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Unveiling the Crisis of Atherosclerosis: A Group Collaborative Problem-Solving STEM Lesson for SSI

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A B S T R A C T

This study introduces a STEM course titled “Unveiling the Risks of Atherosclerosis,” designed as an SSI group collaboration problem-solving activity. The course design is based on the SSI teaching philosophy, incorporating real-world complex problems into the classroom to guide students in solving problems through group collaboration. Students will assume the role of medical science communication model engineers, designing and constructing a scientific, intuitive, and simple dynamic model to visualize the hazards of atherosclerosis. The course content aligns with Unit 4, Chapter 4 of the seventh-grade lower semester textbook and Chapter 7 of the eighth-grade upper semester textbook, primarily addressing Big Ideas 5, 6, and 9 in the curriculum standards. Through this course, students will deeply explore the causes, risks, and relationship between atherosclerosis and blood pressure changes, design solutions, and implement them to seek answers to scientific questions. The course adopts the GRASPS model to design the teaching process, which includes the introduction phase, simulation and modeling phase, experimental exploration phase, and concept construction phase. Implementation strategies include a three-way integration of biology, engineering, and physics based on complex system modeling, as well as a dual perspective of humanities and science in the context of social and public health. Through interdisciplinary project-based learning, students not only acquire scientific knowledge but also gain a deep understanding of the health risks associated with atherosclerosis, develop an awareness of healthy living, and cultivate a sense of responsibility for their own health.

1. Introduction

In today’s society, health issues are increasingly becoming the focus of people’s attention, and atherosclerosis, as a common and harmful chronic disease, is quietly threatening the lives and health of countless people. It is like a latent “time bomb”, quietly accumulating in the wall of blood vessels, gradually eroding the health of blood vessels, triggering a series of serious cardiovascular diseases, such as coronary heart disease, myocardial infarction, stroke, etc., which brings great threats to the life and health of patients (Zhang et al., 2017). With the aggravation of population aging, more and more elderly people are suffering from atherosclerosis. However, due to its complex and difficult-to-understand pathogenesis, many patients still have limited knowledge of this disease, which largely affects the early intervention and effective treatment of the disease.

Ms. Zhou Jiayu from Beijing Bayi School captured this social issue with her keen educational insight and skillfully introduced it into the classroom, designing a “Group Collaborative Problem Solving STEM Lesson for SSI.” The introduction of the concept of STEM education provides us with a brand-new perspective and methodology. Education emphasizes the interdisciplinary integration of Science, Technology, Engineering and Mathematics, and focuses on cultivating students’ innovative thinking, practical ability and teamwork spirit (, 2020). Based on the teaching concept of SSI (Socio-Scientific Issues) (Xu et al., 2023), this course emphasizes the introduction of real-world complex problems into the classroom, and guides students to problem solving through group collaboration, which not only closely matches the requirements of interdisciplinary thematic learning in the Biology Curriculum Standards for Compulsory Education (2022 Edition), but also through real-world problems, it also builds a broad platform for students to combine theoretical knowledge with practical operation through the creation of real situations (Macalalag Jr et al., 2024). In such a classroom, students are able to explore scientific issues in depth, enhance their comprehensive abilities, develop a sense of social responsibility and a spirit of innovation, and lay a solid foundation for becoming citizens with a global perspective and scientific literacy in the future.

2. Instructional Design of SSI’s Group Collaborative Problem Solving STEM Curriculum

2.1. Design background and development significance

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Atherosclerosis is one of the leading causes of cardiovascular disease worldwide, leading to over 10 million deaths each year (Chen et al., 2023). However, the public does not have a deep understanding of its principles and dangers.

In this course, with the theme of "Uncovering the Crisis of Atherosclerosis", students will play the role of medical science modeling engineers to design and create a scientific, intuitive, simple and dynamic model to visualize the dangers of atherosclerosis. The content of the course corresponds to Chapter 4 of Unit 4 in the second book of Grade 7 and Chapter 7 in the first book of Grade 8 of the Humanistic Education Edition, and mainly implements the major concept 5 "The human body's structure is compatible with its function, and the systems are coordinated and unified to accomplish complex life activities", and the major concept 6 "The human body's health is threatened by cardiovascular diseases" in the curriculum. The problem solving in real life situations usually requires the integrated use of concepts, methods and ideas from science, technology, engineering and mathematics to guide students to investigate in depth the causes of atherosclerosis, its harms and its relationship with changes in blood pressure, and to design and implement solutions to prevent atherosclerosis. Programs are designed and implemented to seek answers to scientific questions.

