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Research Article

Math and Science Integrated Curriculum: Pedagogical Knowledge-Based Education Framework

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Many researchers investigated students' attitudes towards learning mathematics and science. Educators were trying to be more innovative in creating different teaching strategies to engage students in these subjects which they find complex or not relevant to their lives. Namely, curriculum designers were trying to find ways to make these subjects more enjoyable and meaningful for students. Many studies found that the problem could be in the way that teachers use to deliver these subjects but not in the content itself. Additionally, students cannot see the benefits of the learnt output coming out of studying several topics in science or mathematics. As educators, we realized that many skills like problem solving, investigation, critical thinking, interpretation, creativity, reasoning, and others cannot be gained easily when the knowledge is separated away of the application in real world. This study tends to give an example of how we can integrate mathematics and science curriculum in a pedagogical knowledge-based framework that enables teachers to show how beneficial and effective is this scientific knowledge in real world application, particularly by using an integrated curriculum. Knowledge and skill from 6th grade in Bahraini public schools were used to design the integrated model.

1. Introduction

There was a consensus among general managers, staff supervisors, education administrators, and other specialists in different market sectors on the fact that newly graduated students have limited practical skills and insufficient industry knowledge when they join the job market [1]. Noticeably, there is a rapidly growing educational scarcity of implementing integrated curricula as an urgent need for acquiring the 21st century skills [2]. Hence, it became a recent trend in education to embed several different knowledge disciplines in a practical way while teaching students as an integrated curriculum. This allows teachers to deal with two or more of the knowledge disciplines to explore the best topics that can be taught simultaneously and to design the best teaching activities. Integrated curricula need to be connected somehow to allow students apply acquired knowledge in a certain discipline in gaining new knowledge in another discipline.

Frykholm and Glasson [3] define integrated curriculum as substantial shift from teaching different knowledge fields as an accumulation of rote facts and procedures to teaching an authentic context. According to Sayuti and Rahiem [4], an integrated curriculum is viewed as a strategic instrument to enable concepts to be structured based on systematic, hieratical, and measurable ways by adjusting the curriculum design and learning process. Integrated curriculum as seen by Dhlamini and Mwakapenda [5] is the notion of having a sufficient knowledge of each learning area to be practiced through the awareness of a broad range of other areas of knowledge.

There are significant differences in favour of integrated curriculum and there is a positive impact of using integrated curriculum teaching strategies. Syafei et al. [6] argued that there are three different methods of implementing integrated curriculum, including thematic arrangement, students' project, and students' activity unit. They pointed at the importance of implementing these three methods for better students' learning, deep engagement in educational experience, and consideration of multiple connections throughout subjects. According to Rochman et al. [7], their study showed variation in science and technology literacy skills when starting to use integrated curriculum in later education stages. Based on Vargas and Alvarado's [8] study, it can be useful or sometimes necessary to avoid portion balancing between different disciplines while teaching integrated curriculum. Main subjects can have higher focus than minor or supportive disciplines [9–11].

The purpose of this study is to plan and develop integrated pedagogical knowledge-based education units in science and mathematics based on their concepts and skills into the primary education curriculum in the Kingdom of Bahrain. The study specifically investigates in details the intended teaching strategies of integrated curriculum in a pedagogical approach leading to an engineering design as an outcome within the requirements of the Ministry of Education for primary education. The study describes the best practices that can be embedded in the integrated curriculum.

2. Literature Review

2.1. Perspective of Integrated Math and Science Curriculum. The concept of integrated curriculum emerged to the existence in business, industry, medicine, and education fields to bridge the gap between market needs and insufficient graduated labourers' skills and to eliminate the negative consequences of such economical phenomenon. Specifically, the integrated curriculum terminology was introduced in 2011 to the public as a US nation strategy to enable the educational system to graduate highly qualified students to the labour markets [12].

Relevant research and specialists see three main features of the integrated curriculum: considering real world, connecting knowledge disciplines authentically, and reasoning knowledge for application [4]. These three main keys are necessary for students to build a cohesive and comprehensive awareness of how and why to learn. Successful teaching and learning integrated curriculum practices require redesigning of the traditional curriculum and creating vital connection to real world application and problem-solving scenarios that are relevant to their experiences. Students' learning involvement in an active learning environment can be attained by integrated curriculum [1]. It creates an attractive progressive learning journey for students motivating them to learn more knowledge and apply it ([1, 13, 14]).

