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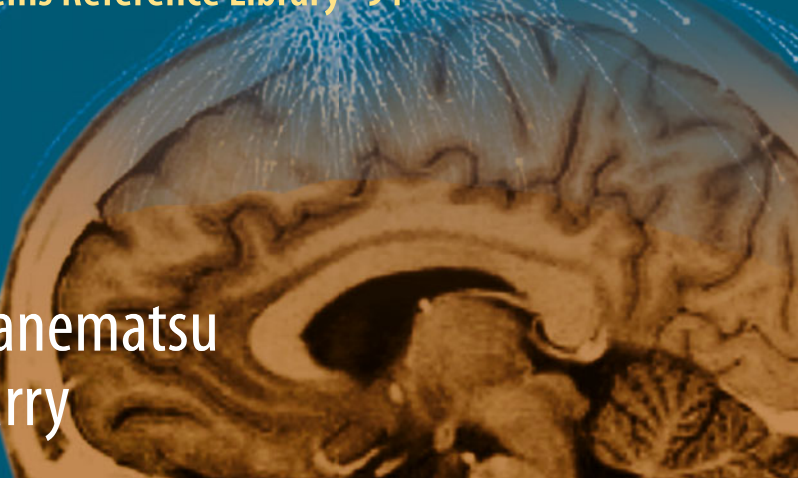

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STEM and ICT Education in Intelligent Environments

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This book is dedicated to Hideyuki Kanematsu's wife Reiko and to Dana Barry's husband James.

It is also written in part for Hideyuki's children Hitomi and Hiroyuki and for Dana's sons James, Brian, Daniel, and Eric.

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Contents

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Introduction

Children and youth are now living in the digital age. The impact of the digital revolution has affected them tremendously. It has changed our daily lives, social structures, and philosophy for everyday life. Therefore, education is also affected by it. There are a number of devices, media, equipment, etc., that relate to information and communication functions, which are important for educational purposes. These functions need computers. When the focus is placed on technology it is called information technology (IT). On the other hand, when the use of computer technology is stressed and the importance is attached to communication inevitably, it is called information and communication technology (ICT). ICT contains two main categories, hardware and software. Hardware refers to items such as personal computers and digitizing cameras. Examples of software use include websites and videos.

This book combines information and communication technology (ICT) with a creative interdisciplinary teaching approach known as STEM Education, where STEM refers to science, technology, engineering, and mathematics. *STEM and ICT Education in Intelligent Environments* has five parts. The first part is called *STEM and Creative Education*. It describes creativity as the ability to produce original work and ideas by exercising the higher levels of thinking such as synthesis. Creativity is especially important for the teaching and learning of science, technology, engineering, and mathematics (STEM). Countries depend on a supply of qualified STEM graduates to creatively solve challenging problems and to compete globally.

The second part is *ICT and STEM Education*. ICT includes hardware and software for information and communication functions. It enhances and expands the opportunities for STEM Education. With ICT, instructors and their students are able to use the Internet, audio-visual classrooms, social networking, and more. Part III of the book contains nine STEM Activities for the Real World, with various topics involving airplanes, vegetables, nutrition, the planets, weather, the environment, and more. Each activity uses information technology (IT), has a problem to solve, contains methods for student assessment, and includes the following four components: science, technology, engineering, and mathematics. These components are numbered according to the frequency in which they appear in each lesson. The activities give students, especially those between the ages of 12 and 18 years, opportunities to search for lesson-related references and to design and carry out investigations (in the real world) as creative problem solvers.

The fourth book part has STEM Activities for the Virtual World, with topics such as a Mars Simulation Mission, an international discussion held in a virtual classroom in Second Life, and a number of problem-based learning and design lessons that also take place in the virtual world. The format for each activity differs from those carried out in Part III (the real-world activities). They all involve information and communication technology (ICT), have a problem to solve, contain methods for student assessment, and include science, technology, engineering, and mathematics. Once again these STEM components are numbered according to the frequency in which they appear in each lesson. The activities give students, especially those between the ages of 16 and 20 years, opportunities to design and carry out investigations (in the virtual world) as creative problem solvers. This book section also discusses Video-Sharing and Massive Open Online Courses (MOOCs), as the most advanced forms of STEM Education based on ICT. The final book section (Part V) is a prediction about the classroom of the future as it relates to advances in the development of ICT.

We carefully designed this unique book which combines information communication technology (ICT) with a creative interdisciplinary teaching approach known as STEM (science, technology, engineering, and mathematics). The book is ideal for instructors to use as a text with students of various ages in creative education and engineering classes. It also serves as a great reference and guide. Readers in general who want to learn more about ICT and its impact on STEM and modern education will enjoy and benefit from it too.

We greatly enjoyed preparing this book and hope that you enjoy using it.

Hideyuki Kanematsu
Dana M. Barry

Part I
STEM and Creative Education

Creativity is essential for education at all learning levels. It is the ability to produce original work and ideas and involves higher levels of thinking such as synthesis. Creativity is especially important for the teaching and learning of science, technology, engineering, and mathematics (STEM). Countries wanting to strengthen their national status and power need a sufficient supply of qualified STEM graduates to creatively solve problems and compete globally.

Chapter 1
Creativity and Its Importance for Education

Abstract Creativity can be defined as the ability to produce original ideas and items. It also includes the combining of existing work and objects in different ways for new purposes. Creativity involves higher levels of thinking and is very important for all areas of education. Every field of study has problems to solve and relies on creative ideas for the possible solutions. Educators need to support children in the process of discovering and developing their creative potential, which is essential for them to adapt in an ever changing world and to become innovative scientists, artists, engineers, and entrepreneurs of the future.

Creativity, which has had various meanings over the years, is essential for education at all learning levels (elementary school through college graduate students). For the purpose of this book, it is defined as the ability to produce original ideas and even new products like drinks, toys, and medicine. Creativity also includes the combining of existing work, objects, and ideas in different ways for new purposes. One example is the wheelchair. It was created by combining wheels with a chair. The creative process starts with a creative person (a scientist, musician, engineer, etc.) who is usually energetic and full of ideas. It results in new services, processes, and products [1].

Creativity involves higher levels of thinking such as synthesis in Bloom's Taxonomy [2]. Bloom's taxonomy is a pyramid with six cognitive categories: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation (Fig. 1.1). Students memorize and recall information at the knowledge level. They understand concepts at the comprehension level and apply rules at the application level. Many engineering problems are at the analysis level, where students usually analyze one technical solution. However in order for engineers to solve problems creatively, they must work at the synthesis level (where one creates ideas, etc.) or the evaluation level (where one makes value judgments, etc.).

Barriers to creativity exist. They must be identified and overcome to enhance the higher levels of thinking needed to solve problems related to education as well as to real life. Some barriers include knowledge, perceptual, emotional, cultural, and expressive blocks. Students need to possess a certain amount of knowledge in order to generate creative yet practical solutions to problems. A perceptual block prevents

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one from clearly viewing the problem that needs to be solved. Emotional blocks tend to hinder one's willingness to try something new, especially if the individual has a fear of failure. An example of a cultural block is when a resistance to change and new ideas exists at the school or workplace. The expressive block is an important barrier to creativity too. In this case a person is not able to affectively communicate with others in defining a problem or its possible solutions. Instructors can help students overcome these barriers by using textbooks that motivate students to ask questions and by encouraging them to participate in brainstorming sessions where the classmates have an opportunity to generate ideas and possible solutions to problems. Teachers should be open-minded, value originality, and seek imaginative solutions to problems. Also they need to be more like facilitators instead of just lecturers.

Today there is concern about the sustainability of our global society. In order to adapt and survive we need to be creative problem solvers. People solve problems on a daily basis. Some are easy tasks such as deciding what clothes to wear and what to eat for dinner. Others are more difficult like solving the challenging restoration and recovery problems from earthquakes and tsunamis. Therefore, creative education is important for humankind throughout the world [4].

Creativity is essential to all topics in education whether students are majoring in psychology, economics, communications, science, engineering or other fields. Each has its own problems to solve and relies on creative ideas for innovative solutions. Several specific disciplines are briefly discussed.

From the viewpoint of engineering education, it is very important to have trained and innovative engineers now and in the future. The world depends on them to creatively design items, processes, and services to satisfy human needs. Engineers use a design process (which is really a problem solving model) to solve problems and meet the demands of society. This process involves engineering design skills that make it possible for them to solve complex problems that have multiple answers [5]. These problems relate to the higher cognitive levels such as the

Fig. 1.1 Bloom's taxonomy [3]

synthesis stage in Bloom's Taxonomy. The United States and other countries would also like to have a large number of highly qualified engineers to compete globally in areas like space exploration. Therefore, there is a great need to recruit and retain engineering students of all ages. Instructors are strongly encouraged to introduce youngsters to engineering and to motivate them to pursue studies and make career choices in this field.

Barry, who initiated an international program in creative education, carried out a project about tsunamis with engineering students in Japan to help promote their creative thinking skills. She asked them to solve the following problem. How will the coastal areas of Japan be protected from future tsunamis? The participants brainstormed in groups and tested their ideas using simulated tsunamis in a laboratory setting. After performing some experiments with waves and various barriers (including seawalls), the class generated many creative ideas for addressing this problem. Some possible solutions included planting rows of pine trees along the coast to reduce the impact of tsunamis and placing structures of different sizes and shapes in the water to block and change the direction of the waves [6]. NOTE: Keep in mind that creativity is the ability to generate ideas and it involves the higher levels of thinking (example: synthesis).

Another way to promote creativity for engineering students and others is to have them exercise reverse thinking using their senses. For example, ask them to create a new and improved orange with a better taste and more fruit. To begin, have the students take apart, analyze, and compare the components (skin, fruit, seeds, etc.) of various orange types. Tell them to smell and taste the fruit, count the seeds, and measure the thickness of the skin for each examined orange. This activity was successfully used by Barry in a science class to promote the generation of creative ideas [7, 8].

Creativity is also important for Entrepreneur Education, which is sometimes included as part of the School of Business in universities. Colleges in various countries offer programs in entrepreneurship to provide young people with the career choice of being self-employed or business owners. Simply stated, an entrepreneur is an individual who is able to obtain resources for new business opportunities. Steve Jobs was a famous entrepreneur, who co-funded Apple Computer, Inc. Some of his contributions to the world include the iPod (music player), iTunes (media player), the iPad, and iPhones.

To be successful, entrepreneurs must generate (create) valuable ideas for new products and services that will be of interest to some identifiable market. They need to create a way to make their product a reality. Also if money is required to develop the new venture, then entrepreneurs must create ways to convince others of the great need and importance of their product. Therefore, instructors of Entrepreneur Education must do everything possible to promote creativity and to develop students' creative thinking skills.

A good example for creative education is the teaching of English (or any other language). This is especially true if the course includes audio books and creative writing. Audio books help stimulate our imagination. While listening to the characters talk and react, students can imagine their looks and personalities. They can also generate ideas about the time period and setting (examples: inside a house, outside near a stream, etc.) of the story.

In addition, English class provides students with an opportunity to write creatively about fiction and non fiction topics. They also have a chance to create names for interesting characters and items used in their stories and for potential new products for the marketplace. This is done by creatively combining concepts, ideas, and words [9]. Take for example the combining of two nouns "mouse" and "pad." Together they form mouse pad, a popular item used with computers. Words of opposing meaning can be combined too. The words "nonalcoholic" and "beer" give us nonalcoholic beer, which is an attractive drink for health conscious people who like to socialize. Also modifiers can be added to non creative words. The simple word "shoes" can be made more creative by placing modifiers in front of it. Several examples are golf shoes and dress shoes.