Through this course, students will master the basic knowledge of human physiology and health, form the view of structure and function, homeostasis and equilibrium, and localization and wholeness, have a preliminary grasp of scientific thinking, be able to analyze cardiovascular disease problems in real situations, take the initiative to propagate the concepts and knowledge of life safety and health, and become a promoter and practitioner of a healthy China.

2.2. Design background and development significance

The learning objective of this unit is to provide students with a comprehensive understanding of atherosclerotic diseases and their impact on human health. First of all, students need to understand the structure and function of different kinds of blood vessels, and make it clear that atherosclerosis is a lesion of the arterial blood vessel wall caused by lipid deposition, fibrous tissue proliferation and other problems. Second, students will learn about the components of blood and their functions, and analyze how diet and lifestyle affect blood vessel health from the perspective of the digestive, circulatory, and locomotor systems, thus making connections to atherosclerotic disease. Students will also visualize the causes of atherosclerotic disease and analyze how atherosclerosis affects human health by creating a scientifically intuitive model of a blood vessel, asking scientific questions and making hypotheses, and then simulating and designing a physical model to visualize the effects of diseased blood vessels on health issues such as blood pressure and designing a controlled experimental protocol. By assembling the model and conducting experimental investigations to determine the difference in pressure after blood flows through a model of a healthy or diseased blood vessel, the experimental data will be analyzed to scientifically illustrate the impact of disease on a particular health problem. Finally, students will iterate and integrate the models to demonstrate and explain the dangers of atherosclerosis using a complete dynamic model and write a companion science brochure.

The learning focus and challenge of this unit is to use simulation modeling to interpret the harm caused by atherosclerotic disease. Students need to visualize the abstract pathological process through hands-on practice and scientific experiments, so as to deeply understand the multifaceted impact of atherosclerosis on health.

2.3. Design background and development significance

This course is aimed at students who already have certain basic knowledge and ability, and at the same time there are some learning needs and characteristics. In terms of knowledge base, students have a clear understanding of the basic structure and function of blood vessels, and also know the causes of atherosclerosis and its hazards, but do not yet understand the concept and formation of blood pressure and the formation mechanism of hypertension and other diseases, which provides an entry point for the course to further expand related knowledge. In terms of ability level, students have basic experimental operation ability and teamwork experience, but they may not be familiar enough with the engineering design process, such as design, testing, optimization, etc. They need to be guided and trained in the course to help them master the complete project implementation process. From the point of view of interest characteristics, students show strong interest in hands-on practice and solving real disease problems, but they may need guidance from teachers in the learning process in order to stay focused and think deeply, avoiding superficiality, so as to better combine knowledge with practice and explore the nature of the problem in depth.

2.4. GRASPS model

The GRASPS model is an educational and assessment tool designed to assist in the design and implementation of expressive tasks (Leung,2017). It consists of six elements: Goal, Role, Audience, Situation, Product and Standards as shown in Table 1. This model helps to solve new problems or create outcomes in real or simulated situations by applying the acquired knowledge and skills, and then show the students' learning ability and level, which provides a systematic instructional design framework for teachers to help them better organize their teaching activities and ensure the achievement of teaching goals, and also provides clear standards for teaching evaluation, which helps to improve the scientific and effectiveness.

Table 1. GRASPS model

Goal	Design and create a dynamic biological model for the medical center to visually demonstrate the relationship between vascular stenosis, vessel wall sclerosis and health, as well as the clinical treatment methods for this disease, ultimately educating the audience about the hazards of arterial sclerosis.
Role	Medical Science Popularization Engineer
Audience	Primary audience: patients with arterial sclerosis and their families Secondary audience: science popularization area of the science and technology museum
Situation	In the medical center or the science popularization area of the science and technology museum, students use intuitive models instead of abstract medical terms to help audiences of different ages understand complex pathologies.
Product	A demonstrative model of atherosclerotic plaque, accompanied by an explanatory science-popularization manual.
Standards	Scientificity, innovativeness, functionality, science popularization effect, and teamwork.