Over years, science teachers found that students find it difficult to apply related mathematical concepts such as converting units, understanding and interpreting graphs [15], proportional concepts [16], computational fluency, and intensive quantities which combine direct and inverse proportion. Students' difficulties in physics were caused by the abstract nature of subject and the inclusion of mathematical computational skills. Akatugba and Wallece [16] indicated that physics concepts such as force, acceleration, and pressure require a better understanding in mathematics including proportional reasoning.

Based on the aforementioned perspectives of mathematics and science integrated curriculum, it seems that mathematics and science activities need to be redesigned to be taught in a way that students can apply knowledge to learn new knowledge. Such curriculum integration may convey promising potentials and could be apt to some barriers.

2.2. Learning Math and Science within Integrated Curriculum. Applying integrated curriculum can be beneficial in increasing students' achievement and developing positive attitudes towards learning mathematics and science [17]. It increases the passion of learning mathematics and science and increases students' motivation. It dispels the high level of anxiety by focusing more on learning by doing. It allows students to focus more on their practical skills to be used for higher level of thinking and problem solving in mathematics and science. Students develop better understanding when they learn by integrated curriculum because they focus on the basic skills and content to reach the mastery level in learning [18, 19].

According to Barry [14], students were taught scientific processes and do mathematical calculations for the topics: evaporation, thermal energy, and condensation, and they were asked to write reports. Students improved their high-level thinking skills and writing structured paragraphing and achieved high grades in standardized tests. Students performed better in mathematics when it was taught in parallel with science about exploring the Solar System through modern dance. Hiong and Osman [20] conducted a study to see the connections between biology and mathematics. It was used to help students acquire the 21st century skills. Biology was the core discipline of content knowledge. Mathematics was used as computation tool to get results and data analysis, draw hypothesis, and design study experiments. Study showed improvement in students' development of academic achievement and the 21st century skills [21, 22].

Integration of mathematics and science can make learners see the shared concepts and factors in a meaningful and enriched way. Research indicates that using an integrated curriculum provides opportunities for more relevant, less fragmented, and more stimulating experiences for learners [3, 23, 24]. The Principles and Standards for School Mathematics [25], the National Science Education Standards [26], and Next Generation Science Standards [27] emphasized the connection between science and mathematics, along with the NCTM Standards [25, 28]. NCTM [25] makes "connections" one of its process standards and advocates the use of integrating subjects like mathematics and science.

2.3. Approaches to Integrated Math and Science Curriculum. Educational specialists in mathematics and science view the integrated curriculum based on three different approaches, including multidisciplinary, interdisciplinary, and transdisciplinary approaches. These three approaches meet in some points and differ in others based on the criteria, nature, and standards of each approach. Some topics can fit into one approach and some other topics can fit into more than one based on the nature of the topic [10, 13, 29].

Learning is an experience-based process of inquiring, discovering, and exploring information. A constructivist approach to learning that contemplates active participation of students enhance this experience by construction of knowledge based upon a comprehensive view of learning. It is a powerful learner-centred approach where students construct knowledge through active involvement in experiences that are meaningful which can be created as an ideal learning environment to establish connection. Engaging with hands-on learning activities stimulate their imagination and profound academic learning as the teacher act as a facilitator of learning [4].

Throughout the interpreted approaches of mathematics and science integrated curriculum, the sacristy of a clear conceptual framework appears to strategically conduct any study. Approaches of integrated curriculum in mathematics and science can heavily impact the conceptual framework and influence the nature of its phases.

2.4. Conceptual Framework for the Integrated Math and Science Unit. Several conceptional frameworks were designed, implemented, and analysed while studying the integrated curriculum. Many common elements were used to identify and describe stages of work in many frameworks and others have its own unique stages based on the integrated curriculum approach, context, and study design [19].

Hudson et al. [30] suggested a conceptual framework consisting of eleven stages to teach mathematics, science, and engineering integrated curriculum, including planning, timetabling, preparation, teaching strategies, content knowledge, problem solving, classroom management, questioning skills, implementation, assessment, and viewpoints. Their context was divided into two parts. Carbonell et al. [18] created a conceptual framework of integrated curriculum of algebra in mathematics and physics in science consisting of three phases, planning, research lesson, and postlesson reflection and discussion. During planning phase, the learning content was chosen, learning objectives were determined, and pilot teaching was conducted to improve actual teaching in the next phase.

