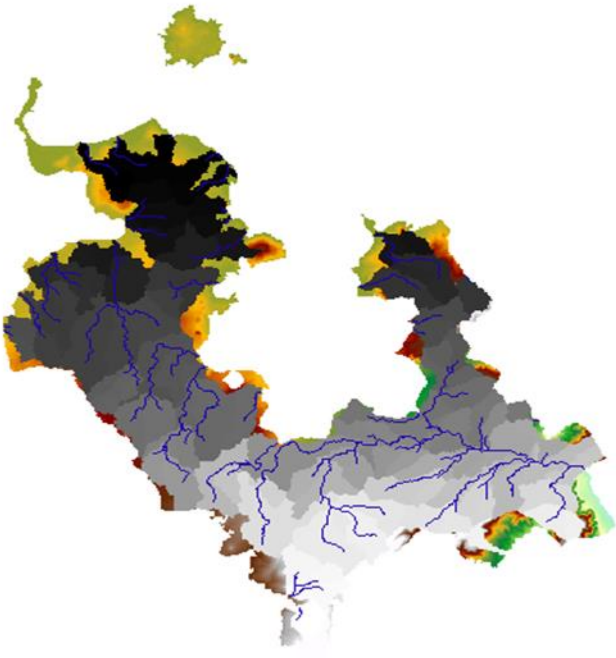


Figure 3: Activity Three shown to Students how to lookup of Preprocessing Step

HEC-GEOHMS preprocessing components from fill up to adjoining catchments are depicted in Figure 3. This is the watershed's general condition, suitable for project creation with the HEC-GEOHMS program. The graphic makes it evident which way the stream flows and most likely where the watershed's exit will be. Generally the figure shows lowlands, highlands, flow direction, polygons and joining catchments.

Figure 4: Activity Four HECH-GOHMS Modeling process up to Project Setup step for Gilgel Abay watershed at Bahir Dar Zuria woreda

After an outlet was chosen using a variety of procedures, the software displayed number of sub watersheds and the direction of stream lines, generally the HEC-GEOHS software produced the project shown in **figure 4** above. The green lines are stream lines showing the flows from each sub watersheds to the outlet. The smaller polygons inside the larger polygon are sub watersheds.

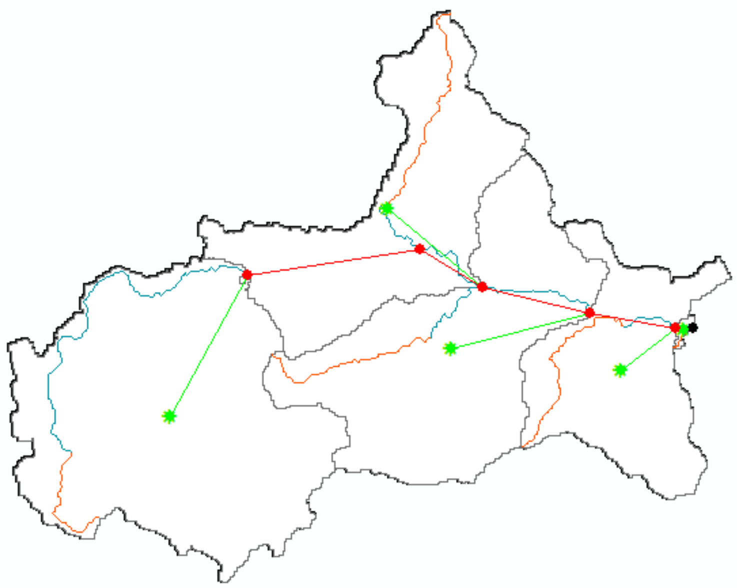


Figure 5: Activity Five shown to Students HECH-GOHMS Successfully Completed Model for Gilgel Abay watershed at Bahir Dar Zuria woreda

Figure 5 illustrates the appearance of HMS schematics after they have been drowned using HECH-GEHMS Tool bars.In order to help students visualize the notion, HEC-HMS can call the work that has been done with HEC-GEOHMS at this point. It would clearly display the watershed's characteristics, the centroid's location, the outlet's location, etc. The polygons inside the watershed are subbasins whereas the red and green straight lines show the flow direction from each subbasin to the outlet marked by the black point. The red and green points show the centroids of each subbasin. Red and blue zigzag lines inside the subbasins indicate longest flow path to the outlet of each subbasin.

