

(1) Description of experimental methods

①Digital model method

The project simulates the process of garden construction by digital model method. the installation parts and raw materials of veranda, rainwater garden and pavement site are displayed in three-dimensional mode to construct the actual appearance of garden facilities. During the virtual simulation experiment, students can observe the lapping mode and structural method of each part of the veranda directly from multiple angles, the components and working principle of rain garden, the construction method of paving site, select the building materials and decoration styles according to different construction requirements. Digital model method plays a very good auxiliary role in students' cognition of three-dimensional space.

②Scene experience method

The project shows the actual process of facility site selection, gallery construction, paving site construction and rainwater garden construction in the process of garden construction by scene experience method and shows the actual scene of various benefits of the site through simulated rainfall, simulated tour and other events. In the virtual situation, the system closely relates the virtual situation with theoretical knowledge, vividly displays the abstract concepts of various garden construction process and combines with the construction technology to form a complete practice teaching process of landscape construction theory. In the experimental process, the system will record the students' operation steps in real time and record the scores and strengthen the practice of students' weak. In the two simulation situations of garden construction and garden benefit, students can have intuitive cognition on the actual operation method of construction process, the principle and quantitative analysis of various benefits.

③Contrast and evidence-based method

In this project, according to the structural differences between different landscape facilities and the modeling differences between similar landscape facilities, a garden construction process material library is constructed. According to the comparison of the performance evaluation before and after the design, the quantitative evaluation material library of landscape performance is constructed. In the process of garden construction, the material library compares the structural

differences among different types of construction facilities, such as paving site, rainwater garden, veranda, etc., and intuitively shows the different implementation methods, connection and fixation methods and different physical properties of different materials in the actual construction to make students have a deep understanding of the different effects of different types of plants, construction materials and engineering practices. The landscape performance evaluation material library contains the benefit evaluation data corresponding to various construction materials and plant materials, generates various evaluation results such as ecological benefits and economic benefits according to various achievements formed by different construction methods. Through the comparison of different results, students have developed a clear concept of evidence-based design, and provide specific guidance for the research of evidence-based design.

(2) Student interaction instructions

This experimental teaching project belongs to landscape architecture design course, with a total of 12 periods. Among them, the virtual simulation experiment of site and gallery construction has 4 periods. Virtual simulation experiment of rainwater garden construction and plant design has 4 periods; Virtual simulation experiment of site stormwater process simulation and Evidence-based performance Evaluation has 4 periods. Through virtual simulation technology, the scenario of low-impact development green space (gallery and rainwater garden) construction is simulated. Students can conduct 14 interactive operations in the whole scene and context.