Fitria et al. [21] applied a conceptual framework based on the ADDIE model that consists of five stages, including analysis, design, development, implementation, and evaluation stages during the use of integrated curriculum of mathematics and science. Needs analysis and content analysis were conducted during the analysis stage. The integrated curriculum materials were redesigned and the supportive activities were created throughout the design stage.

2.5. Problem Statement and Research Questions. Kalogiannakis [31] mentioned that it is important for any teacher to teach new courses within school curriculum, and it is crucial to extend the development of pedagogical role, in order to apply new methods in education. In is not an easy matter to manage the administrative and structural changes.

As a common finding, studies indicated that integration of science and mathematics enhance students'achievement (e.g., [32, 33]) as well as students' motivation and problem-solving skills and helps students to make abstract concepts more concrete by using multiple representations (e.g., pictures, tables, and graphs). It is also argued that the integration of content areas can help students learn to think critically and help develop a common core of knowledge necessary for success in the next century.

The involvement of students in an integrated science and math unit lends itself to motivating students [34, 35] and increases student achievement in both disciplines [36]. This idea relates directly to the constructivist approach of hands-on minds-on learning. This kind of program might be helpful in increasing the implementation of interdisciplinary teaching and learning activities. Riordain et al. [37] reported that teachers have positive views about the benefits of integration with respect to students' learning and motivation in their study. The understanding of science and mathematics integration, adopted by Lonning and DeFranco [38] and Roebuck and Warden [39], shown in Figure 1, shows the continuum included in the models and describes the borders and intervention between different subjects, including mathematics and science.

The current curricula that teach subjects as separate topics cannot provide students with the 21st century skills that are necessary for them to live usefully in the modern society. It is important to teach students integrated subjects, such as science, mathematics, engineering, and technology, to make learning more reasonable. Such integrated curriculum can be done by educational robotics that helps students to master many skills, like algorithmic calculation, problem solving, critical thinking, decision making, and computational thinking in an atmosphere of creativity and collaboration [40].

Integrating different disciplines of STEM education including science, technology, engineering, and mathematics conveys many advantages in terms of improving students' learning mastery and developing other important real world skills. Teachers need to develop their teaching strategies and adopt new teaching activities to be able to teach STEM effectively [43].

According the aforementioned and analysed conceptual frameworks of the previously conducted research in mathematics and science integrated curriculum, there is a significant need to suggest and adopt more practical conceptual framework of integrated curriculum. It is clear that there is a lack in describing the design stages, in terms of planning, pedagogical approach, and outcome stages. After reviewing the relevant studies, it seems there is a gap in between the suggested integrated frameworks and the teaching activities that can be done in classrooms. Moreover, many of the previous studies left the assessment part in integrated unit to the teacher to determine the suitable tasks; however, it is essential to provide an assessment guidance of such integrated curriculum, particularly in mathematics and science.

Therefore, this study tends to overcome these limitations by shedding the light on the planning stage and the

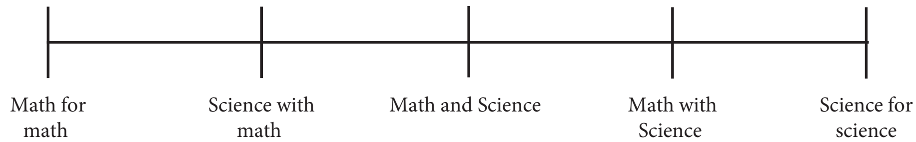

Figure 1: Continuum included in the models.

development of mathematics and science concepts and activities. It describes in more detail the pedagogical stage and the teaching strategies in a way that can be designed and examined. At the end, this study clarifies the outcome stage by focusing on the outcome assessment of integrated activities. Such curriculum integration and particularly between mathematics and science can be done in several systematic methods to achieve effective learning. Such integration methods can diverge sometimes and intersect in other situations depending on the specific factors.

Hence, this study aims to answer the following questions:

(1) What are the phases of designing an integrated curriculum unit in mathematics and science?

(2) What are the most suitable teaching strategies that can be used to teach knowledge and skills of mathematics and science as an integrated curriculum unit?

(3) What are the best assessment techniques that can be used to measure the students' learning outcome after using the integrated unit of mathematics and science?