Music Education provides creative experiences too. For this field of study, students learn music appreciation, music, theory, and music notation. They also learn to sing and play instruments in groups or as soloists. Music classes have three fundamental ways to engage individuals in music: listening, composing, and performing. As for performing, students can sing or play the music written by others or they can create (at the moment) and perform their own music which is referred to as improvisation. Improvisation (which can simply be described as a self created solo) is frequently incorporated into various jazz compositions. After mastering the basic skills, students are encouraged to compose their own music by creating various combinations of notes and rhythms.

Artists and art students of all ages can express and share their creative ideas through sketches, sculptures, and paintings. Their clever use of color, shading, paints, and distortions can channel good and bad emotions to the viewer. Famous paintings like the Mona Lisa and the Last Supper by Leonardo da Vinci are treasured and enjoyed by many.

Yes. Creativity is very important for all areas of education. Only a few topics have been discussed here. However, every field of study has problems to solve and relies on creative ideas for the possible solutions. Educators need to support children in the process of discovering and developing their creative potential, which is essential for them to adapt in our ever changing world and to become innovative scientists, artists, engineers, and entrepreneurs of the future.

References

1. Barry, D. M., & Kanematsu, H. (2006). International program to promote creative thinking in chemistry and science. *The Chemist, 83*(2), 10–14.
2. Bloom, B.S.,& Krathwohl, D.R. (1956). *Taxonomy of Educational Objectives: The Classification of Educational Goals, by a Committee of College and University Examiners.* Handbook 1: Cognitive domain. New York, Longmans.
3. Diagram prepared by Dana M. Barry.

4. Barry, D.M. & Kanematsu, H. (2008). International program promotes creative thinking in science, *The education resources information center (ERIC) online paper*, ED 500317, The Institute of Education Science, The US Department of Education.
5. Barry, D.M. & Kanematsu, H. (2010). International collaboration: creative engineering design program between the US and Japan, (book chapter) *Innovations 2010*, a publication of the International Network for Engineering Education and Research.
6. Barry, D., Tanaka, T. & Kanematsu, H. (November 2013). Osaka university students use english to carry out a creative engineering project about tsunamis. *International Journal of Engineering Research & Technology,* 2(11).
7. Kanematsu, H., Barry, D.M., Shimofuruya, H., & Kobayashi, T. (2003). International education project chemical sensation—a challenge for attractive chemical classes, *Materia Japan (Bulletin of Japan Institute of Metals),* 529.
8. Barry, D. M., Kanematsu, H., Kobayashi, T., Shimofuruya, H. (Summer 2003). Using the senses to turn students onto chemistry: a comparison between the united states and japan. *The Chemist,* 13.
9. Ward, T. B. (2004). Cognition, creativity, and entrepreneurship. *Journal of Business Venturing*, 19(2), 173–188.

Chapter 2
Theory of Creativity

Abstract Creativity is the ability to produce original work and ideas. It starts with a creative person using a creative process to make a creative (new) product. Various studies have been carried out to obtain information about the behavior of creative individuals. These people are usually energetic and full of ideas. When confronted with a problem, they consider all of the different ways to solve it and tend to come up with unique solutions. Many models have been developed to explain creativity and the creative thinking process. Some of them are presented and discussed in this chapter. However, it should be mentioned that most of them include steps with the common themes of synthesis, analysis, and evaluation (which are the higher levels of thinking).

Creativity can be defined as the ability to produce original ideas and new items. It also includes the combining of existing work, objects, and ideas in different ways for new purposes. Three important components of creativity are the creative person, the creative product, and the creative process [1].

A recent study showed that most people tend to be more creative when they walk than when they sit. They generate more creative ideas while walking. This research is published in *the Journal of Experimental Psychology: Learning, Memory, and Cognition* [2]. About two hundred volunteers were asked to complete a creativity test twice: once while sitting and once while walking. The results indicated that 81 % of the participants improved their creative output when walking. The degree of creativity was measured by verbal tests. A creative response was defined as one that was both appropriate and original (not said by anyone else in the study).

2.1 Creative Person

A creative person is usually energetic and full of ideas. This individual is also characterized by having a desire to grow and a capability to be puzzled, spontaneous, a divergent thinker, open to new experiences, persistent, and a hard worker [3].

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Studies have been carried out to obtain information about the behavior of creative individuals. Chavez-Eakle, Lara, and Cruz found creative people to be exploratory when encountering novelty, to be optimistic, tolerant of uncertainty, and to pursue their goals with intensity [4]. Martindale et al. found highly creative individuals to be over reactive to stimulation [5]. Also the Torrance Tests of Creative Thinking (TTCT) have been used to assess creative potential. They provide a creativity index and scores for various categories like fluency, originality, elaboration and flexibility [6]. Fluency refers to the total number of meaningful ideas (responses) generated, while originality relates to the rarity of the responses. Elaboration is the amount of detail in the responses and flexibility corresponds to the number of different groups of responses. Educators need to identify and nurture students' creative potential and take it into account when developing educational programs.

For years scholars have tried to determine the thinking strategies of famous people like Einstein, Darwin, and Mozart. Most individuals think reproductively to solve problems. They select a promising approach based on past experiences and exclude others. In contrast, famous people like those previously mentioned are productive thinkers. When confronted with a problem they consider all of the different ways to solve it. They tend to come up with some unconventional and unique solutions. For example, they have the ability to force relationships between dissimilar subjects. Leonardo da Vinci (a well-known artist and scientist) connected sounds to waves and is credited with discovering the sound wave [7]. Albert Einstein did not invent the concepts of mass (m), energy (E), and the speed of light (c). However, he combined them in a novel way to express his equation for energy ($E = mc^2$). Famous creative thinkers are productive and able to visually display their ideas in various ways. Thomas Edison, who invented the light bulb, was one of the most prolific inventors of the late 19th century. Wolfgang Amadeus Mozart prepared many music compositions. He began composing minuets at the age of 5 and symphonies at 9 [8]. Also Einstein, da Vinci, Galileo, and others had the flexibility to make their thoughts visible through diagrams, maps, graphs, and simple drawings, in addition to the mathematical and verbal approaches.

2.2 Creative Product

The creative product is one that never existed before like a new book, song, or invention. It could be a child's creative game to play with friends or a housewife's innovative recipe for cookies. Other examples include Shakespeare's plays and Einstein's Theory of Relativity. Products such as publications, works of art, and musical compositions, can be counted and are often available for viewing or judging. Some creative items (like paintings by Michelangelo) remain popular for long periods of time while others have never been socially noticed.

2.3 Creative Process

The creative process starts with the creative person and results in a creative product. It includes the thinking and the acts that take place to produce an original item. *The Cambridge Handbook of Creativity* summarizes ten theories of creativity [9]. They are as follows. The Developmental Theory states that creativity develops over time. It starts with creative potential which leads to creative achievement as a result of an individual interacting with the environment (surrounding places, family, etc.). The Psychometric Theory measures creativity in terms of assessing the reliability and validity of the creative product. It is not related to IQ but focuses on the product itself. Economic Theories are concerned with creative ideas and behavior that are influenced by the marketplace and the economy. In the Stage and Component Theories, creative expressions proceed through a series of stages such as preparation, incubation, and verification. Cognitive Theories relate to creative people who use remote associations, divergent (where ideas move in varied directions) and convergent (where ideas converge to one correct answer) thinking, conceptual combinations, and metacognitive processes. The Problem Solving & Expertise-Based Theory leads to creative solutions to ill-defined problems. It relies on individuals using rational processes and expertise-based approaches. The theory referred to as Problem-Finding is where people proactively use an exploratory approach in order to identify problems to solve. The Evolutionary Theory begins when ideas are combined in a blind fashion (a chance combination). Then the most interesting combinations are retained and consciously made into creative products which are judged by other people. Typological Theories take into account individual differences such as the creators' personalities, work habits, and career choices. The final type of theory presented in the book is called Systems. This approach views creativity as a result of a complex system with interacting subcomponents (examples: the body of knowledge that exists at a particular time, the individuals involved, etc.).

Various models have been developed to explain the creative thinking process. Most of them include a set of steps that provide helpful guidance. However they should not be used too rigidly. A popular model was proposed by Graham Wallas in 1926 [10]. He believed that creative thinking involved four phases: preparation (defining an issue), incubation (setting the issue aside for a period of time), illumination (the moment the new idea arrives), and verification (checking out the new idea). His incubation and sudden illumination stages suggested that creative thinking is a subconscious mental process. Contrary to this belief, Perkins felt that subconscious mental processes are behind all thinking and therefore have no special role in creative thinking [11]. While many models exist, most of them include steps with the common themes of synthesis, analysis and evaluation (which are the higher levels of thinking).

Creative thinking stimulates curiosity and uses the skills of originality, fluency, flexibility, and elaboration (which are all categories in the Torrance Tests of

Fig. 2.1 Spiral Path [13]

Creative Thinking). It is exploratory, looks for relationships, and develops many original and diverse ideas. These new ideas are then evaluated by critical thinking, which involves logic and reasoning.

Creative thinking, which is part of our thinking process, can be described in a simple way by Ebert's Cognitive Spiral Model [12]. This model contains five modes of thought: perceptual thought, creative thought, inventive thought, metacognitive thought, and performance thought. These modes of thought occur in sequence along a spiraling path. They recur over and over but do not return to the spot where they began (Fig. 2.1).

In Perceptual Thought the brain detects stimuli (such as flower fragrances) and translates them into neuro-chemical impulses. The next step of the model is called Creative Thought. This is defined as the search for patterns and relationships between a perception and the individual's knowledge. A person's long term memory is searched for prior experiences that are similar to the new one. If the sound of a ringing bell is perceived, then Creative Thought comes up with possible sources for the sound such as a door bell or a cell phone. During Inventive Thought, the information provided by Creative Thought is assembled into a product (such as a ringing cell phone). Then Metacognitive Thought (also known as critical thinking) evaluates the product. If this product is found to be an acceptable solution, then it is expressed (in the model's final mode) through a performance like speaking or writing. However if it is not acceptable, then the process starts again (but at a new starting point).

As already discussed in this chapter, creativity includes three important components. It starts with a creative person who uses a creative process to produce a creative (new) product. Various studies have been carried out to obtain information about the behavior of creative individuals. These people are usually energetic and full of ideas. When confronted with a problem, they consider all of the different ways to solve it and tend to come up with unique solutions. Therefore, as a result of these studies and others, it is not surprising that many models have been developed to explain creativity and the creative thinking process. However, it should be mentioned that most of them include steps with the common themes of synthesis, analysis, and evaluation (which are the higher levels of thinking).

References

1. Barry, D. M., & Kanematsu, H. (2006). International program to promote creative thinking in chemistry and science. *The Chemist, 83*(2), 10–14.
2. Study: A Stroll Helps Creative Thinking, *Watertown Daily Times*, A2 (May 4, 2014).
3. Anderson, H. (1959). Creativity in Perspective. In *Creativity and Its Cultivation* (pp. 236–242). New York: Harper Brothers.
4. Chavez-Eakle, R. A., Lara, M. C., & Cruz, C. (2006). Personality: a possible bridge between creativity and psychopathology. *Creativity Research Journal, 18*(1), 27–38.
5. Martindale, C., Anderson, K., Moore, K., & West, A. N. (1996). Creativity, oversensitivity and rate of habituation. *Personality and Individual Differences, 20*, 423–427.
6. Torrance, E. P. (1990). *Torrance Tests of Creative Thinking*. Bensenville: Illinois. Scholastic Testing Service.
7. www.Stmary.ws/highschool/physics/sound_1.htm.
8. Landon, H.C. (1992). Mozart, wolfgang, amadeus. In *Lexicon Universal Encyclopedia* (pp. 628–629). Lexicon Publications, Inc.
9. Kozbelt, A., Beghetto, R.A., & Runco, M.A. (2010). Theories of creativity. In: J. C. Kaufman, & R. J. Sternberg (Eds.) *The Cambridge Handbook of Creativity* (pp. 20–47). New York: The Cambridge University Press.
10. Wallas, G. (1926). *The Art of Thought*. New York: Harcourt Brace.
11. Perkins, D. N. (1981). *The Mind's Best Work*. Cambridge, MA: Harvard University Press.
12. Ebert, E. (1994). The Cognitive spiral: creative thinking and cognitive processing. *Journal of Creative Behavior, 28*(4), 275–290.
13. Sketch by Dana M. Barry.