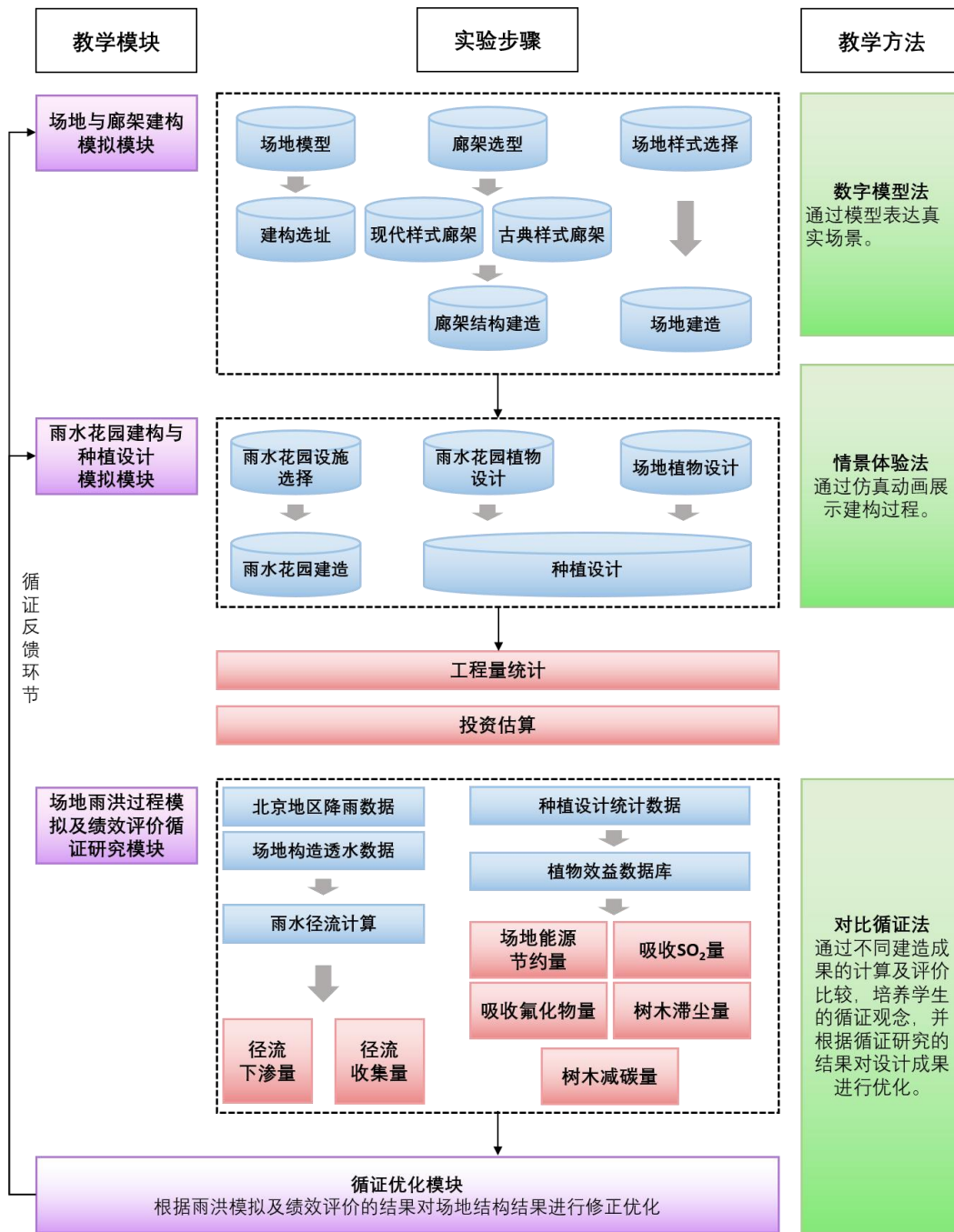


图 10 实验组成结构

The experimental procedure is as follows: Login system → Obtain the laboratory instruction → Site cognition and Construction site selection → Select gallery style → gallery construction → Select site style (paving, plant pond, etc.) → Site construction → Selection of rainwater garden facilities → Rainwater garden construction → Rainwater garden plant selection and design → Site plant selection and plant design → Engineering quantity calculation and investment estimation → Rainwater runoff calculation → Calculation of infiltration reduction and rainwater collection → Landscape performance evaluation → Conduct evidence-based optimization according to the calculation and evaluation results (see Figure 11 for the specific operation process of the experimental project)