3. Methodology

3.1. Context of the Integrated Unit. The educational system in Bahrain applies the principle of mandatory education for all students in both elementary and preparatory education levels. The elementary education level is from the 1st to 6th grade that involves students from age 6 to 12 years old. Namely, the modal age range of 6th graders in Bahrain ranges between 11 and 12 years old. After that, students move to the preparatory educational level that lasts for three years. Accordingly, students have equal opportunities to accomplish the necessary knowledge and skills, particularly in mathematics and science. The educational system in Bahrain accommodates both sectors of public and private schools under the supervision of the Ministry of Education. The public schools provide a high quality of education that is completely free of charge. There are approximately 150 thousand students studying in public schools and around 80 thousand students receiving their education in private schools. This statistics shows clearly that public schools accommodate almost double (2 : 1) of what private schools have of students, which indicates that around 65% of total students study in public schools.

This study provides a proposal of integrating mathematics and science in 6th grade of Bahraini public schools. The researchers produced the ultimate integrated unit possible based on their professional experience and subjects' standards of planning, teaching, and assessment. Hence, there was no actual students' participation while designing this module, because it gives a promising design to practitioners and teachers, so they can use it to teach their students, because results may differ from a teacher to another and a group of students to another based on their characteristics, including teaching skills and learning readiness.

This study is based on all 6th graders science curriculum in the public school system, as the same curriculum is used across all public schools. The selected science unit comes under physics and the topics covered are motion and force and Newton's laws of motion. The researchers selected this unit because it provides an ideal opportunity of integrating mathematics and science due to the nature of this unit and its topics, knowledge, and skills that allow to use mathematics.

The integrated mathematics topics are algebraic expressions, balancing linear equations, integers, proportional reasoning, and graphing. This integrated activity is designed in three stages. In stage 1, students use a toy car to define motion by identifying constants (frame of reference), compare the effect of push/pull using Venn diagram, investigate various types of forces, calculate net-force using integers (signed numbers), explore Newton's first law of motion, and draw and interpret distance-time graph. During stage 2, students use another source of energy (a balloon powered car) to investigate the same topics plus measure speed, distance, velocity, acceleration, and the second and third laws of motion by Newton. Stage 3 is considered to be a higher order thinking activity that can be used as a common assessment for both mathematics and science, in which the students improvise the design of their car with another power source (engine or rubber band) to investigate the effect of different types of forces on the movement of the three cars. At present, 6th graders have 3 science periods and 5 math periods per week. This curriculum/activity is proposed for two weeks with four periods per week for each subject.

3.2. Designing the Integrated Curriculum Unit. In order to design an integrated curriculum unit, the researchers suggested to conduct three main phases as shown in Figure 2, as it presents the hierarchical design of the adopted conceptual framework and connects the procedures of each phase, including planning as a detailed road map, pedagogical approach based on relevant teaching strategies, and outcome as integrated teaching and learning activities. Each phase is a unique process that requires several different identified processes based on relevant learning theories and teaching strategies to be achieved.

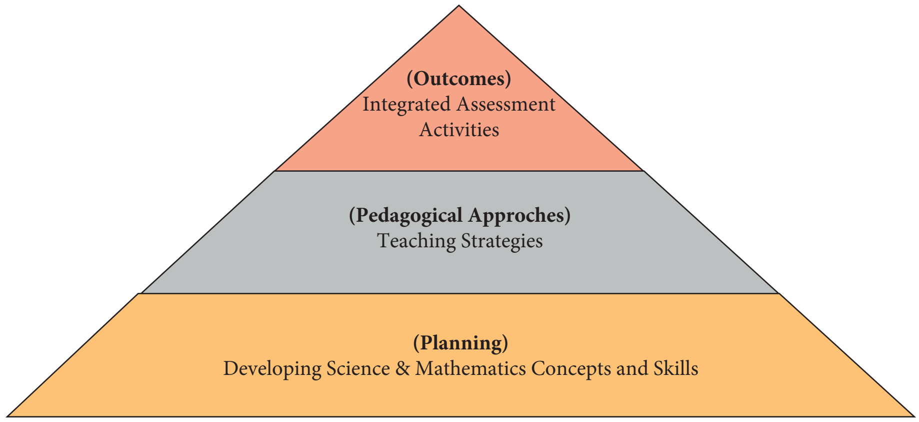

Figure 2: The adopted conceptual framework.