Chapter 3
STEM and Creativity

Abstract STEM education refers to the teaching and learning in the fields of science, technology, engineering, and mathematics (STEM). This type of education, especially when combined with creativity, is of great importance to all countries wanting to strengthen their national status and power. World leading nations need a sufficient supply of qualified STEM graduates to creatively solve problems and compete globally. In order to do this, a country must have creative STEM students at the postsecondary level. Therefore, it is essential to introduce children to the STEM topics (science, technology, engineering, and mathematics) and motivate them to pursue studies in these fields. Barry initiated such a program (in collaboration with Kanematsu) to promote creativity and combine it with STEM education. The program is presented and briefly described.

STEM education refers to the teaching and learning in the fields of science, technology, engineering, and mathematics (STEM). It includes all grade levels, from pre-school to post-doctorate positions. During recent years there has been a concern in the United States and in other countries for developing future scientists, technologists, engineers, and mathematicians (STEM careers). These countries want to be viable and competitive in a growing global economy. Therefore, they need to promote and improve STEM education.

Studies have been carried out to determine a general profile for students pursuing degrees in science, technology, engineering, and mathematics (STEM). *Statistics in Brief* obtained data from three major U.S. studies. It examined information from the 1995–96 Beginning Postsecondary Students Longitudinal Study, the 2003–04 National Postsecondary Aid Study, and the Education Longitudinal Study of 2002/06 [1]. The results showed that overall the percentage of students entering STEM fields was higher for male students, younger (age 19 or less) and dependent students, Asian/Pacific Islander students, and for foreign students or those who spoke a language other than English as a child [2]. Also there were more students majoring in STEM areas who had a strong academic program in high school and who had parents with at least a 4-year college degree. In addition it was found (through these studies) that after 6 years of initial college enrollment, the STEM students were better at completing a Bachelor's degree than the non-STEM majors.

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However, STEM majors only accounted for 14 percent of all undergraduates enrolled in U.S. postsecondary education in 2003–2004 [3]. To help increase the number of STEM graduates, improvements need to be made to school curriculums, student performance on international mathematics and science tests, funding for academically capable students requiring financial assistance and to the quality of K-12 teachers [4]. Also at the postsecondary level, efforts need to be made to remediate and retain students in STEM majors.

The U.S. has been involved in STEM-related issues since the 1800s. The Morrill Act of 1862 established colleges and universities and supported their science and engineering programs [5]. Also during this time period graduates of West Point designed many of the railroads, bridges, and roads that were important to the country's early expansion.

In 1957 the Soviet Union's Sputnik orbited the Earth. This technical achievement caught world attention. The United States' reaction to the launch of Sputnik, along with criticism of the American educational system, set the stage for the government to provide funding for reforming public education at all levels. In 1958 Congress passed the National Defense Education Act [6]. Much of this funding was used to support academically capable students (especially those in STEM areas) who needed financial assistance to pursue undergraduate and graduate degrees.

Nearly 50 years later (about 2007), the U.S. was not just competing with one rival but with many in the global marketplace. STEM education (especially when combined with creativity) is of great importance to all countries wanting to strengthen their national status and power. Innovation (which involves creativity) drives a country's economy by providing jobs and a good standard of living. World leading nations need to have innovative industries and a sufficient supply of qualified STEM graduates to creatively solve problems and compete globally. In order to do this, a country needs creative STEM students at the postsecondary level. Therefore, it is essential to introduce children to the STEM topics (science, technology, engineering, and mathematics) and motivate them to pursue studies in these fields.

A typical teacher does not give creativity a high priority because he/she must organize and manage a group of students each day and make sure that they learn specified curriculum information in various subjects. Teachers need to realize the importance of creativity (which is part of our thinking process) and incorporate it into their teaching. They can use creative teaching techniques and materials in their classes. Also they should encourage children (of all ages) to express innovative ideas and to seek imaginative solutions to problems.

Today there is concern about the sustainability of our global society. In order to adapt and survive, it is necessary for us to be creative problem solvers. Also we depend on STEM graduates to creatively design items, processes, and services to satisfy human needs. Therefore, creative education is important for humankind throughout the world.

To address this problem, Barry initiated a program to promote creativity and combine it with STEM education. She developed five different teaching methods (along with innovative teaching materials and books), that provide students with mental exercises in the higher levels of thinking. Barry and her collaborator Kanematsu successfully used the creative teaching models and hands-on activities with thousands of students in the U.S. and Japan. Several of these teaching methods have been formally incorporated into the advanced engineering course at the National Institute of Technology, Suzuka College, Japan. In addition, the Multisensory Teaching component of the program won a national ChemLuminary Award from the American Chemical Society in 2004.

Barry and Kanematsu emphasized student safety for all investigations included in their program. See Chart 1 for Student Safety Tips.

Each teaching model has an important and unique way for STEM students (especially those in the fields of science and engineering) to creatively solve problems. Together as a whole (the five teaching models) include all learning styles of students and provide a variety of methods for the synthesis process (generation of ideas). To focus on and only use one model limits creativity. Having all of the models available increases the flow of ideas, originality, and creativity. These teaching methods make use of mathematics and technology. They also support the components of a typical problem-solving model (science) and a typical engineering design process, which contain similar steps. A summary of the creative teaching models, a typical problem solving model for science (Chart 2), and a typical engineering design process (Chart 3) are provided [7, 8].

3.1 Creative Teaching Models

3.1.1 Multisensory Teaching Approach (Known as the Chemical Sensation Project)

This method (which combines audio media, visual aids, and student investigations) was developed to meet the learning style needs of all students [9–13]. Some learn by seeing, while others learn by listening, or by carrying out hands-on activities. It requires instructors to incorporate the use of the senses (examples: seeing, smelling, touching, and tasting) into their science lessons and engineering design projects. For this approach, students are usually given a problem to solve and are encouraged to work on their own. Consider the following design question. Can you design a corn popper to make great popcorn? For this activity the proposed corn poppers are judged by their products (the popcorn that they make). The sense of seeing determines the appearance quality of the popcorn. Also the senses of tasting and smelling are used to evaluate the popcorn.

3.1.2 The Science Fair Project Teaching Approach

This method gives students opportunities to create/select an interesting problem to solve for their science fair and/or engineering design projects [14–22]. They perform many mental exercises during the investigation and use various forms of communication (which is essential for all aspects of science and engineering). This approach includes components of the engineering design and problem-solving models. The students are encouraged to work on their own as they perform mental exercises in collecting, analyzing, and interpreting data to draw conclusions about the outcomes of their exciting investigations.

3.1.3 The Reading and Solving a Mystery Teaching Approach

This method encourages students to act on their own as detectives to solve a story's mystery (crime or problem) by collecting and analyzing evidence (data). It includes published books written in English and Japanese by Barry and Kanematsu [23–26]. These books contain mystery stories and activities in science and engineering. For this teaching approach, students read a mystery story and treat it as a research project. They identify the main problem or crime and solve it by creatively designing and carrying out an investigation. This method allows individuals to think beyond the science and engineering fields, which are somewhat restrictive. As a result, originality and creativity increase.

3.1.4 The Space-Related/Space Exploration Teaching Approach

This method nurtures communication skills, creativity, and the planning capability of science and engineering students [27–29]. Also it helps students imagine unknown objects, especially when they are carrying out science and engineering design projects beyond planet Earth. For this model students are usually given a problem to solve by their instructors, who serve as facilitators. Groups of students (with diverse backgrounds) work as teams to brainstorm and discuss the problem and to generate possible solutions. They prepare many sketches, diagrams, etc. to express their ideas. This model can also be used with non- space-related projects.

3.1.5 *Innovative E-learning and a Team Approach for Problem Solving in Virtual Reality*

This method includes software and electronic media. It is flexible so that all or part of the project activities can take place using e-learning. This special model provides participants with simulations like the Mars Explorer Missions and problem-based learning (PBL) projects in Metaverse (a three-dimensional virtual community, such as Second Life), where avatars perform activities on behalf of us [30–34]. Students are encouraged to work in groups to solve a problem posed by their instructors. They generate possible solutions by brainstorming and using computers with special software. In addition, they can display their solutions in a three-dimensional virtual community. This option removes constraints and restrictions so that more creative solutions can be considered. One example is to have the students design and build the house of the future using primitives in Second Life [35].

The STEM Activities in the Real World (Part 3 of this book) relate to the first four creative teaching models. The fifth model about Innovative E-Learning was used to prepare the STEM Activities in the Virtual World (Part 4 of this book).

Students need to think about safety first before doing the STEM activities or any other science/engineering experiments. Instructors should emphasize the importance of safety along with presenting and discussing a list of safety rules with the class. Also they need to enforce these rules and supervise all experimental work performed by the students. Some important safety tips are provided in Chart 1.

3.2 Chart 1: Important Safety Tips for Students

1. Follow your instructor's safety rules.
2. Know the location of and how to use all safety equipment (for example: a fire extinguisher).
3. Read the directions and the Material Safety Data Sheets (MSDS) for chemicals that you plan to use.
4. Get the instructor's approval for your experimental setup and protective attire before you begin.
5. Keep tools and appliances unplugged when not in use.
6. Perform your experiments under the supervision of an adult or your instructor.
7. Work carefully and cautiously.
8. Properly dispose of chemicals and do not return them to their original containers.
9. Clean up after each activity.
10. Wash your hands thoroughly after each experiment.

3.3 Chart 2: Typical Problem-Solving Model for Science

The following components are generally included in most problem-solving models for science investigations.

1. Problem: The problem is what needs to be solved. It can be written in the form of a question and answered by carrying out an experimental investigation.
2. Hypothesis: The hypothesis is an educated guess that answers your question (or solves the problem).
3. Variables: The variables are the conditions or things that change during the experiment.
4. Controls: The controls are items or conditions that remain constant (the same) during the experiment.
5. Materials: The materials are the items and resources needed to carry out the investigation.
6. Procedure: The procedure is a set of instructions to carry out the investigation.
7. Data Collection: Data is collected by making measurements and observations. Measurements can be made by using tools such as scales, thermometers, and various instruments. This information should be recorded on organized Data Charts.
8. Results: The results of the experiment can be described in words or displayed on graphs, etc.
9. Analysis: An analysis is when one closely examines the data and results.
10. Conclusion: The conclusion is how one evaluates the findings of the investigation. It may or may not support the hypothesis.

3.4 Chart 3: Typical Engineering Design Process

The following components are generally included in a typical engineering design process (model).

1. Identify The Problem: Select or determine a problem that needs to be solved. It can be written in the form of a question. (This component is also included in the problem-solving model for science.)
2. Collect Data to Solve the Problem: Data is collected (to solve the problem) by making measurements and observations and by searching the literature. (This component is also included in the problem-solving model for science.)
3. Identify Design Requirements: In creating a design to solve the problem, one must incorporate the design requirements. For example, if one were to design a new house, several design requirements would be the size and shape of the house.