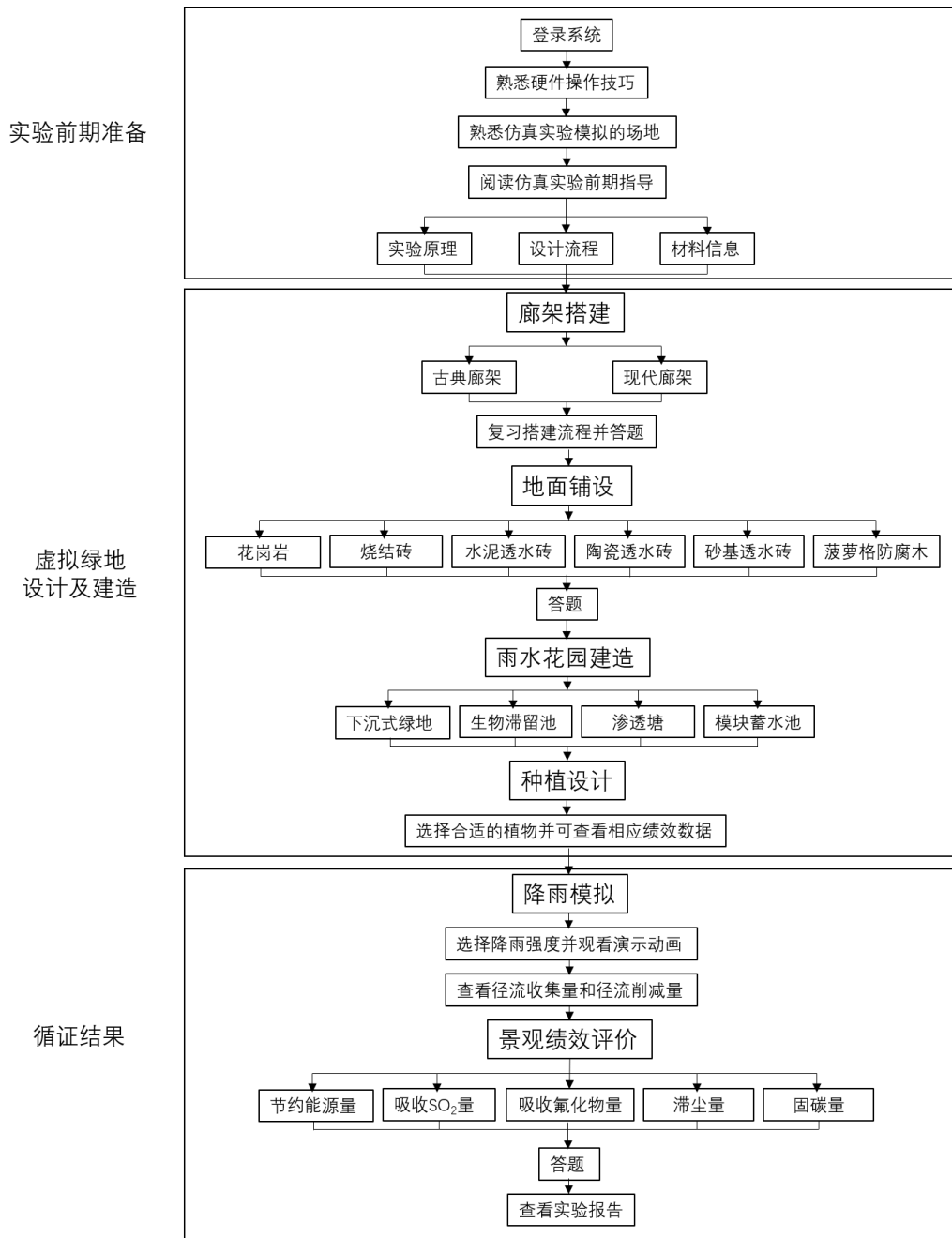


Figure 11 Specific operation process of the experimental project

Step 1 : Log in to the project website and enter the website to understand the project description, characteristics, network requirements and other relevant information. Get the experimental instructions from the lower right corner of the website. Click "start experiment" to experiment.



Figure 12 Start the experiment

Step 2: Get familiar with the interface operation, through the keyboard WASD key and mouse operation, the three symbols in the upper right corner from left to right are full screen, operation instructions, return to the home page. Students follow the operation path to enter the virtual scene space of garden construction.