2.5. Teaching process

2.5.1. Introduction: Focusing on the scientific question

The teaching design framework for this unit is shown in Figure 1. At the beginning of the lesson, the teacher introduces atherosclerosis, the main cause of cardiovascular disease, and the current situation of insufficient understanding of it by the public by displaying the data on cardiovascular disease mortality rate from the National Center for Cardiovascular Disease and combining it with the background of the year of weight management mentioned in the National People's Congress in 2025. Subsequently, students were organized into

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groups to share the models of diseased blood vessels made in the introductory lesson, review the causes of atherosclerosis, and ask the key question, "How does atherosclerosis in the arterial vasculature change the blood pressure?" The results of the questionnaire are also displayed to stimulate students' thinking and interest. The design of this link is based on the theory of context-driven learning, which stimulates students' interest in learning and desire for investigation through the introduction of real situations, and makes students feel the practical significance of learning (Başer et al., 2023). Combined with the results of the questionnaire (as shown in Figure 2), it guides students to reflect on their existing cognition and provides motivation for subsequent learning activities.

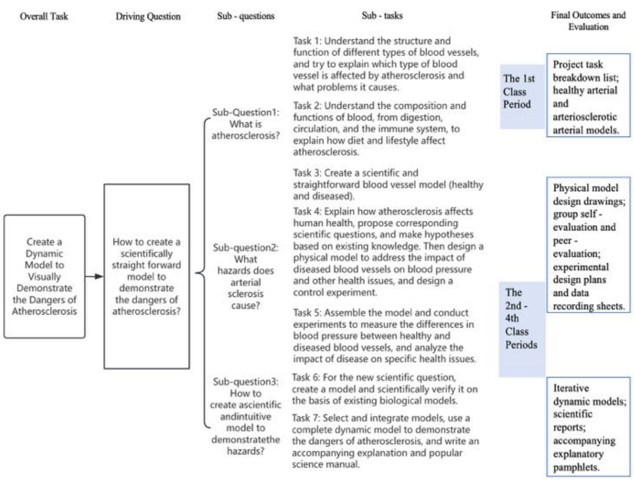

Figure 1. Overall teaching ideas of the unit

Figure 2. Questionnaire results

2.5.2. Simulation and Modeling Session

The teacher guided students to work in groups to design a simple physical model from the perspectives of simulating the heart pumping blood, characterizing normal and diseased vascular states, and visualizing changes in blood pressure. The groups summarize their ideas and make drawings of the model design, after which the teacher displays the groups' design drawings on a large screen, organizes students to share their group's design ideas, and records key points on the board. The teacher provides an evaluation scale and organizes students to assess the feasibility of the solution, complete self-assessment and mutual assessment, and iterate the design drawings based on the feedback. Finally, the teacher provides materials and students initially complete the assembly of the model according to the design drawings, and identify and analyze the stuck points encountered during the assembly process (Figure 3). The design of this session is based on the theory of design thinking, which emphasizes the use of design thinking in the problem-solving process and the continuous optimization of solutions through iterative design. The design process of teamwork embodies the theory of collaborative learning, in which students divide up the work in a team and fully utilize their respective strengths to complete the task together. In addition, this session fully embodies the core concepts of STEM education, in which students synthesize their knowledge of biology, physics and engineering in an interdisciplinary context, and transform abstract scientific concepts into intuitive visualization tools through the design and production of the model, which cultivates students' innovation and practical ability (Clark et al., 2006).

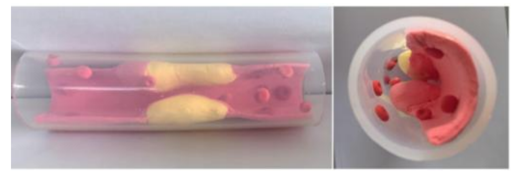

Figure 3. Display of Disease Vascular Model

2.5.3. SessionExperimental investigation session: Determination of blood flow pressure in healthy and diseased blood vessel models