4. Identify Design Limits: What are the limitations to your design? For example if you are building a new house, several design limits are the amount of money and resources available.
5. Generate Possible Solutions to the Problem: For example if you were asked to design a new ladder, possible solutions could be a rope ladder, a step ladder, or an extension ladder.
6. Evaluate the Alternatives: Look over the alternatives (possible solutions to the problem) to determine which one is best for solving the problem.
7. Select the Best Approach: After evaluating the alternatives (possible solutions), select the best approach for solving the problem.
8. Communicate the Selected Design: The selected design may be shared with others by using sketches, words, a descriptive procedure, etc.
9. Implement the Design: Use the design to make the product, etc.
10. Test the Product: For example, if you designed and made a paper airplane to fly a great distance, then test it.
11. Modify the Design: If you are not satisfied with the product, then modify the design to improve it.

As pointed out in this chapter, STEM Education, especially when combined with creativity, is very important for the Global Community. Countries wanting to strengthen their national status and power need a sufficient supply of qualified STEM graduates to creatively solve problems and compete globally. Therefore, creative STEM students are essential at the postsecondary level. In order for this to be possible, children need to be introduced to STEM topics (science, technology, engineering, and mathematics) and motivated to pursue studies in these fields. The program initiated by Barry helps address this problem by promoting creativity and combining it with STEM Education.

References

1. Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. *Statistics in brief*. Institute of Education Sciences, National Center for Education Statics, U.S. Department of Education, 1–24 (July 2009).
2. Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. *Statistics in brief*. Institute of Education Sciences, National Center for Education Statics, U.S. Department of Education, 3–13 (July 2009).
3. Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education. *Statistics in brief*. Institute of Education Sciences, National Center for Education Statics, U.S. Department of Education, 17 (July 2009).
4. Gonzalez, H. B., & Kuenzi, J. J. Science, Technology, Engineering, and Mathematics (STEM) Education: A Primer. (2012). *CRS Report for Congress*, 12–15 (Aug 2012).
5. Jolly, J. L. (2009). Historical perspectives: The national defense education act, current STEM initiative, and the gifted. Gifted Child Today, *32*(2), 50–*53*.
6. Jolly, J. L. (2009) Historical perspectives: The national defense education act, current STEM initiative, and the gifted. *Gifted Child Today*, *32*(2), 50–51.

7. Barry, D. M., & Kanematsu, H. (2010). International collaboration: Creative engineering design program between the US and Japan. *Innovations 2010*. International Network for Engineering Education and Research.
8. Barry, D. M. (2010). *Creative engineering design: A collaborative program between the US and Japan.* Ph.D. thesis, Osaka University, Japan Oct 2010.
9. Barry, D., & Kanematsu H. (2007). Workshops in creative education for students and teachers in the United States and Japan. In *Proceedings of the American Society for Engineering Education's International Frontiers in Education Conference,* Milwaukee (Oct 2007).
10. Barry, D. M., Kanematsu, H., Kobayashi, T., & Shimofuruya, H. (2003). Multisensory science. (Idea Bank) *The Science Teacher, 66*.
11. Barry, D. M., & Kanematsu, H. (2003) Students enjoy chemical sensation. *The Science Education Review*, *2*.
12. Kanematsu, H., Barry, D. M.; Shimofuruya, H., & Kobayashi, T. (2003) International education project chemical sensation—a challenge for attractive chemical classes. *Materia Japan (Bulletin of Japan Institute of Metals)*, *529*.
13. Barry, D. M. (2003). International chemical sensation project. *Tokai Kagaku Kougyoukai*, in Japan, *11*.
14. Barry, D. M., Kanematsu, H., & Kobayashi, T. (2009) *Science fair fun in Japan* (2nd ed.). Japan: Gendai Tosho.
15. Barry, D. M., & Smith, R. W. (2008) *Plan, develop, display, present science projects.* U.S.: Teacher Created Resources.
16. Kanematsu, H., Ezaki, H., & Barry, D. M. (2007). Science fair as an introductory education for suzuka national college of technology. In *Conference Proceedings paper of Japan's Society for Engineering Education* (p. 556).
17. Kanematsu, H., & Barry, D. M. (2006) Science fair fun in Japan—science fair for creative education. *Materia Japan*, *380*.
18. Barry, D. M., & Kanematsu, Hideyuki. (2006). International program to promote creative thinking in chemistry and science. *The Chemist, 83*(2), 10.
19. Kanematsu, H., & Barry, D. (2006). Science fair project for delivery classes in elementary and secondary schools and its significance in Japan. In *Annual Conference Proceedings for the American Society for Engineering Education,* Chicago.
20. Barry, D. M., & Kanematsu, H. (2006) Science fair competition generates excitement and promotes creative thinking in Japan (ED 491740). U.S.: Education Resources Information Center.
21. Barry, D. M., & Kanematsu, H. (2005) (representing M.S. & E. Department Faculty, SNCT). *Science fair fun in Japan*. Japan: Gendai Tosho.
22. Kanematsu, H., & Barry, D. M. (2005). Science Fair and Critical Thinking—Development for Creative Engineering. In *Proceedings of Teachers Workshop in Toba, Japan sponsored by the Institute of National Colleges in Japan* (p. 227).
23. Barry, D. M., & Kanematsu, H. (2007) *Develop critical thinking skills, solve a mystery, learn science.* U.S.: Tate Publishing.
24. Barry, D. M., & Kanematsu, H. (2007) *Develop critical thinking skills, solve a mystery, learn science.* (Audio Book, Tate Out Loud) U.S.: Tate Publishing.
25. Barry, D. M., & Kanematsu, H. (2007) *Creative science book*: *Develop critical thinking skills, solve a mystery, learn science* (similar but yet a different book from the book published by Tate). Japan: Pleiades Publishing.
26. Kanematsu, H., & Barry, D. M. (2007). *Mysteries and creativity: The application of mysteries to creative education* (vol. 40, p. 67). Memoirs of Suzuka National College of Technology.
27. Kanematsu, H., & Barry, D. M. (2008) Creative space exploration project for engineering design. In *Proceedings of the JSEE Annual Conference, the International Session*, Kobe, Japan (Aug 2008).
28. Kanematsu, H., Shibagaki, K., & Barry, D. M. (2008) Space explorers project and engineering design. *The Education Report of National Colleges Subcommittee*, Tokai Association of Engineering Education (no. 2, pp. 31–32).

29. Kanematsu, H., & Barry, D. M. (2007). World first MarsLink mission as educational material for design skills—as a PBL Class. In *Conference Proceedings paper of Japan's Society for Engineering Education* (p. 250).
30. Barry, D. (2005). World first MarsLink mission participants learn and enjoy science. *The Science Education Review, 4*(3).
31. Barry, D. M., Kanematsu, H., Fukumura, Y., Kobayashi, T., Ogawa, N., & Nagai, H. (2014). Problem-based learning activities in second life. *International Journal of Modern Education Forum, 3*(1).
32. Barry, D. M., Kanematsu, H., Fukumura, Y., Kobayashi, T., Ogawa, N., & Nagai, H. (2012). Problem based learning for US and Japan students in a virtual environment. In Watanabe, T., et al. (eds.) *Intelligent Interactive Multimedia Systems and Services, SIST 14* (pp. 479–488). Berlin : Springer-Verlag.
33. Barry, D. M., Kanematsu, H., & Fukumura, Y. (2010) *Problem based learning in metaverse* (ED 512315) U.S: Education Resources Information Center.
34. Barry, D. M., Kanematsu, H., Fukumura, Y., Ogawa, N., Okuda, A., Taguchi, R., & Nagai, H. (2009). International comparison for problem based learning in metaverse. In *Proceedings of the International Conference on Engineering Education and Research (ICEE & ICEER*), Seoul, Korea (Aug 2009).
35. Barry, D.M., & Kanematsu, H. (2010). International collaboration: Creative engineering design program between the US and Japan. In *Innovations 2010*. International Network for Engineering Education and Research.

Chapter 4
The Importance of STEM for Modern Education

Abstract STEM is essential for modern education. Nations become world leaders, in part, through the hard work of their experts in science, technology, engineering, and mathematics (STEM careers). Countries need to maintain a supply of qualified STEM graduates to meet their economic needs and to compete globally, especially since the workforce is becoming more technology driven. Therefore, it is important to introduce young children to STEM courses and to encourage them to pursue these subjects in every grade. This chapter describes various ways to promote STEM and combine it with modern education.

STEM (science, technology, engineering, and mathematics) education is important for everyone and vital for the future of each country. STEM is everywhere. The science component includes the study of the natural world like the oceans, the Sun, the Moon, weather, animals, plants, water, fuels, and much more. Today's technology means computers, smart phones, iPads, flat screen televisions, state-of-the-art microscopes, and other equipment. The field of engineering is used for designing buildings and bridges, and for solving challenging problems such as environmental, medical, and transportation issues. Mathematics (the final STEM component) is incorporated into every STEM area, whether it is the act of purchasing items, paying taxes, or making calculations to solve science and engineering problems.

Nations become world leaders, in part, through the hard work of their experts in science, technology, engineering, and mathematics. Countries need enough qualified STEM graduates to meet their economic needs and to compete globally, especially since the workforce is becoming more technology driven. Therefore, it is important to introduce young children to the topics of STEM and to motivate as well as encourage them to pursue STEM subjects in every grade. These essential tasks are the responsibility of the K-12 (kindergarten through twelfth grade) educators.

It is believed that qualified STEM teachers are needed for grades K-12, in order to improve student performance and interest in STEM fields. These instructors must be recruited, trained, and retained. One concern today in the U.S. is that a number of teachers (especially in the middle school grades) are teaching subjects out of their

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area of expertise. Another problem is that graduates with STEM degrees are lured into industrial jobs (by higher salaries) so they are not available for teaching. On the other hand, some individuals with degrees in STEM and an interest in teaching are not certified. The extra time and money needed to obtain educational certification might discourage them from pursuing teaching careers.

Solutions for providing a supply of qualified STEM teachers exist. College programs are available for training STEM teachers. For example, individuals can earn a Master's degree in STEM Education at the University of Cincinnati as well as at other colleges [1]. Organizations like Hood College provide elementary school teachers an opportunity to become certified in STEM education too [2].

Also policy makers could create programs that do the following [3].

1. Develop and implement special certificates for engineers and other technical professionals transferring to teaching programs.
2. Provide STEM graduates financial support for teacher certification.
3. Increase STEM coursework in pre-service/university teacher training.
4. Provide in-service professional development that focuses on STEM curricula.

President Obama's Fiscal Year 2015 budget proposal includes investments to improve teaching and learning in STEM subjects for teachers and students. He wants to prepare 100,000 effective STEM teachers and to identify America's brightest math and science teachers [4]. These brightest teachers will then become school and community leaders and advocates for STEM education.

The partnership of industry with K-12 education and beyond, promotes STEM education too. Gulfstream (a General Dynamics Company) is looking for future leaders to pursue career paths in engineering that relate to design development, flight science, aircraft systems, structural design, as well as flight and lab testing. It has already provided education outreach initiatives for over 11,000 K-12 students and teachers [5]. Company employees visit classrooms and serve as guest speakers for schools and local communities. Gulfstream also offers facility tours, youth apprenticeship internships, and college co-ops.

In 2013 Chevron invested about $94 million in education partnerships and programs worldwide [6]. They are helping students and teachers get the tools and resources they need to take advantage of STEM opportunities. Chevron believes that today's schoolchildren will be their future engineers. Therefore, the company focus is to improve instruction in science, technology, engineering, and mathematics (STEM).