Figure 13 Get familiar with hardware operation

Step 3: Click the experimental principle, design process and material

information to view

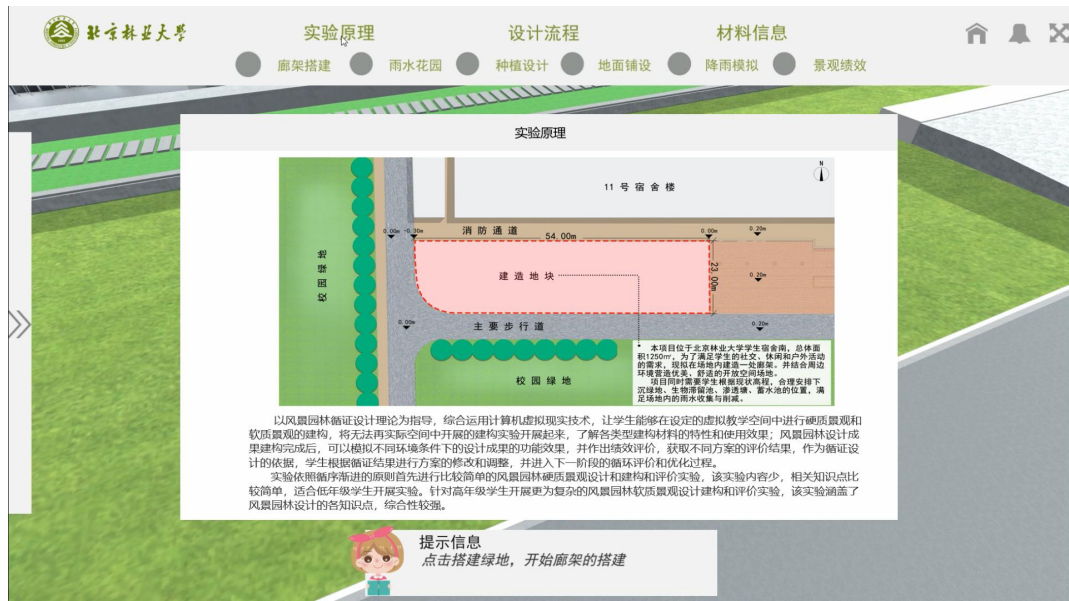


Figure 14 Understand the principle of experiment



Figure 15 Understanding the design process



Figure 16 Learn about experimental materials

Step4: Understand the campus public activity area and understand the environmental layout of the experimental site. The intensity of pedestrian activities around the site is large, which requires a rest space for staying. At the same time, the site is also a low-lying land, suitable for rainwater garden.



Figure 17 Cognitive model environment

Step 5: After entering the square, click on the top shelf with the mouse to pop up the type of gallery. Select a type of rack to build the gallery, which can build classical and modern style.



Figure 18 Choose the type of gallery to build

Step 6: The construction of classical and modern gallery is carried out respectively. Click the pop-up button on the left side to pop up the type of corridor structure and link mode required for the experiment, drag them into the designated area in order to finally complete the construction of the corridor. Students can understand the design of landscape architecture structures and be familiar with the construction process of steel structure and wood structure.



Figure 19 Select the classical gallery to build



Figure 20 Construction of classical Gallery: get familiar with building area



Figure 21 Construction of classical Gallery: lime soil layer



Figure 22 Construction of classical Gallery: colonnades



Figure 23 Construction of classical Gallery: thick lime soil layer



Figure 24 Construction of classical Gallery: concrete layer



Figure 25 Construction of classical Gallery: beams and purlins



Figure 26 Construction of classical Gallery: roof boards



Figure 27 Construction of classical Gallery: rafters



Figure 28 Construction of classical Gallery: tiling



Figure 29 Construction of classical Gallery: bench



Figure 30 Select the modern gallery to build



Figure 31 Construction of modern Gallery: get familiar with building area



Figure 32 Construction of modern Gallery: plain soil layer



Figure 33 Construction of modern Gallery: concrete layer



Figure 34 Construction of modern Gallery: concrete bedding



Figure 35 Construction of modern Gallery: columns and beams



Figure 36 Construction of modern Gallery: merbau anticorrosive wood



Figure 37 Construction of modern Gallery: roof

Step 7: The construction process will pop up after the completion of the rack construction. Students watch and review, answer questions on the part of corridor construction, review the construction process of modern steel and wood frame and traditional wood structure, and investigate

their cognition of structural mechanics.