The Results of 4th Action implementation

On the date 10-04-2025GC after repeated lecturing and practical guidance exam measurement with some marks were taken on all students in order to know how many of them understood the HECH-GEOHMS and can run independently. Evaluation was made after the students were instructed to run HECH-GEOHMS software independently. Among a total number of seventeen students six students run the model successfully without errors and scored full mark. These students were found to have personal computer and have access of their own training rooms. The other eight students run the model with some errors and they were practicing in the computer laboratory classroom have personal computer access in the recent days. The remaining three students couldn’t run the software successfully because they didn’t have personal computer accesses and they didn’t make practices in the computer class regularly. To alleviate this gap the researcher has mad special practical class arrangements for the three late students and made compensation mechanism.

Post-Assessment Survey: Assess changes in understanding and attitudes towards hydrological models. Using methods such as Exam Tests, Observation checklists and Desk review. The Results discovered under this research are presented both in tables and different types of graphics.

Table 12: The numbers of students successfully run HEC-GOEHMS

Criteria	Number of Students	Percent
Run HECH-GEOHMS successfully	6	35.29 %
Run HECH-GEOHMS with some errors	8	47.06 %
Couldn’t run HECH-GEOHMS	3	17.65 %

Because the software is new to the students, as can be seen in **Table 12** above, six students or 35.29 percent from seventeen total students were able to run the HECH-GEOHMS software successfully, eight were able to run it with some errors, and three were unable to run it even up to certain steps. There were two less students who were able to run the HECH-GEOHMS program effectively than there were who were able to run it with some mistakes, and the fewest students were unable to run the software at all. Since most students are using this program for the first time, the data indicates that they are making good progress in comprehending and using it effectively. With a lot of effort, the students were able to become proficient with the software, and most of them were able to use it successfully. It all comes down to allocating their time and effort to exercises on a timetable.

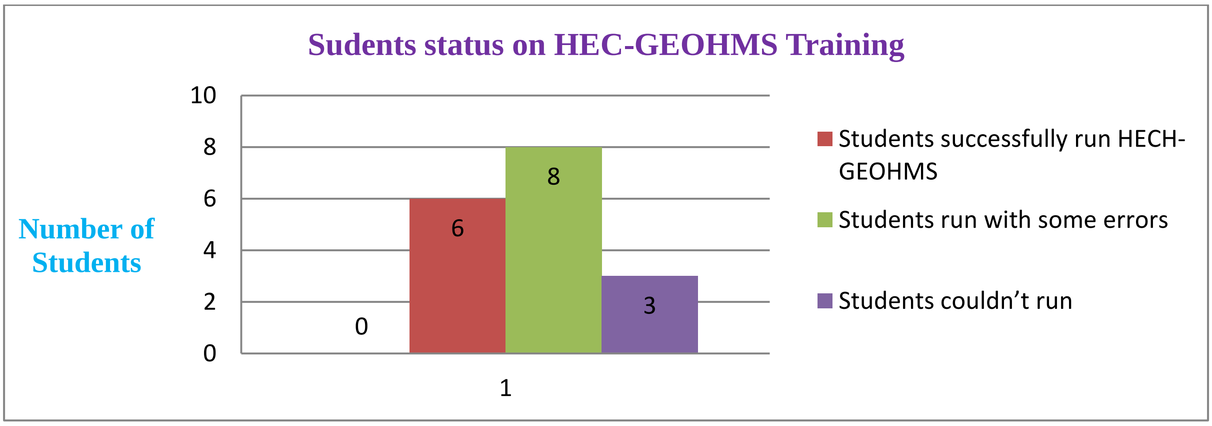


Figure 6: The Status of Students on HECH-GEOHMS Simulation Practices

Figure 6 makes it evident that there are six students who have completed HEC-GEOHMS satisfactorily. The second-longest of the three charts is the red bar chart. As seen by the longest chart, the green bar chart, eight students completed their tasks of running the software with some procedural and data entry problems. Compared to the number of students who could run the software with some faults, the number of students who have successfully ran the software is less than two. Three students, or half of the total number of students that ran the HEC-GEOHMS successfully, were unable to complete it at all, as can be seen in the shortest chart three.