3.3. Planning: Developing Science and Mathematics Concepts and Skills. In order to enable students to successfully achieve the targeted learning objectives, it is crucial for students with the needed prerequisites and required background knowledge. Hence, students of grade 6 are expected to possess certain content knowledge which helps them in constructing the new knowledge throughout the proposed integrated unit of mathematics and science disciplines. Table 1 shows the prior knowledge required to learn this lesson and provides a detailed list of essential prerequisites to learn targeted content in mathematics and science.

In our proposal, we have used science as the centre and mathematics is utilized as a supportive tool on the science side of the continuum. Table 2 explains in detail the activities to be carried out throughout the flow of timeline, discipline, topics, objectives, and targeted objectives, over the two weeks of study.

3.4. Pedagogical Approaches: Teaching Strategies. There are several mathematical teaching strategies that can be helpful in facilitating students' learning using mathematics and science integrated curriculum. Mathematical teaching strategies can be used through any of the aforementioned general forms of curriculum integration. However, these mathematical teaching strategies are varied in terms of the nature of targeted topic and required teaching and learning processes [13]. We have used various teaching strategies that are suitable for teaching mathematics and science specifically for the integrated unit we designed such as questioning, reasoning, hands-on activities, problem solving, guided inquiry, and constructivist learning to engage students in learning. Questioning is considered as a key teaching strategy when teaching initiates acquiring a new knowledge or skill in mathematics and science. It sparks the learning environment with rich amount of questions from teacher and students based on a certain topic. In the integrated curriculum of mathematics and science, questioning helps students to explore new topics and portray a virtual image of new concepts [3]. Reasoning is a suitable teaching strategy for mathematics and science when students need to create conceptual connections and discover the relationships among different concepts based on specific rules [9].

Hands-on activities enable students to practice the skills and master the practical learning. It helps students to put their knowledge together and experience it in a tactile way. Learning through hands-on strategy boosts learning achievement and lasts for a long time. This strategy enables students to transfer practical knowledge and skills to solve problems [4]. Problem solving is a higher level of learning activity and teaching strategy in mathematics and science. It requires an advanced stage of data mental processing and knowledge transferring [13]. It is more useful when students solve problems in groups collaboratively because they learn from each other and fix their possible mistakes. Prince [42] suggested that there appears to be some focus and support of the essential techniques of learning by active collaborative problem-based learning strategy.

Guided inquiry strategy can be used when introducing students to a complex knowledge that requires several sequential steps in mathematics and science. Missing any of the proposed steps can cause loss of information and may cause delay in learning. Individual as well as group or pair activities can be designed in both subjects to improve communication and collaboration skills and increase student achievement and learning [21]. Constructivist learning strategy can be used perfectly in teaching mathematics and science in integrated curriculum because it is based on knowledge mental construction. It provides a good opportunity for students to see the relevance of ideas by relating learnt concepts to formulate others. It helps students generate new knowledge from background learnt concepts and information [2].

3.5. Outcomes: Integrated Assessment Activities. The final project assesses all areas of mathematics as well as science concepts using a single activity. This particular project helps students to demonstrate their knowledge and understanding and higher order/critical thinking skills by making learning collaborative. Integration of these two subjects can also facilitate the development of student motivation, engagement, problem-solving skills, and relevance of concepts studied. Venville et al. [43] report that teachers observed several benefits of integration for their students, including increased motivation, engagement, and application of

Table 1: List of prerequisites.

	Prerequisites
Science	(i) Classify objects by their observable properties, e.g., size, shape, colour, and texture (ii) Represent the path of movement of various objects in different ways such as straight, zigzag, round, up, down, back and forth, slide, roll, bounce, spin, swing, and glide (iii) Distinguish between mass and weight of an object
Mathematics	(i) Perform basic mathematics operations on whole numbers, fractions, and decimals (ii) Sketch horizontal, vertical, and slanting lines and curves and circles by describing their properties. Measure lengths accurately with the help of a meter scale (iii) Measure distance, time, mass, and weight accurately (iv) Calculating elapsed time between two activities (v) Measure time and length with appropriate units (vi) Convert the units of measurements such as cm to m, g to kg/N, and minutes to seconds (vii) Calculate the average of quantities (viii) Gain knowledge of the XY coordinate plane and properties of straight lines

mathematics and science concepts. Additionally, it can promote student-centred pedagogies. As described in Table 3, it sheds the light on the details of the assessment activity by providing a clear description of the expected outcome and specifying the learning objective. Then, it lists the assessment activities in more executive details and shows the assessment criteria that need to be used.