Figure 38 Review the construction process of corridor

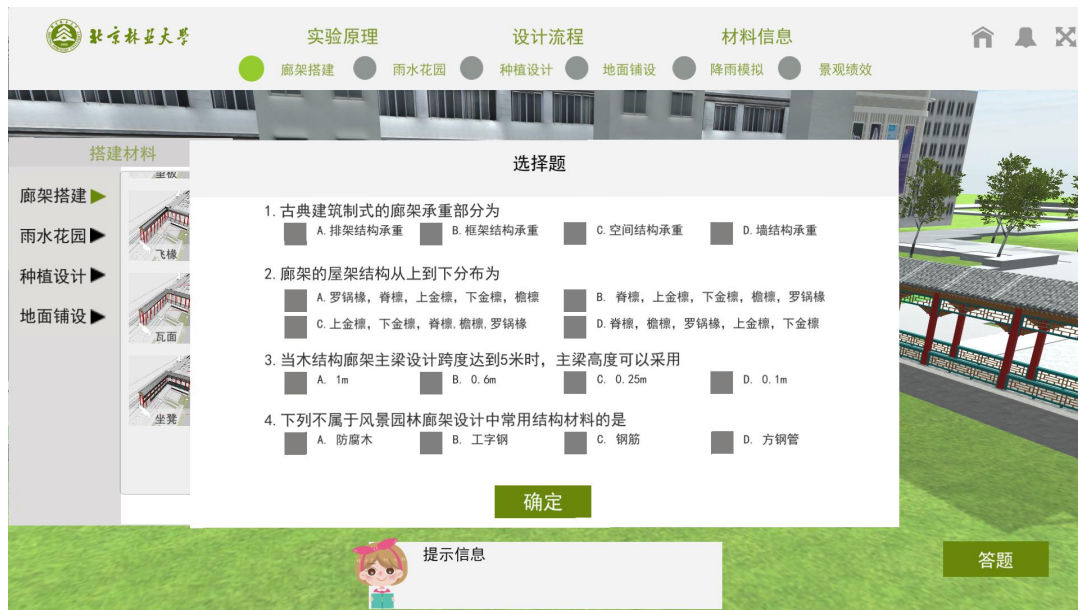


Figure 39 Answer the questions of gallery construction

Step 8: Click the above ground pavement to pave the ground, respectively pave the five areas in the site with hard paving materials with infiltration function. Different materials can be selected for different paving, and the pavement structures will be dragged into the designated area in order. After the completion of five areas, students will answer questions of this part to investigate their

cognition of the surface layer materials, structural materials and construction methods.



Figure 40 Select the material for the five areas in the model to pave the ground



Figure 41 Ground paving of area 1: get familiar with building area



Figure 42 Ground pavement of area 1: plain soil layer



Figure 43 Ground pavement of area 1: lime soil layer



Figure 44 Ground paving of area 1: concrete layer



Figure 45 Ground paving of area 1: cement mortar layer



Figure 46 Ground pavement of area 1: brick layer, finish



Figure 47 Ground pavement of area 2



Figure 48 Ground paving of area 3



Figure 49 Ground paving of area 4



Figure 50 Ground pavement of area 5



Figure 51 Answer the questions about the steps of laying the ground

Step 9: Click the rainwater garden above to select the type of green space to build and recognize the different types of green space with low impact green space design.



Figure 52 Choose a low-impact development green space to build

Step 10 Drag the construction materials of the pop-up rainwater garden into the designated area in order to build different types of green space to make students familiar with the construction sequence and construction materials of low impact development green space.