After completing the model design and assembly, students entered the experimental investigation session. The group assembled the model according to the plan, turned on the pump to simulate blood flow, and used pressure measuring instruments to measure and record the pressure data in the models of normal blood vessels and blocked blood vessels. Afterwards, teachers and students analyze the experimental data together, compare the pressure changes in different situations, determine whether the experimental results are consistent with the scientific hypothesis before the class, and guide students to draw conclusions, such as "the experimental data show that the pressure increases when the blood vessel diameter becomes narrower as well as the elasticity decreases, supporting the hypothesis that atherosclerosis leads to an increase in blood pressure". Teachers make a simple model in advance for demonstration, show the pump pumping water outward, the rubber tube, clogged rubber tube, rigid plastic tube pressure signals, and fill in the table (as shown in Figure 5). The design of this link is based on the theory of inquiry-based learning, which emphasizes that students take the initiative to explore in the problem situation and verify the hypothesis through experiments, so as to acquire knowledge and skills (Papaevripidou et al., 2017). At the same time, through data analysis, students learn to use data to support conclusions and enhance critical thinking and problem solving skills, reflecting the scientific inquiry and data analysis skills in STEM education. Teachers help students think deeply and promote their understanding and mastery of knowledge by asking questions and guiding them during the experiment, which is in line with the guided inquiry teaching method and stimulates students' thinking activities.

Figure 5 Simple model

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2.5.4. Conceptual construction link

Teachers teach the concept of blood pressure through the double destructive mechanism of the board: "stenosis → resistance ↑ → pressure ↑" "hardening → elasticity ↓ → pressure ↑", explaining the definition of hypertension, the harm and the importance of a healthy lifestyle in conjunction with the literature. Students combine the experimental findings with the teacher's guidance to understand the principle of atherosclerosis leading to changes in blood pressure, to establish the concept of blood pressure, and to review the learning process of this lesson to deepen their understanding and memory of the knowledge. Finally, the teacher assigns a post-class task to guide students to choose more suitable materials and iterate the science display model to further clearly illustrate the relationship between the disease and blood pressure. The design of this link is based on the conceptual transformation theory, which helps students raise the experimental results to the theoretical level and form scientific concepts through the teacher's explanation and summarization (Li et al., 2023). Assigning post-class tasks to guide students to further improve the science display model embodies the concept of project iteration and continuous improvement in STEM education, extends classroom learning outside the classroom, promotes students' in-depth understanding and application of knowledge, and fosters students' independent learning ability.

3. SSI's Group Collaborative Problem Solving STEM Program Implementation Strategies

3.1. Three-way integration of " biology-engineering-physics " based on complex system modeling

Taking atherosclerosis as the research object, we construct a complete scientific inquiry chain of "biological pathology analysis → engineering model reduction → physical principle verification" to break the traditional disciplinary boundaries (Ji et al., 2023). Biology provides the pathological mechanism, physics explains the macro phenomenon, engineering realizes the technical transformation, forming a closed-loop logic from "micro mechanism" to "macro phenomenon" to "technical intervention", which enables students to intuitively understand atherosclerosis. Logic, so that students intuitively understand the chain reaction of "decreased vascular elasticity → increased peripheral resistance → increased cardiac load".

3.2. Dual perspective of "humanities and science" in society and public health

Extending scientific inquiry to the level of social influence, students are guided to think about the concepts and knowledge of life safety and health (Smith et al., 2023). Teachers guided students to transform the research results into easy-to-understand scientific props with accompanying instructions for use, aiming to popularize the causes and consequences of atherosclerosis among hospital patients. This approach fully embodies humanistic care, as atherosclerosis is a common and serious chronic disease, and many patients lack a clear understanding of its pathogenesis and potential risks. Through the students' demonstration of the model, the patients were able to understand their condition more intuitively, thus enhancing their treatment compliance and awareness of healthy lifestyles. This activity also cultivated students' empathy and social responsibility, and made them realize that what they learned not only belongs to the academic field, but is also a powerful tool to serve the society and improve public health.

4. Reflection on the Interdisciplinary Program

This lesson is centered on "Uncovering the Crisis of Atherosclerosis", in which students work in small groups to discuss, design and optimize models. At the same time, the course encourages students to be bold and innovative in model design, and further improve the model through iterative optimization. Students not only mastered the scientific knowledge, but also deeply realized the health hazards of atherosclerosis and established the awareness of healthy living. This way of combining scientific knowledge with health education enables students to gain knowledge while developing a sense of responsibility for their own health.

Overall, this lesson successfully realized the multidimensional goals of knowledge, ability and emotional attitude through interdisciplinary integration, authentic context-driven, cooperative learning and innovative thinking cultivation, which provided a platform for students to learn in depth and a useful exploration of innovative practices in science education.

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