ExxonMobil started a Future Leaders Academy in response to two major concerns [7]. One is the growing demand for future engineers over the next 10 years as projected by the U.S. Department of Labor statistics. The other is the need to promote more diversity (a greater number of women and minorities) in the engineering field. The Corporation awards scholarships so that talented minority students of engineering and ExxonMobil Senior Management can be brought together at the Academy. This program (which lasts for a few days) includes presentations, tours, and interviews for internship opportunities. It provides the students with leadership skills and information about careers in science, technology, engineering, and mathematics (STEM). Also the students are motivated to excel and to make a positive change in the world.

School districts can partner with universities to inspire a new generation of scientists, engineers, and mathematicians too. This partnership allows teachers to take their classes on college tours to see science and engineering laboratories and to witness demonstrations of high-tech equipment such as 3-D printers and scanning electron microscopes. Also college professors (of STEM courses) are encouraged to give presentations and carry out hands-on workshops in the local schools. In addition, some colleges like Clarkson University actually incorporate K-12 students into their programs. Clarkson (located in Northern New York) has competitive SPEED teams (Student Projects for Engineering Experience and Design). These teams are really student run clubs that use engineering to build race cars, concrete canoes, portable steel bridges, and more. The university has a special FIRST Robotics club too. It is different and allows secondary school students to participate. Clarkson students act as mentors and coaches for teams of local high school students [8]. These children enjoy designing and building robots that they enter in robotic competitions. This is an exciting way to attract students into STEM careers.

In Colorado, the Denver School of Science and Technology is actually a network of STEM schools [9]. It consists of five campuses that operate as charter schools under the Denver Public Schools system. These charter schools (which are among Denver's best) emphasize science, technology, engineering, and mathematics. They offer advanced placement courses and require juniors to do an internship, which could be done at a university such as the University of Denver. The internship is a direct link to STEM professors and their research and also provides students with active learning experiences.

In addition to obtaining qualified STEM teachers and forming partnerships with educational institutions and industry, K-12 schools are incorporating STEM into their new curricula. A prime example is the *Next Generation Science Standards (NGSS*). The NGSS were developed to provide direction in science teaching and learning, especially since many scientific breakthroughs (such as in genetic research and digital technology, etc.) have occurred that greatly affect our daily lives [10]. The main goal of the standards is to help all learners in the U.S. develop the science and engineering skills needed to live successful, productive lives, as well as help them create a sustainable planet for future generations.

These new standards integrate the three dimensions of science and engineering practices, disciplinary core ideas, and crosscutting concepts, into performance expectations [11]. The performance expectations are assessed because they describe what students should be able to do after instruction. This approach has students learn content material (core ideas) by combining them with science and engineering practices.

4.1 Components of the Three Integrated Dimensions Are Provided [12, 13]

4.1.1 Science and Engineering Practices

(Students carry out certain practices during their lessons and activities that are similar to those performed by scientists and engineers.)

1. Asking questions (especially for science) and defining problems (especially for engineers)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (especially for science) and designing solutions (especially for engineering)
7. Engaging in argument from evidence (example: Reasoning and arguing are needed to determine the strength and weakness of the evidence for finding the best solution to a problem.)
8. Obtaining, evaluating, and communicating information

4.1.2 Disciplinary Core Ideas

(This section refers to specific content included in the four categories listed below. The content/core ideas are the building blocks for learning within a discipline. For example, energy is an example of a content topic within the category of Physical Sciences. Energy, which is the ability to do work, exists in various forms such as potential energy, kinetic energy, mechanical energy, etc.)

1. Physical Sciences (examples: matter and its interactions, forces and motion, energy, waves, etc.)
2. Life Sciences (examples: ecosystems, growth and development of organisms, etc.)
3. Earth and Space Sciences (examples: Earth and the Solar System, weather and climate, etc.)
4. Engineering, Technology, and Applications of Science (examples: engineering design and the interdependence of science, engineering, and technology)

4.1.3 Crosscutting Concepts

(These concepts are major ideas that cut across various science disciplines.)

1. Patterns (example: Observe patterns.)
2. Cause and effect: mechanism and explanation (example: Notice that events have causes.)
3. Scale, proportion, and quantity (example: Recognize proportional relationships between different quantities.)
4. Systems and system models (example: Define the system under study and make a model of it.)
5. Energy and matter: flows, cycles, and conservation (example: Track energy flows into and out of systems.)
6. Structure and function (example: The shape and structure of an object determine some of its functions.)
7. Stability and change (example: For a system, consider the conditions of stability.)

STEM is everywhere and vital to the future of each country. Nations become world leaders, in part, through the hard work of their experts in science, technology, engineering, and mathematics (STEM careers). Countries need a continuous supply of qualified STEM graduates to meet their economic needs and to compete globally, especially since the workforce is becoming more technology driven. Therefore, it is important to introduce young children to STEM courses and to encourage them to pursue these subjects in every grade.

Parts 3 and 4 of this book contain STEM activities for both the Real and Virtual Worlds. They give students active learning opportunities to design and carry out investigations as creative problem solvers. The results of a study described in the *Proceedings of the National Academy of Sciences* support active learning as a way to increase student performance in science, engineering, and mathematics [14].

Each STEM lesson includes four separate components (science, technology, engineering, and mathematics) which relate to the typical engineering design and problem-solving models displayed in Chap. 3. These activities promote higher levels of thinking like the synthesis level (where one creates ideas) and the evaluation level (where one makes value judgments). Also they fulfill the requirements of the *Next Generation Science Standards* and contain methods for student assessment.

References

1. http://mastersed.uc.edu/masters-degree-in-education-online-programs/stem-science-technology.
2. http://www.hood.edu.
3. Strengthening Pre-College Science, Technology, Engineering and Mathematics (STEM) Education in the U.S.: A Technological Literacy & Workforce Imperative (2010). *ASME General Position Paper*, PS10-20 (April 2010).
4. Science, Technology, Engineering and Math: Education for Global Leadership. U.S. Department of Education. http://www.ed.gov/stem.
5. Hodesh, M. R. (2012). Growing our future workforce. *S.T.E.M. Magazine*, 5–8.
6. http://www.chevron.com/corporateresponsibility/community/education/?utm_campaign=20.
7. Torma, T. (2014). Inspiring future leaders. *The Lamp, Number, 2*, 25–26.
8. http://www.clarkson.edu/speed/speed_teams/robotics/index.html.
9. Cernansky, R. (2013). The very model of a modern major STEM school. *Smithsonian Magazine*. http://www.smithsonianmag.com/innovation/the-very-model-of-a-modern-major-stem-school.
10. Krajcik, J. (2013). The next generation science standards: A focus on physical science. *The Science Teacher, 80*(3), 27–35.
11. Willard, T. (2013). A Look at the next generation science standards. *The Science Teacher, 80*(3), 36–37.
12. Krajcik, J. (2013). The next generation science standards: A focus on physical science. *The Science Teacher, 80*(3), 27–35.
13. Willard, T. (2013). A look at the next generation science standards. *The Science Teacher, 80*(3), 36–37.
14. Freeman, S., Eddy, S., McDonough, M., Smith, M., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active Learning Increases Student Performance in Science, Engineering, and Mathematics. *PNAS Early Edition.* http://www.pnas.org/content/early/2014/05/08/1319030111.full.pdf.

Part II
ICT and STEM Education

Information and Communication Technology (ICT) is very important for STEM Education, especially since we are living in a digital age. ICT includes hardware such as computers and software used for videos and websites. It increases opportunities for STEM Education, the teaching and learning of science, technology, engineering, and mathematics. With ICT, instructors and their students are able to use the Internet, audio-visual classrooms, social networking, and more.

Chapter 5
ICT and the Impact on Education

Abstract Now youngsters live in a digitized world. They are surrounded by lots of digitized equipment and facilities on a daily basis. In such an age, the education process has been changed by the effect. In this chapter, we discuss how the classroom activities are being changed and what kinds of ICT equipment are typically being used.

Children and Youth are now living in the digital age. The impact of the digital revolution has affected our youth tremendously so far. It has changed our daily lives, social structures, and philosophy for everyday life. Therefore, education is also affected by it, inevitably. The digital revolution was brought about by having lots of digital equipment surrounding our daily lives. There are lots of devices, media, equipment, etc. that relate to information and communication functions. From this viewpoint, information and communication functions are very important for educational purposes. Concretely speaking, these functions need computers. When the focus is put on the side of technology, it is called information technology (IT). On he other hand, when the utilization of computer technology is stressed and the importance is attached to the communication inevitably, it is called information and communication technology. However, the demarcation between the two concepts is generally vague and not clear.

IT stands for Information Technology, while ICT signifies Information and Communication Technology. As already described, ICT is a technology oriented strongly for utilization. Since society has been affected by the digital revolution, people's behavior in the twenty-first century has also been affected by ICT. Figure 5.1 shows the kinds of digital equipment and software that constitute ICT. As shown in the figure, ICT can be classified into two main categories, the hardware and software. As for the hardware, you can mention personal computers (PC), slide projectors, video cameras, digitizing cameras, projection equipment, etc. On the other hand, examples for software refer to websites, video films, CD-ROMs, and various software applications. All of these items have affected education and changed it drastically.

Even though the digitizing equipment and software might have potential capabilities to change education, the concrete application of ICT technology to education had to pass through many development stages. Figure 5.2 shows the important

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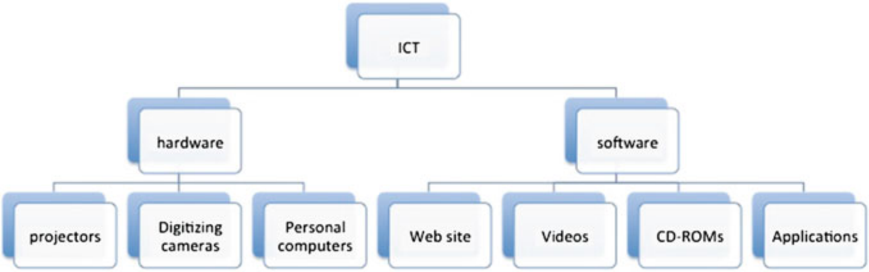
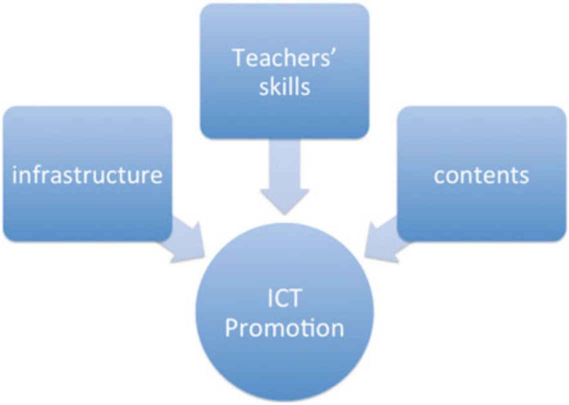


Fig. 5.1 ICT and digitizing equipment

Fig. 5.2 Three components to promote ICT on the national scale



factors for ICT education. Here ICT education is defined as the education based on ICT. First of all, the infrastructure had to be prepared and developed in educational organizations. For example, computer based education requires computers. However, in the early stage, there were few computers in schools. In Japanese elementary and secondary schools, the number of computers gradually increased during the first 10 years of the twenty-first century. However, teachers' skills needed to catch up with the development of infrastructures. To develop and improve teachers' skills, lots of seminars, workshops, etc. were held as well as individual lessons. However, the contents of these sessions had to be expanded and improved. When the three factors—infrastructure, teachers' skills and content—are generally harmonized and made satisfactory, ICT education works well. In Japan, the situation was realized from 2001 to 2010 and the situation is still improving.