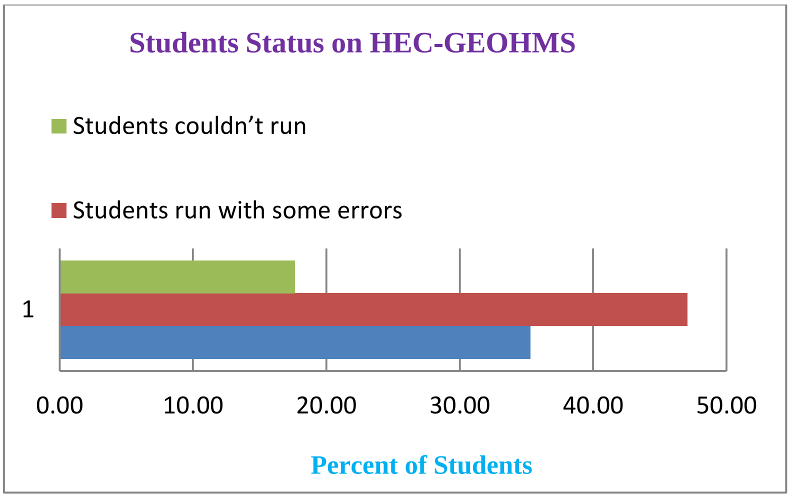


Figure 7: Percent Status of Students on HECH-GEOHMS Simulation Practices

As a percentage of the HEC-GEO HMS program run, the students' status is displayed in **Figure 7** above. About half (50%) of the students, or 47.06 percent, are making considerable development in their ability to utilize the software; even 35.29 percent are capable of being competent users. Of the students, just 17.65 percent of they were unable to use the software due to various issues.

5.6 Implementation of 5th Action

On the date 23-04-2025 the researchers made the second hydrologic modeling software practical simulation lecturing on HEC-HMS software in the usual way as that of HECH-GEOHMS software. Before conducting the practical works the researchers tried to minimize as much as possible the obstacles that faced during 1st phase of HECH-GEOHMS software training. Before practice startup action measurements were taken such as delivering softcopy of practical procedures, installing proper compatible software and maintaining good class environment. Most Students showed better simulation performance than that of 1st training on HECH-GEOHMS software.

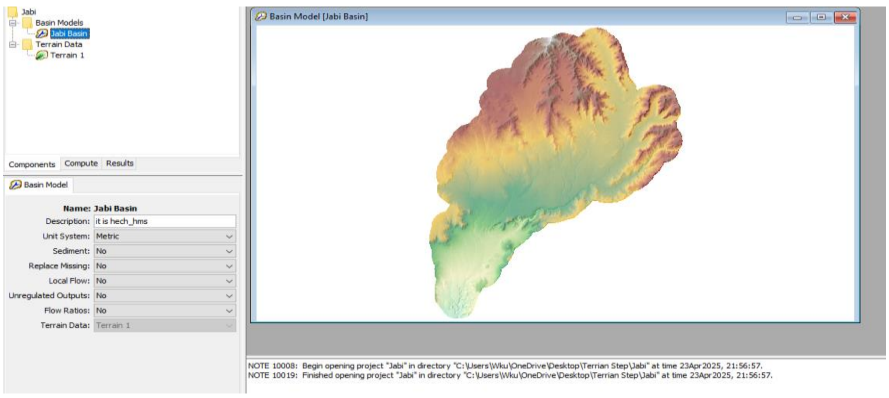
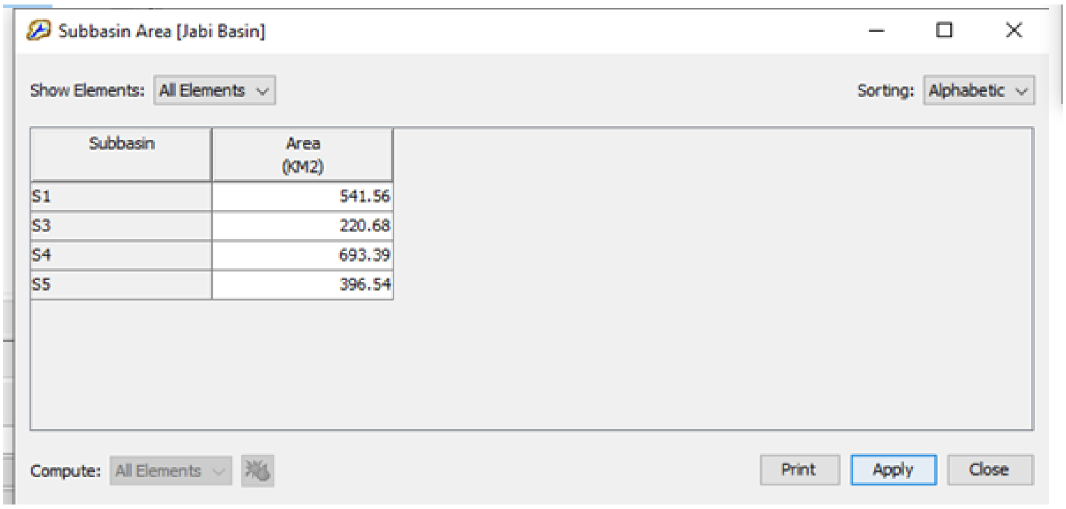