3.6. Findings. Questioning integrated activities is preferable to be introduced at the beginning of teaching and learning new knowledge about algebraic expression [13]. Students have to identify the features of an algebraic expression through the following questions by the teacher: what is a variable? What do they represent? How is a variable different from a constant?

Reasoning integrated activities clarify the connections among science and mathematical terms. The teacher can describe the proportional reasoning concept by using the ratio language in the context of a ratio relationship. Students have to recognize and represent proportional relationships between quantities by generating two numerical patterns and identifying apparent relationships between corresponding terms, including direct and inverse proportion. Hands-on activities are very powerful integrated activities when they are used in teaching students how to perform calculations involving integers [20]. Students can use the chips with the help of the teacher. Students model zero (0) in different ways (zero-pairs) to discover the fact that the sum of any integer and its opposite is equal to zero and the concept of additive inverse.

Problem-solving integrated activities seem promising when teaching students balancing equations using appropriate operations [1]. Teacher asks students to solve the problem by solving equations via undoing the operations in the reverse order of how the expression would have been evaluated. They have to simplify the equation. Students need to get the variable term on one side by itself. They have to isolate the variable. Guided inquiry integrated activities can enable students to acquire the targeted skill of drowning and interpreting graphs. Teacher guides students to record and organise data (example: average temperature of 5 days of a particular week) in appropriate tabular format.

Constructivist learning integrated activities are designed based on the sequence of conceptual knowledge considering the prior knowledge [9]. Teacher can use it when teaching students how to find the slope of a line when given the graph/equation of the line or two coordinates through which it passes. Students locate coordinates in the XY plane and construct the given line.

Using Newton's first law, students have to predict what will happen to the car, the figure, and the book when the car hits the book. The teacher adds more examples from daily life about this law and students in pairs choose creative example that suits the law.

4. Discussion and Suggestions

Research has shown that collaboration and integration have proven to be beneficial in education. Mathematics and science educators work together to make them more globally competitive through integration [9]. When two teachers are focusing on similar concepts but in different environments in essence, time is gained. Because of the integration of mathematics and science in this particular unit, we can reduce the teaching time to two weeks instead of four so that the teachers will then be able to work with students at a higher level of cognition to explore concepts in depth making integration a meaningful learning experience. Its nature supports improving critical thinking skills, practical applications, cognitive development, and student attitudes in science and mathematics. Carr and Claxton [44] reported increased student interests and achievement in integrated instruction. The integrated approach of mathematics and science can motivate and increase achievement in both disciplines [18].

There are several studies suggesting that quality improvement in the education of science and mathematics is possible with various methods and techniques of teaching [13]. Science offers context and applications for abstract mathematical principles whereas mathematics offers the necessary skills and processes required for science to make sense of the natural world. Traditionally science and mathematics lessons are detached and students do not find any connection between the lesson ideas and its relevance in real world. Researchers found out while teaching force and

Table 2: Details of activities to be carried out.