Such a systematic establishment for ICT education should be promoted by governments, local communities etc. In Japan, the activity was promoted by the Ministry of Education, Cultures, Sports, Science and Technology. At around the turn of the century, several goals were set and realized. For example, all of the public elementary and secondary schools in Japan should have access to the Internet. Also all teachers in the schools should have computer skills and half of them should be able to use computers for teaching student lessons. The second goal was set around 2005. All of public elementary and secondary schools in Japan were supposed to have all of their teachers and students utilize computers and the Internet.

In the United States, there are no integrated curriculum guidelines provided by the government. It differs from state to state and the decision is entrusted to a state's government. One of the representative standards for ICT education in the USA is "National Educational Technology Standards" made by the International Society for Technology in Education (ISTE). Their standard has been used in more than 80 % of the states as a standard to make curricula within states or school areas. It may be a reason why the overall achievement was attained on a high level. According to the data by the National Center for Education Statistics [1, 2], about 95 % of the schools in the US could have access to the Internet to some extent even in the 1990s. In 1998, 51 % of all schools had access to the Internet and after 1 year passed, the number increased to 63 %. The USA is the most advanced country in various ways. Therefore, it sounds very natural that the infrastructure was established very rapidly and faster than those in any other countries. In regards to content, there is a lot of useful information not only for students, but also for teachers everywhere on the Internet. You can say the same for the advancement of ICT education on a high level in regards to availability of information and content. In addition, it provides a support system for teachers to enhance their computer skills and the use of the Internet.

In the UK, a tremendous budget has been assigned to ICT and its education. In 1998, the budget for ICT education in elementary schools was 49,000,000£. However, it tripled in 2001. At first the rate of elementary schools that could have access to the Internet was just 17 % in the country. However, the rate increased to 96 % in 2001. The percent of elementary school teachers having experiences in ICT seminars was 45 % in 1998 and 72 % in 2001. It means both the infrastructure and teachers' skills were developed rapidly around the turn of the century. The development of the content for ICT education increased with them inevitably.

The ICT education in the UK has been promoted by some organizations. Several of them are the British Educational Communications and Technology Agency (BECTA), the Office for Standards in Education (OFSTED) and the National Grid for Learning (NGfL).

BECTA is the Government's lead partner in the strategic development and delivery of its e-strategy for the schools and the learning and skills sectors. BECTA provides strategic leadership in the innovative and effective use of ICT to enable the transformation of learning, teaching and educational organizations for the benefit of every learner [3]. The organization is actually the center of the ICT education policy in the UK and provides teachers, coordinators, administrators, and principals useful advice and suggestions.

OFSTED is the Office for Standards in Education, Children's Services, and Skills. It is a non-governmental organization and they inspect/regulate services that care for children and young people, and services providing education and skills for learners of all ages [4]. It provides us with versatile data for the diffusion and condition of ICT education in the UK.

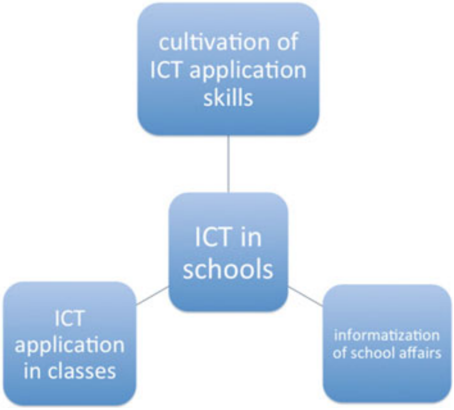


Fig. 5.3 The purpose for the introduction of ICT in schools

NGfL is a United Kingdom Government-funded gateway to educational resources on the Internet. It is basically a portal site run by BECTA and provides many documents and resources for ICT education that students, parents, and teachers can utilize if needed [5].

As examples in advanced countries, we have reviewed the movement of ICT and ICT education in the US, the UK and Japan. For all of those countries, you can see that the three factors—infrastructures, teachers' skills and content have been developed very rapidly since the Internet appeared in the 1990s and around the turn of the century.

Nowadays, we are already living in high information and communication societies. Therefore, it is very important for us to change education with ICT, to utilize ICT for collaboration among schools, homes and communities, etc. The purposes to promote the introduction of ICT into schools are mainly composed of the cultivation of ICT application skills for children and youngsters, ICT application in classes and informatization of school affairs (Fig. 5.3). Regarding the concrete meaning of ICT for education and the effect on it, we will describe them from the viewpoint of STEM in the following chapters.

References

1. National Center for Education Statistics. (2000). Internet Access in U.S. Public Schools and Class-Rooms: 1994–99 (Feb 2000).
2. National Center for Education Statistics. (2000). Teachers Use of Computers and the Internet in Public Schools (Apr 2000).
3. Web page of BECTA. http://www.eep.ac.uk/dnn2/Organizations/Becta/tabid/65/Default.aspx.
4. Web page of OFSTED. https://www.gov.uk/government/organisations/ofsted.
5. National Grid for Learning. (1997). The Governments Consultation Paper—Connecting the Learning Society. https://www.education.gov.uk/consultations/downloadableDocs/42_1.pdf.

Chapter 6
Why Is ICT Important for STEM?

Abstract This chapter discusses the merits that ICT has for classroom activities and also for education. It also describes how ICT would be favorable for STEM (Science, Technology, Engineering, and Mathematics) education.

How did the introduction of ICT and its dissemination affect the educational outcome concretely? In Japan, the Ministry of Internal Affairs and Communications (MIC) used questionnaires to find out based on the Web in 2012. Figure 6.1 [1] shows the results. The scores were classified into two types, according to an ICT score. Here the ICT score is defined as how much the school's educational system utilized ICT according to a certain evaluation method. When the school's score exceeded the average value for all, it was considered as a high ICT school. On the other hand, when its score was lower than the average one, the school was recognized as a low ICT school. The horizontal axis shows educational items affected by the change of ICT. And the vertical axis shows the effect as a result of the introduction of ICT. It corresponds to the rate of positive answers by the introduction of ICT. Figure 6.1 shows the advanced ICT schools, which in general have the positive effects. The items investigated were the following points.

#1: The extent of communication among teachers.
#2: Enhancement of training teachers and using seminars for the purpose.
#3: The improvement of teaching methods and lesson contents.
#4: The alleviation of duties other than classes.
#5: Shortening work hours for teachers.
#6: Activation of communication between teacher and student.
#7: Academic development for students.
#8: Improvement of students' attitude.
#9: Improvement of students' attendance rate.
#10: Improvement of students' skills for utilization of ICT.
#11: Activation of communication between teachers and students' parents.
#12: Improvement of information sharing between teachers and parents.
#13: Activation of exchange with other schools.
#14: Activation of dispatch of information.

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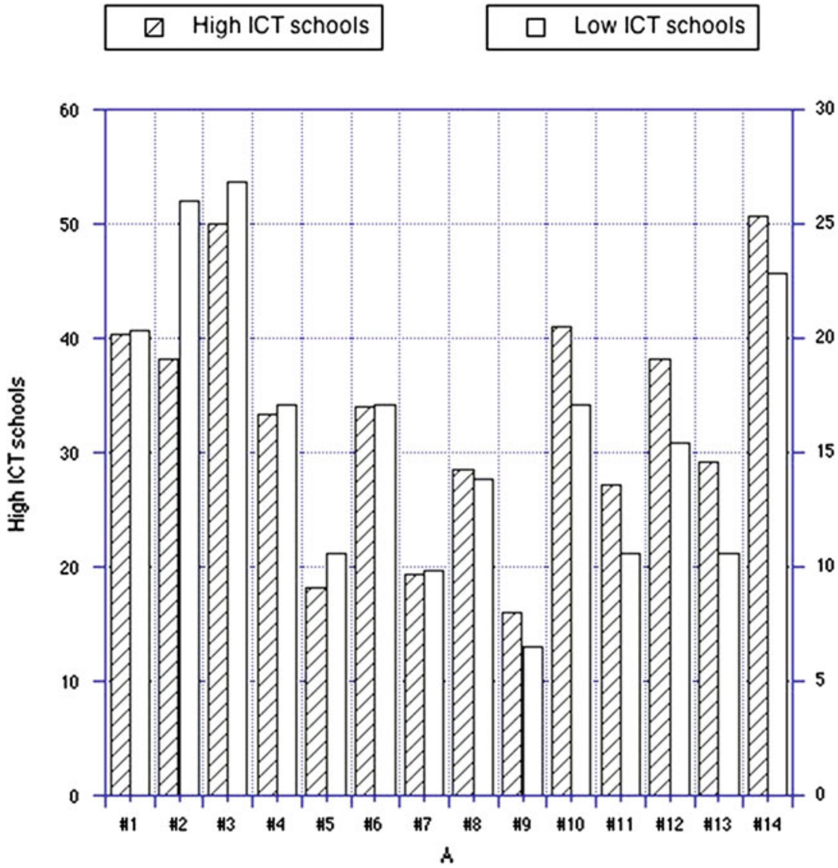


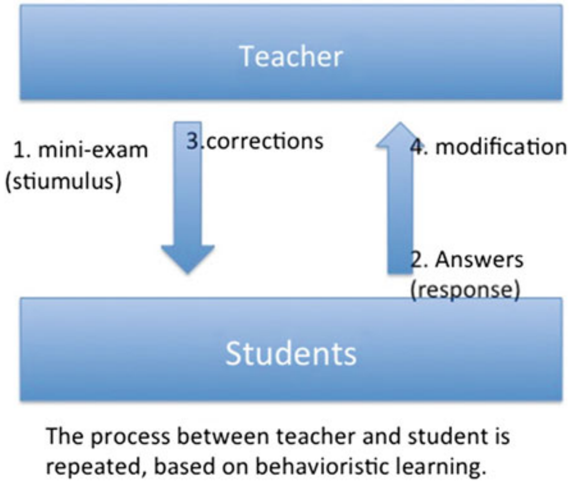
Fig. 6.1 How did the introduction of ICT affect education?

Among all of the items mentioned above, #1–#6, affect the teachers. And #7–#11 affect the students themselves, while #11–#14 belong to the parents (benefactors). [1]

As for the effect on teachers, #3 (The improvement of teaching methods and lesson contents.) and #1(The extent of communication among teachers.) were relatively high. Regarding the effect on students, #10 (Improvement of students' skills for utilization of ICT.) was high. #7 (Academic development for students.) and #8 (Improvement of students' attitude.) were also remarkable for the improvement with ICT.

Many researchers have pointed out that ICT could enhance a youngster's independence. [2–4]. We presume that it would lead to the positive effect of ICT for education. It has a close relation to so called "constructivism", as one of the three main educational theories from the viewpoint of educational psychology [5]. Usually, behaviorism and cognitivism are mentioned in addition to constructivism.

Fig. 6.2 Schematic illustration for learning style based on behaviorism



Behaviorism insists that human beings would learn and enhance the educational effect by repetition. Therefore, youngsters must be provided repeated stimuli (repetitive learning), e.g. mini-exams, etc. Figure 6.2 shows the basic concept for this type of learning. The mini-exam is given to the students as an eternal stimulus. They think and submit their answers as responses. Teachers correct and give the results back to the student as strengthening exercises. The process is repeated again and again and the learning is enhanced by the repetition. The concept is based on the idea that human beings could learn only by the repetition. It is natural that the repetition would lead to learning. However, this type of learning would not produce any creative matters. Human beings usually add some meanings to the thinking process.