Figure 8: An image shown to students how to create a new terrain dataset of basin model on Nile basin at Jabi Tehnan Woreda using HEC-HMS and ArcGIS

The terrain data set that was imported by HECH-HMS following ArcGIS preparation is shown in figure 8 above. Several ArcGIS toolbox procedures are used to process this for further processes. ArcMap was used to prepare terrain data in the form of Digital Elevation Model (DEM) raster from open-source elevation and watershed boundary. A DEM is a representation of the bare ground topography (elevations) excluding trees, buildings, and any other surface objects. It was used as an input to HEC-HMS to create a terrain dataset, which can then be loaded into a Basin Model for hydrologic analysis. It was used to prepare watershed boundary to clip the extent of the terrain raster for smaller file sizes and faster processing.

Table 13: Shown for students how they can calculate subbasin area after merging several subbasins in to four



Subbasin	Area (KM2)
S1	541.56
S3	220.68
S4	693.39
S5	396.54

Table 13 shows the average number of subbasins formed by combining and modifying subbasins of the bigger total watershed. Analysis of these subbasins was what we were doing. Merging of adjacent subbasins was done for the sake of making easy analysis and data entry for each subbasin properly.

The Results of 5th Action implementation

The Researchers used additional way of technical teaching methods to alleviate challenges that faced during first software simulation practices. Among new techniques used the researchers delivered HEC-HMS software simulation samples for students to practice at their homes before they come to class. Almost all students show very good progress and run the software in good order and tried to understand the output of the simulation.

5.7 Action Evaluation

After different action implementation student's hydrologic model simulation skill became improved from time to time because they adopted conditions and characteristics of software. They adapted to attend the software training class a long periods of time. They also improved to practice independently in the class while learning. The department also agreed to increase the situation of the practical room more favorable for practice and to follow the student's day to day improvement understanding of software. The students' software simulation skills problem was improved, but not as much as the researcher was intended to do.

Among the negative sides of the implementation;

- ❖Because of shortage of time, the researcher could not assess students simulation skill changes on other software such as SWAT and HECH-RAS perfectly
- ❖ Miss behavioral students showed unnecessary words in the class during practical session due to the time taking nature of the training
- ❖Some students keep spoon feeding from the trainer rather than dig out by their own self
- ❖The inputs for the software are not found easily and the procedures of arranging them are lengthy and some students become disinterested

Table 14: Analyses of the number of students who can successfully run HEC-HMS

Status	Number of Students	Percent
Run HEC-HMS successfully	15	88.24
Couldn't Run HEC-HMS Successfully	2	11.76

There has been a significant shift from the initial HEC-GEOHMS software exercise, as evidenced by the **Table 14** above, which shows that fifteen students were able to run HEC-HMS successfully while only two were unable to do so. Students gain familiarity with software processes, suggesting that consistent practice leads to improvements.

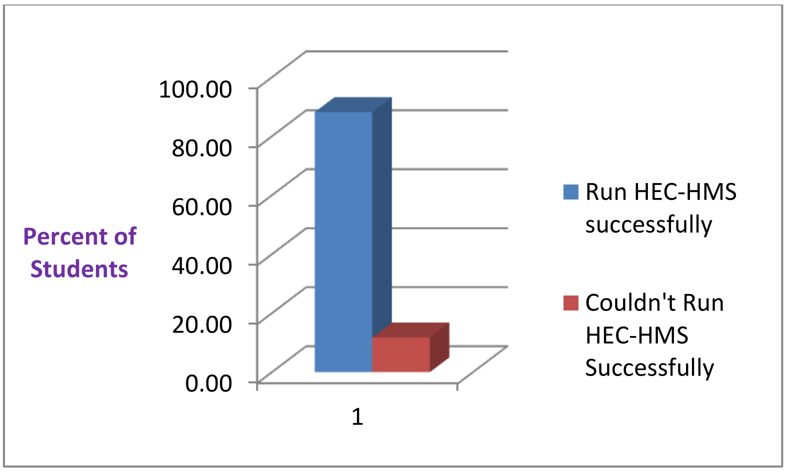


Table 9: The Percent Status of Students on HECH-HMS Simulation Practices

The blue chart in figure 9 above indicates that 88.24 percent of students were able to effectively execute HEC-HMS. The number of students who were unable to effectively run HEC-HMS is much smaller, at 11.76 percent, as seen in the red chart. Significant improvements have also been made to HEC-HMS simulation procedures. The percentage of students that run the HEC-HMS program successfully ranges from 80 to 100, while the percentage of students who never run the software ranges from 0.00 to 20.00.