Week #	Subjects	Topics	Objectives	Integrated objectives
Stage #1: week #1	Mathematics	Algebraic expressions	Describe the terms: variables and constants	Define motion by identifying constants (frame of reference) and variables
	Science	Motion & force	Define motion with respect to still objects based on its direction	
	Mathematics	Venn diagrams	Use Venn diagrams to group items according to their properties	Compare the effect of push/pull using Venn diagram
	Science	Motion & force	Define force by explaining the effect of push/pull on displacement of objects	
	Mathematics	Ratio & proportion	Describe proportional reasoning	Investigate various types of forces
	Science	Newton's second law of motion	Analyse and interpret relationship between net-force on an object and its change in motion as summarised by Newton's second law of motion ($F = \text{ma}$)	
	Mathematics	Integers	Perform calculations involving integers	Calculate net-force using integers (signed numbers)
	Science	(i) Balanced and unbalanced forces (ii) Newton's first law of motion	(i) Distinguish between the effects of balanced and unbalanced force applied on an object and calculate net-force (ii) Apply Newton's first law of motion in daily life	
	Mathematics	Integers	Perform calculations involving integers	Explore Newton's first law of motion
	Science	(i) Balanced and unbalanced forces (ii) Newton's first law of motion	(i) Distinguish between the effects of balanced and unbalanced force applied on an object and calculate net-force (ii) Apply Newton's first law of motion in daily life	
	Mathematics	Graphs/ Coordinates	Draw and interpret graphs	Draw and interpret distance-time graph
	Science	Distance-time graph	Sketch the movement of the object using distance-time graph	
Stage #2: week #2	Mathematics	Graphs/ Coordinates	Draw and interpret graphs	Calculate the speed by measuring distance and time
	Science	Distance-time graph	Sketch the movement of the object using distance-time graph	
	Mathematics	Ratio & proportion	Describe proportional reasoning	Describe velocity by identifying direction of motion
	Science	Speed and velocity	(i) Identify speed(s) as the distance(d) an object travels in a given amount of time(t), and calculate speed using the formula ($s = d/t$) (ii) Identify that velocity is described by both speed and direction	
	Mathematics	Graphs/ Coordinates	Draw and interpret graphs	Construct velocity-time graph
	Science	Velocity-time graph	Construct velocity-time graph	
	Mathematics	Ratio & proportion	Describe proportional reasoning	Calculate acceleration
	Science	Acceleration	Define acceleration and calculate it using the formula $a = \Delta v/\Delta t$ and classify it as positive, negative, and zero	
	Mathematics	Ratio and proportion	Describe proportional reasoning	Investigate the relationship between force, mass, and acceleration by Newton's second law of motion
	Science	Newton's second law of motion	Analyse and interpret relationship between net-force on an object and its change in motion as summarised by Newton's second law of motion ($F = \text{ma}$)	
	Mathematics	Linear equations	Balancing equations using appropriate operations	Describe Newton's third law of motion with the help of balancing linear equations
	Science	Newton's third law of motion	Describe Newton's third law of motion	

Table 2: Continued.

Week #	Subjects	Topics	Objectives	Integrated objectives
Stage #3: common assessment	Mathematics	All the above mathematics topics	Conduct measurement (distance, time), unit conversions, calculations (velocity, acceleration) and graphing skills	Demonstrate applicable mathematics skills and scientific investigation skills
	Science	All the above science topics	Investigate the effect of different types of forces on the movement of the three cars	

Table 3: Assessment activity.

Stage 3	Final exploration project (higher order thinking activity) Design: improvise the design of the car, using another power source (rubber band/engine)
Outcome	Demonstrate applicable mathematics skills and scientific investigation skills
Objective	Investigate the effect of different types of forces on the movement of the three cars
Activities	(i) Make use of three cars (normal car/balloon powered car/newly designed) (ii) Race and compare the effect of various types of forces (push/pull, gravity, friction, etc.) by answering the given questions (iii) Demonstrate the three laws of motion; find the average speed, velocity, and acceleration of all types of cars: plot distance vs. time, velocity vs. time graphs; and compare the cars in terms of performance
Assessment criteria	**Science:** the car functioning, comparison of various forces, calculation of speed and velocity, acceleration, comparison of performance of the cars **Math:** accuracy in measurement (distance, time), unit conversions, calculations (velocity, acceleration), and graphing skills

motion unit that the majority of students cannot use scientific process skills such as mathematical calculations, comparing process, measurement, interpreting and inferring process, and recoding data properly [20]. Students' operational skills should be developed by mathematics teachers. This proposal integrates the required mathematical operational skills with the science lesson in the sixth grade.

5. Conclusion

Administrators play a central role in providing time for teaching teams to collaborate. The leadership team should be creative in planning the master schedule in such a way that teachers who wish to integrate have time during the day to collaborate and plan integrated lessons. Technology can give teachers tools that permit their students to perform complex tasks that are similar to those in the real world to promote student engagement [20]. As the transfer of mathematical content knowledge and skills into science is required in this integration, lack of experience of mathematics teachers to teach the transferred content to their students thoroughly and deficiencies of science teachers in their mathematical concept knowledge can lead to a failure of this integration process [2]. Hence it is advisable to implement science and mathematics integration training to be given to preservice teachers in their curriculum [1]. Singh et al. [45] suggested that curricular or cocurricular activities related to science and mathematics should be used in order to improve the student's motivation towards their courses. Students' anxiety about mathematics may affect their scientific learning. But when science and mathematics are integrated successfully, this can be eliminated to a good extent improving self-concept, interest, attitude, and motivation in students which in turn contributes to their learning and achievement [9].

Data Availability

This is a descriptive research, so no data were analysed. However, the STEM model was designed and suggested based on certain criteria.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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