Cognitivism insists that human beings need to add some meanings to the repeated results and to integrate them into a systematic structure. The process could be compared with the computer system. For the computer system, the information is put in through typing keyboards. The information is temporarily kept in computer memories. Then the calculation is carried out in CPU and the result is kept in a hard disk drive eternally. For the human brain system, the information is put into the brain through sense organs. It is kept in a brain section (working memory) tentatively. The information is treated in the brain and finally stored in the long term memory section of the brain. The concept would lead to the idea that one must learn something in the context where he/she would add various meanings and his/her own ideas to the outside information. See Fig. 6.3 (below): Three learning styles and the relation based on psychological education theory.

On the other hand, constructivism insists that students should learn by constructing something with their inner knowledge and information, and that the combination of the input information with the inner concepts made on their own would be the effective learning. According to the theory, teachers should give students classes, so that students would learn at their own initiative in the class (Fig. 6.3).

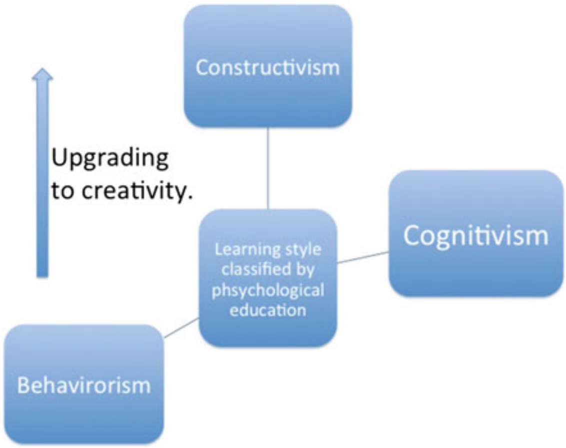


Fig. 6.3 Classification of learning styles from the viewpoint of psychological education

ICT education can realize the learning by constructivism, the most advanced way of learning. In the class based on constructivism, students have to think independently and creatively solve problems. As described above, STEM education could enhance students' independency. Or we should say that students should learn something on their own initiatives. Therefore, ICT would get a chance to realize the purpose of STEM and its effectiveness.

One more factor must be mentioned. Usually with STEM, students can enjoy the school project and learn something in an interesting way. That is one of the very important factors for STEM. Fortunately, facilities and systems for ICT could give students and youngsters delights and relaxation, since students could sometimes pursue the class like playing virtual games.

These two factors, independent-minded learning and enjoyable learning—characteristically compose STEM education. Therefore, ICT education is very suitable for STEM education and will be expected much more in the future.

References

1. Ministry of Internal Affairs and Communications. (2012). *Survey on the effect of ICT on growth*.
2. Shimizu, T. (2006). *The effect and problem brought by ICT, the keynote lecture in innovative Teachers Day*.
3. Tanabe, H. (2009). The direction of improvement shown by the combination of experiments, observation based digitalized contents. *Osaka and science education, 23*, 33–42.
4. Yasunari, J. (2011). *Study on the effective ICT to raise students' positive attitude—through students' activities in high school science classes*. http://www.ysn21.jp/tyousa/tyoukikensyu/houkoku/houkoku23/yasunari_m.pdf.
5. Suzuki, K. (2005). Current trends of instructional design theories and models for ICT utilization. *The Journal of educational system information Society*, *22*(1), 1–22. http://www.gsis.kumamoto-u.ac.jp/ksuzuki/resume/journals/2005a.html.

Chapter 7
Audio-Visual Classroom and STEM

Abstract In this chapter, we introduce concrete facilities and equipment for ICT use in classrooms. Then an example is presented. We show concretely how STEM education could become positive and active with ICT.

Nowadays, the Internet is becoming used widely and universally and the concept of an audio-visual classroom seems to be changing gradually. However, the audio-visual class was originally defined as a type of education trying to enhance the educational effect by appealing to students' senses of sight and hearing directly. Therefore, the classroom for this type of education has a TV, Videos, Slide Show, Electronic White Board, Sound Speaker, Display monitor, etc. which correspond to original and conventional Audio-visual facilities (Fig. 7.1) [1–4].

Speakers and overhead projectors are used for effective presentations not only by teachers, but also by students themselves. Giving presentations about the results of their activities or their plans using audio-visual aids makes the project go smoothly. Regarding these above statements, the book authors carried out an interesting STEM project in the past. It was called the Chemical Sensation Project and it received a national award from the American Chemical Society. In the project, students listened to songs composed by Barry that related to some chemistry topics. The speaker connected to cassettes, CD-players, and computers worked well for reproducing the songs. Also the students enjoyed the pictures (prepared by Barry) that complemented the chemical topics and chemistry songs. The pictures (visual aids) were shown on a big screen in the classrooms. After the students enjoyed the songs and pictures with the audio-visual facilities, they carried out some hands-on experiments. In the project, the book authors Barry and Kanematsu investigated how the five senses affected effective learning. The Chemical Sensation Project was actually one of active learning and also an interesting STEM project. The students enjoyed the scientific projects and learned from them. The simple and conventional audio-visual facilities worked well (Fig. 7.2).

TV, video, slide show, electronic white board, sound speaker, display monitor, etc.

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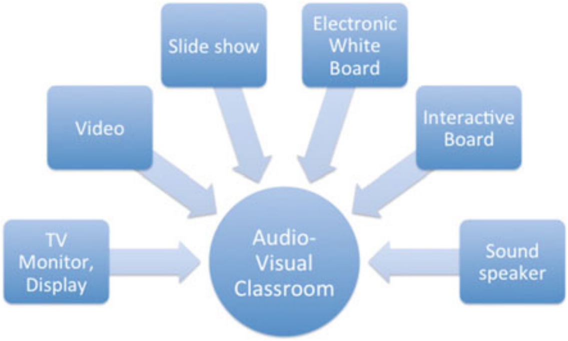

Fig. 7.1 Audio-visual classroom and the facilities

In regards to TV, there are many scientific programs for STEM. For example, in the US, Discovery channels are very well known. In the UK, BBC provides us with many scientific programs, too. And in Japan, NHK, a representative national broadcasting corporation prepares lots of scientific and engineering programs. Some of them are made by the Open University of Japan. Teachers can use the TV programs for students to carry out STEM education and projects. The class may be static and passive for students. And from the viewpoint of active and positive learning, the STEM based on TV may be insufficient. However, TV programs would give students chances to understand the phenomena or figures, pictures, etc.

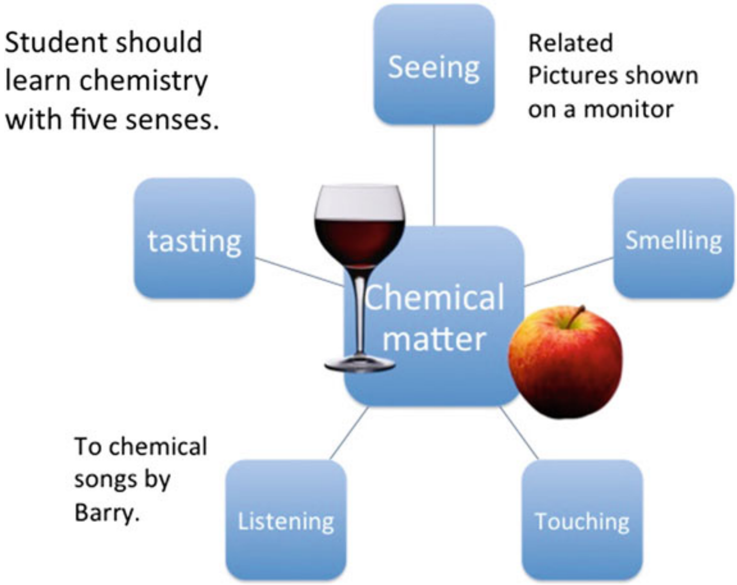

Fig. 7.2 Chemical sensation—STEM learning using our five senses

that usual text media could not express well. In addition, they would give students indirect experiences where students could not carry out the experiments in the classroom directly. The contents range from "free fall experiments and their simulations" to some phenomena in cosmic space. Strictly speaking, the synchronicity is needed for students to have the TV programs. However, teachers and students could use video-taped materials to solve the problems. From this viewpoint, the combination of TV and Videos could provide many possibilities. And of course, there are lots of original videos for STEM that teachers and students could use in their classrooms.

As described above, STEM education using videos and TV may be passive and static. However, that can be changed to positive and active learning easily by a creative teacher.

For example, teachers could combine some hands-on experiments with TV programs. Students would see some parts of a TV program about a scientific topic. Then the teachers could ask the students to carry out some hands-on experiments about the topic. In such a way, teachers could change the negative side of TV and Video to a positive one from the viewpoint of active learning that STEM education needs in the future.

Regarding the hardware side of TV, the following artifice is possible as an example for the purpose of STEM Education. Recently, big TV monitors made of liquid crystal became available. A transparent acrylic board could be attached to the monitor screen. In such a way, students could look at the contents provided by broadcasting or video materials and write something about the contents simultaneously. This artifice could lead to active learning where students would become positive and active during the class. In the conventional TV and Video, students might be passive generally. However, the class would be oriented to the mutual communication. This is just an example to improve conventional audio-visual classes. By both software and hardware approaches, new STEM education would be possible.

Electronic white boards are nowadays one of the typical facilities for audio-visual classrooms. This will open the doors to new worlds where students could encounter many new possibilities to learn something. Electronic white boards are now composed of many functions and they would differ from machine to machine. The simplest type is a white board with a scanner and printer. When students write or describe something on the board, the scanner would read it and print it out using the printer.

Students and teachers can enlarge some arbitrary parts on the board, if needed. Moving pictures are utilized on the board for content material. The voice reading function is sometimes available and is beneficial for students with disabilities.

Previously the scanned contents on the board would not be printed out as printed media, but as the file saved in USB, etc. Recently, the combination with personal computers appeared as an interactive board. This type of electronic white board made it possible for students to use the system not only for the screen, but also for tablets and computers. To communicate bidirectionally, students usually use their fingers or stylus pens. The interactive board may have an access to the Internet.

Using these facilities, the electronic board could have access to the terminal PCs of the students. Using such an interactive board, mutual communication between the teacher and students and also among students is increased. The educational effect with the interactive board is expected very highly.

The digitizing camera is also a very powerful tool for STEM education. The apparatus makes it possible for students to record everything without experimental notes. One of the merits for the digitizing camera, being compared with usual experimental notes, is the reality of pictures taken by the camera. The data is easily saved as an electronic file somewhere. Also the process for recording can be finished in a few seconds. This apparatus can be used to record not only static phenomena, but also any dynamic ones, i.e. moving and changing processes such as matters in motion, flowing media and changing situations. The photos and movies would be easily worked in various ways and used for different purposes.

The conventional audio-visual classroom was composed of a TV, speaker and cassette tape recorder, etc. However, they have been renewed by the digital revolution and many new types of apparatus have been added to the list. In addition to digitization, the combination of conventional audio-visual apparatuses with newly digitizing ones has made newer possibilities for STEM education. Therefore, STEM education will be strengthened and become popular in the future.

References

1. Ishikawa, H., Ohtani, E., Omichi, A., Kainuma, K., Kikuchi, A., Takahashi, H., et al.(1989). The utilization of audio-visual contents for science education. Research report of Komaba High School in Tsukuba University, 29, pp. 33–38.
2. Nakagawa, K. (2011). *ICT education—100 practical examples*. Osaka: Forum A.
3. Tanabe, H. (2009). The future direction shown by collaboration investigations for the applicatoin of digitizing educational tools based on the combination of experiments and observations. *Osaka and science education*, *23*, 33–42.
4. Inoue, M. (1998). A proposal on the use of audio-visual teaching in the teaching of natural science in elementary schools. *The Journal of Educational Engineerinng*, *10*, 107–119.