6. Conclusion and Recommendation

6.1 Conclusion

This action research aimed to enhance the hydrologic modeling skills of fifth-year Hydraulic and Water Resources Engineering students at Wolkite University through the integration of interactive simulation software, specifically HECH-GEOHMS and HECH-HMS. Beginning with HECH-GEOHMS allowed students to build a solid foundation in hydrological processes, while the subsequent transition to HECH-HMS facilitated a more nuanced comprehension of complex modeling scenarios. The interactive nature of these software tools not only engaged students but also encouraged critical thinking and problem-solving skills essential for their future careers. The interactive nature of the software also facilitated a deeper understanding of complex hydrologic processes, enabling students to implement these skills in real-world contexts. The consistent application of these skills in daily tasks demonstrates the effectiveness of using simulation tools in enhancing learning outcomes. The research underscores the importance of incorporating technology in engineering education, suggesting that interactive simulations can bridge the gap between theory and practice. The successful implementation of this approach not only improved the students' modeling skills but also prepared them for future challenges in the field of hydraulic and water resources engineering.

Generally, this research highlights the effectiveness of using simulation software in engineering education, paving the way for more dynamic and interactive learning environments. The positive outcomes suggest that such methodologies can greatly enhance students' practical skills and readiness to tackle real-world challenges in hydraulic and water resources engineering. Future studies could further explore the long-term impact of these skills on professional practice and the potential for expanding the curriculum with additional simulation tools.

6.2 Recommendation

Based on the findings of this action research, it is recommended that there should be full proper integration of HECH-GEOHMS and HECH-HMS software theoretical lecturing session with practical lecturing sessions into the curriculum of Hydraulic and Water Resources Engineering. This integration should involve structured modules that guide students from foundational concepts to advanced modeling techniques, ensuring a comprehensive understanding of hydrologic processes. Regular hands-on trainings should be organized to provide students with practical experience in using these tools, facilitated by faculty or industry experts to enhance learning outcomes. Encouraging collaborative projects will also be beneficial, as they allow students to apply their skills in team settings, fostering peer learning and diverse perspectives. Establishing a feedback mechanism will help gather student insights on their experiences with the software, enabling continuous improvement in teaching methods and tool application.

Implementing assessment strategies to measure learning outcomes will provide valuable data on the effectiveness of the software in enhancing students’ skills. Generally, exploring additional hydrologic modeling tools will broaden students' exposure and adaptability in their future careers. By adopting these recommendations, Wolkite University can significantly enhance the educational experience of its students, equipping them for success in the dynamic field of hydraulic and water resources engineering.

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Reference

[1]. Baker, D. J., & et al. (2015). The impact of simulation technology on learning outcomes in engineering education. Journal of Engineering Education, 104(2), 142-161.

[2]. Baker, R. S., & Goel, A. (2018). The challenges of incorporating simulation software in engineering curricula. Journal of Engineering Education, 107(4), 559-579.

[3]. Barak, M., & Dori, Y. J. (2005). Enhancing undergraduate students' chemistry understanding through modeling. Journal of Chemical Education, 82(1), 153-158.

[4]. Beers, S. Z., & Miro, J. (2018). Interdisciplinary Learning in Engineering Education: A Review of the Literature. International Journal of Engineering Education, 34(4), 947-958.

[5]. Beven, K. J. (2001). Rainfall-runoff modeling: The challenge of nonlinear response. Hydrological Processes, 15(7), 1305-1308.

[6]. Chung, G. K. W. K., Toh, Y. R., & Yew, S. K. (2018). Enhancing student learning through interactive simulations in engineering education. International Journal of Engineering Education, 34(3), 1095-1107.

[7]. Dori, Y. J., & Barak, M. (2009). Engineering education: A holistic approach to learning. Journal of Engineering Education, 98(3), 241-252.