Figure 53 Determine the location of green space



Figure 54 Build plain soil layer



Figure 55 Construct the gravel layer

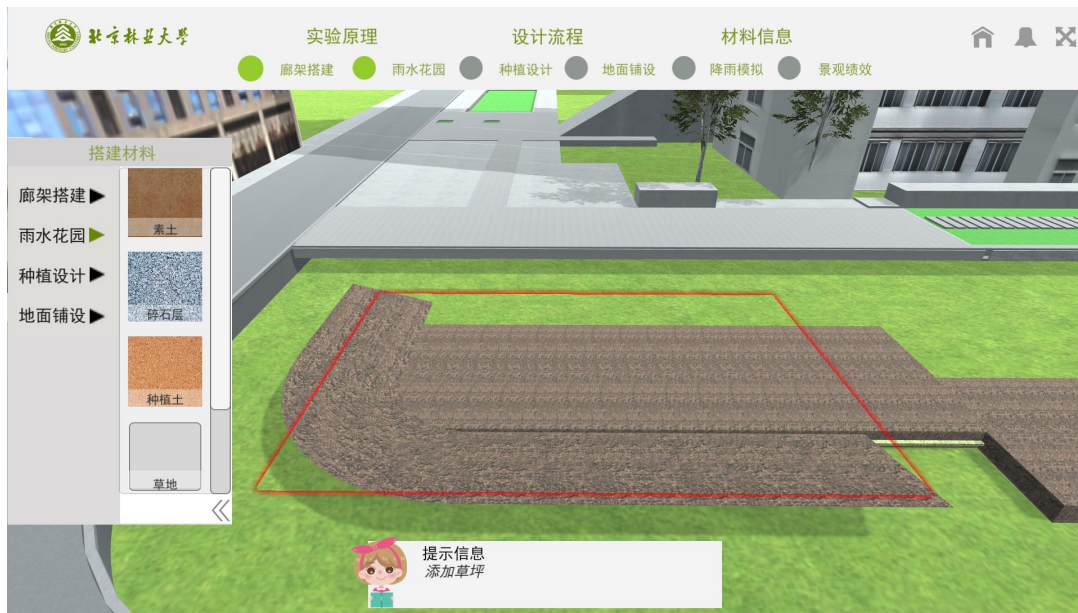


Figure 56 Construct the plant soil layer.



Figure 57 Construct the lawn layer, finish

Step 11 Click the plant design on the top, select the plant community with low water consumption for plant to investigate the students' cognition of ground cover flowers, trees and shrubs and the ability of plant collocation. Students can click the "plant data" in the lower right corner to view the plant performance data in real time to perceive the methods and principles of landscape performance evaluation.



Figure 58 Determine plant design area



Figure 59 Plant grass and local quilt



Figure 60 Plant trees



Figure 61 View real time plant performance data

Step 12 Click the rainfall simulation above, select different rainfall return periods, watch the animation and calculate the runoff to make students understand the organization of surface runoff and learn the calculation of runoff.