[8]. Finkelstein, N. D., Adams, W. K., & Keller, J. (2005). When learning about the real world is better done virtually: A study of student learning in a fluid dynamics course. Physics Education Research, 1(1), 1-16.

[9]. Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Wenderoth, M. P., & Dirks, C. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the National Academy of Sciences, 111(23), 8410-8415.

[10]. Froyd, J. E., & Simpson, N. (2008). Evidence for the Effectiveness of Active Learning in Engineering Education. Journal of Engineering Education, 97(3), 169-185.

[11]. Gikandi, J. W., Morrow, D., & Davis, N. E. (2011). Online formative assessment in higher education: A review of the literature. Computers & Education, 57(4), 2333-2351.

[12]. Gonzalez, M., Mendez, A., & Lazo, J. (2020). The impact of simulation-based learning on student understanding of hydrological concepts. Journal of Hydrology, 580, 124258.

[13]. Hattie, J. (2009). Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement.

Routledge.

[14]. Hegarty, M. (2004). The cognitive science of 3D graphics: A review of the literature. Psychonomic Bulletin & Review, 11(4), 634-648.

[15]. Hwang, G. J., Wu, P. H., & Chen, C. H. (2013). An online collaborative learning environment for enhancing students' problem-solving skills in hydrology. Educational Technology & Society, 16(1), 118-129.

[16]. Hwang, G. J., Wu, P. H., & Chen, C. Y. (2016). Facilitating and bridging the gap between formal and informal learning through mobile technologies. Computers & Education, 95, 119-128.

[17]. Kauffman, D., et al. (2016). Evaluating the educational impact of simulation software in civil engineering. Journal of Professional Issues in Engineering Education and Practice, 142(2), 04015012.

[18]. Kim, S. Y., et al. (2014). The effects of a web-based simulation tool on learning outcomes in an engineering course. International Journal of Engineering Education, 30(4), 1034-1042.

[19]. Kolb, D. A. (1984). Experiential Learning: Experience as the Source of Learning and Development. Prentice Hall.

[20]. Krajcik, J. S., et al. (2008). The role of technology in supporting inquiry-based science education. Educational Technology Research and Development, 56(4), 445-463.

[21]. Kumar, A., Jain, A., & Singh, R. (2019). Hydrologic modeling in engineering education: A review. Water Resources Management, 33(9), 3273-3289.

[22]. Mays, L. W. (2005). Water Resources Engineering. Hoboken, NJ: John Wiley & Sons.

[23]. Miller, G. R., et al. (2014). The role of simulation in engineering education: A review. Journal of Engineering Education, 103(1), 1-17.

[24]. Prince, M. (2004). Does active learning work? A review of the research. Journal of Engineering Education, 93(3), 223-231.

[25]. Rakes, T. A., Valentine, J. C., & McGowan, J. (2016). The impact of instructional technology on student achievement in engineering education. Journal of Engineering Education, 105(3), 317-334.

[26]. Remote Sensing | Space4Water Portal

[27]. Singh, V. P. (1995). Elementary Hydrology. Prentice Hall.

[28]. Twenty-Five Years of Hydroinformatics

[29]. University of Wisconsin-Madison | Infusing Real World Experiences into Engineering Education | The National Academies Press

[30]. Zawadzki, M. (2017). The impact of simulation software on students' understanding of water resources engineering. Water, 9(3), 198.

[31]. Delaigue, O., Brigode, P., Thirel, G., and Coron, L.: airGRteaching: an open-source tool for teaching hydrological modeling with R, Hydrol. Earth Syst. Sci., 27, 3293–3327, https://doi.org/10.5194/hess-27-3293-2023, 2023.

[32]. Singh, V.P. Hydrologic modeling: progress and future directions. *Geosci. Lett.* **5**, 15 (2018). https://doi.org/10.1186/s40562-018-0113-z

[33]. Merck, M.F., Gallagher, M.A., Habib, E. *et al.* Engineering Students' Perceptions of Mathematical Modeling in a Learning Module Centered on a Hydrologic Design Case Study. *Int. J. Res. Undergrad. Math. Ed.* **7**, 351–377 (2021). https://doi.org/10.1007/s40753-020-00131-8

[34]. Tartakovsky, Daniel M. "Assessment and management of risk in subsurface hydrology: A review and perspective." *Advances in Water Resources* 51 (2013): 247-260.

[35]. Pathak, Chandra S., et al. "Uncertainty analyses in hydrologic/hydraulic modeling: Challenges and proposed resolutions." Journal of Hydrologic Engineering 20.10 (2015): 02515003.