Figure 62 Choose a rainfall recurrence period



Figure 63 Watch the rainfall demo animation

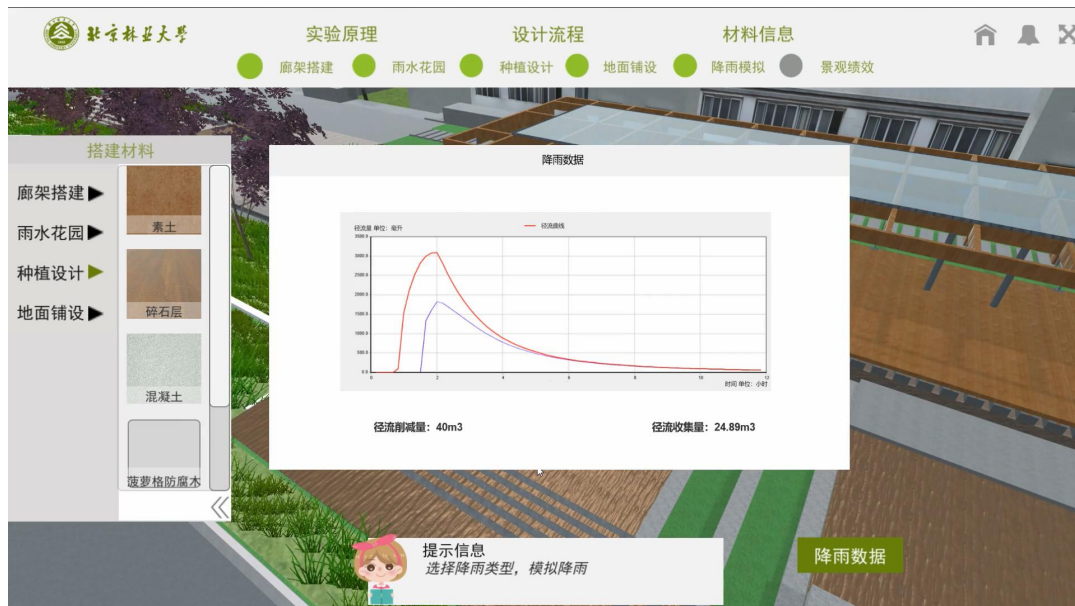


Figure 64 Watch rainfall data

Step 13 Click the landscape performance on the top to get the evaluation result of landscape performance. Click the answer question on the bottom right to answer the question and finally get the experimental report to enable students to understand the research methods of evidence-based design.



Figure 65 View performance scores



Figure 66 Complete the questions of landscape performance part



Figure 67 View the generated experiment report: operation screenshot



Figure 68 View generated lab report: material cost

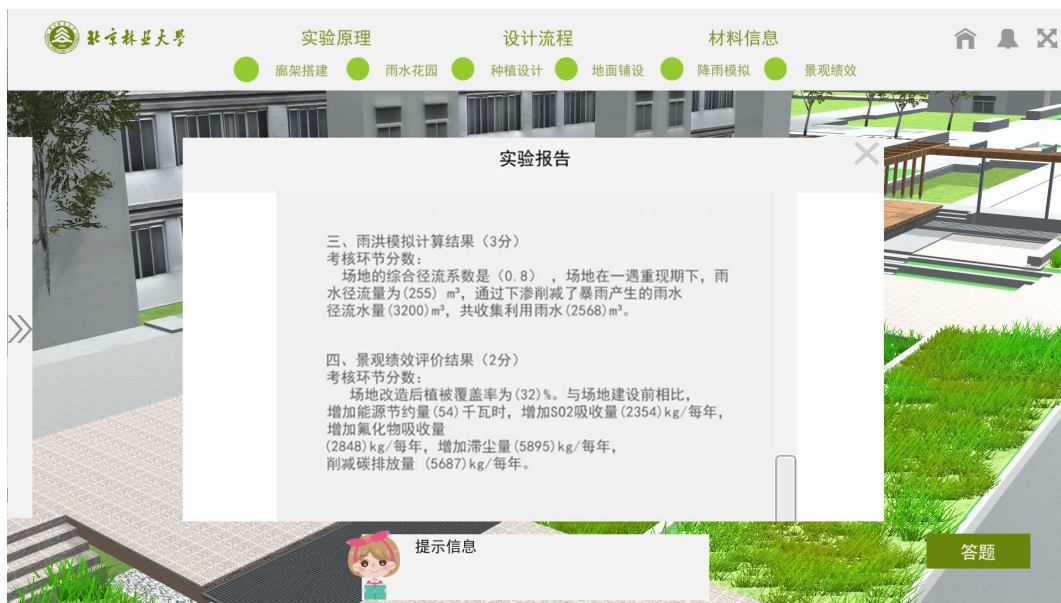


Figure 69 View the generated experimental report: rainfall data and landscape performance



Figure 70 View the generated experiment report: answer results

Step 14 Publish results