Chapter 8
From Desktop Computer to Laptop and Tablets

Abstract In this chapter, we outline concrete examples and possibilities for STEM education using computers. Since the major stream of computers is always changing (from desktop, laptop, and tablets), we show how the changes could broaden the world of STEM.

When we come to think about the application of the computer to school education, the advent of personal computers was really a great epoch. We have to go back to the 1970s to confirm the origin of the personal computer. In the mid-70 s, some personal computers including the Apple II were released. In the 1980s, IBM PC/AT compatible machines appeared. Since then a stream of personal computers arrived and were applied to education. Education assisted by computers is often called computer-assisted instruction (or computer-aided instruction). The abbreviated form, CAI, is more popular. In the 1980s, the teaching machine assisted by computers was investigated very often. At the time, people believed the teaching machine and the system for each student could be established. However, such an ideal system was impossible. In the 1990s, the Internet appeared and CAI was gradually transferred to e-learning and the digitizing textbook. Nowadays, the concept seems to disappear completely.

In many cases, the personal computer is now combined with other ICT facilities for educational purposes. It is more useful for computers to have an access to the Internet. However, it is still useful as a stand-alone type.

Regarding the utilization of stand-alone PCs for STEM, the computer is used for digitizing textbooks or for a simulator. For specific purposes, the application of software or content has to be developed by companies or by teachers themselves. The quality of the class depends not only on teachers' ICT/teaching skills, but also on the software/contents available.

The utilization of stand-alone PCs for STEM.

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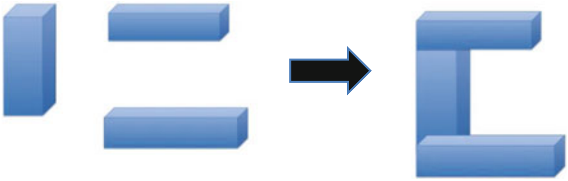


Fig. 8.1 The use of powerpoint for the learning of volume

The use of computer simulators for various vehicles may lead to fascinating STEM education experiences and learning. Some examples are flight simulators, car simulators, ship simulators and space vehicle simulations. However, the software for the stand-alone use would be generally expensive, even though it would be available for use in classrooms. There are many examples available on the web.

Generally personal computers often have office applications such as Microsoft office composed of Word, Excel, and PowerPoint as default settings. To avoid expensive software for STEM education in daily classrooms, teachers can use a computer's office applications. For example, a Japanese teacher in Kyoto used PowerPoint for elementary school children to learn "volume" [1]. As shown in Fig. 8.1, one can make cuboids very easily. Students can combine cuboids in various ways to make new solid figures.

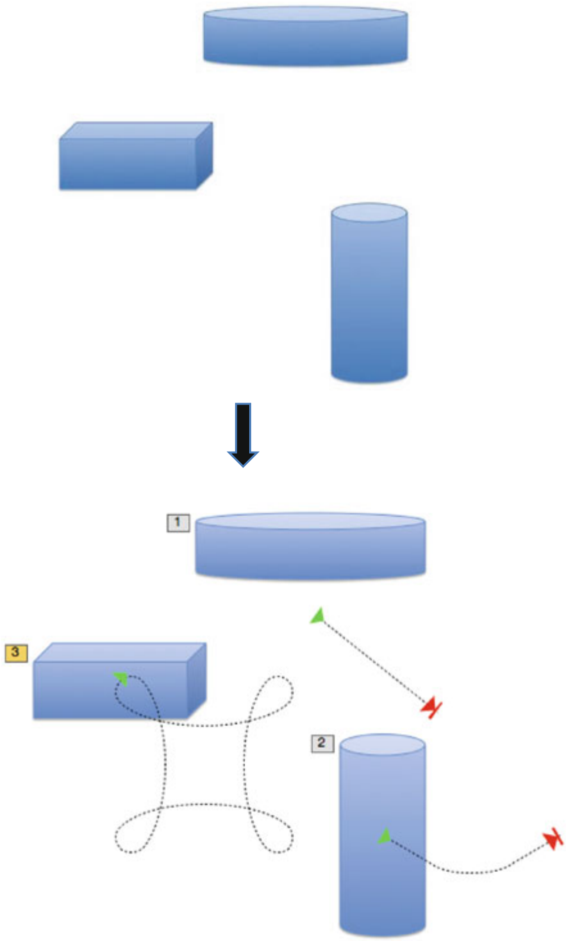
Students can use the animation function to learn figures at the fundamental stage. In Japan, the 4th graders learn combined figures and the calculation of their volume. Then the students can use PowerPoint and its animation function. They can enjoy the mathematical calculations while they try to solve the problems. As shown in Fig. 8.2, students can describe many solid figures. Using the animation function, students can move and combine them. In the past, teachers encouraged students to cut papers with scissors, so that they could see and learn about the figures and their volumes through first hand experience. However, they can learn the same contents more rapidly using PowerPoint (Fig. 8.2). The merits of such a project are as follows.

#1: Students (at elementary level) can understand the combination of figures and the concept of volume very easily. At the same time, they can learn about them.

#2: Turning the contents to digitizing ones, teachers can share them with other classes and those for the other school years.

Excel can be used for STEM education too if installed on stand-alone computers. Here is the author's case as an example. The author has an experimental STEM class for 16 year old students. Usually the class is composed of about 40 students. They have a half day class every week and the class continues 6 weeks totally. They pursue a science fair project during these weeks [2]. The class schedule is usually as follows.

Fig. 8.2 The combination of figures with animation function



#1: The first week—The teacher explains how to carry out the 6 week science fair project. He explains the problem-solving model to the students and stresses the importance of making a hypothesis. He divides the students into some groups composed of 3–4 members, so that each group would tackle the project as a team.

#2: The second week—The teacher encourages the students to select their own problem to solve that is related to their concerns and interest. Each group selects their own problem to solve for the 6 week project, makes experimental plans, and prepares a list of the materials needed for their project.

#3: The third week—They begin their experiments in their half day class.

#4: The fourth week—They continue their experiments in another half day class.

#5: The fifth week—They summarize their experimental results and make their presentation file.

#6: The sixth week—They give their presentations and their results are evaluated by teachers, special guests, etc.

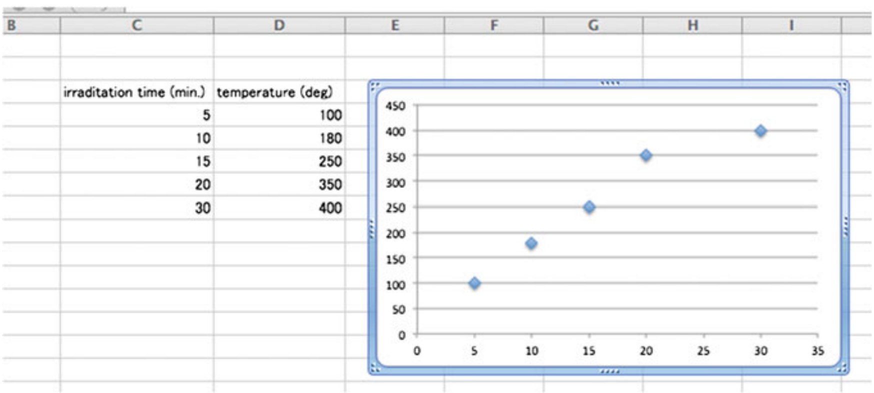


Fig. 8.3 A scatter chart after some experiments for a science fair project

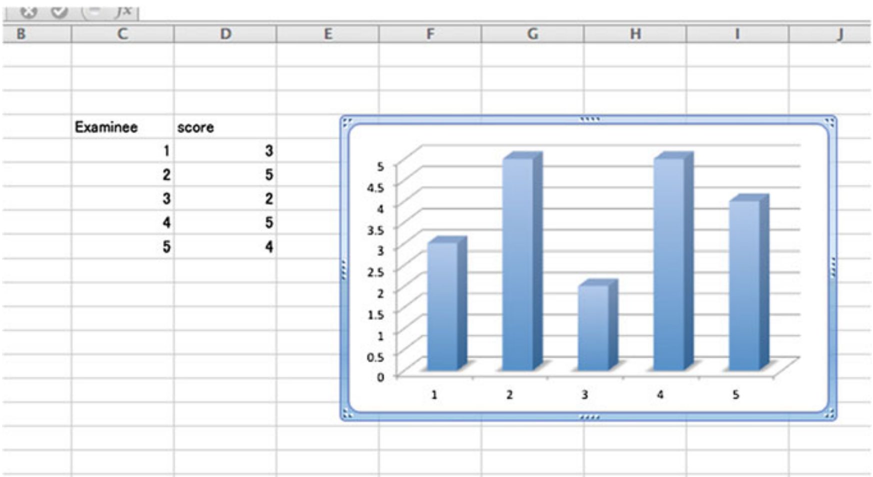


Fig. 8.4 A bar-type figure for an experiment of the science fair

In the fifth week, the students make their presentation files by using Microsoft PowerPoint. This is a good example of using PowerPoint for STEM. Giving a presentation about one's project results is a very important factor for creative STEM education. In addition to that, students make graphs and figures by using Microsoft Excel during that week. They pursue their own unique experiments. For example, a group investigated the temperature change of the paper irradiated by sunlight through a hand glass. The temperature change was measured by an infrared thermometer.

Since the line chart would be the best to show the change clearly, they input their experimental results into an Excel spreadsheet. Then they made a scatter chart, using a function of Excel. (Fig. 8.3).

Another group carried out an investigation to find out if people would be excited by listening to music. They picked up some examinees and let them listen to a song. After that, the examinees were asked the question, “Were you excited to hear the song?” The responses of examinees (answers) were evaluated by a five-step scale. 1: Not at all, 2: A little, 3: Neutral, 4: Pretty much, 5: Very much. The average value was put into a spreadsheet. This time, the results were shown as a bar graph (Fig. 8.4).

These are just some examples for the utilization of stand-alone computers. The type of computer has changed from desktop computers to laptops and to tablet type computers. Even though they might be used as a stand-alone type computer, the change would increase possible applications much more in the future.

References

1. Nakagawa, K. (2011). *ICT education—100 practical examples* (p. 44). Forum A: Osaka.
2. Barry, D.M., Kanematsu, H., & Kobayashi, T. (2009) *Science Fair Fun in Japan* (2nd ed.). Japan: Gendai Tosho.

Chapter 9
The Utilization of the Internet

Abstract In this chapter, we show and discuss how the Internet has changed our society, our thoughts and our education. The concepts for STEM have also been inevitably changed. This chapter also introduces the use of Web 1.0, Web 2.0, and Web 3.0 for STEM education.

The Internet that appeared in the mid-1990s revolutionized our world. At the same time, the applicability and use of computers in schools have changed.

One of the biggest changes is that of content. Figure 9.1 shows the change of content types with the development of the computer and the Internet. Takashima summarized the change well in the case of mathematics education [1].

Before the advent of the computer and the Internet, the contents were prepared as a type of print like teachers' notes, or some handouts. Usually they were just one or two page handouts. The degree of freedom for the kind of content that teachers could select was easy. However, this type of handout was hard for teachers to use for describing detailed information. Inevitably, most of them would be summarized handouts. Therefore, it would be not so good for the students, even though teachers could save time by making them.

Text-type content can contain lots of information on the other hand. It must be quite similar to a textbook. Using computers, teachers can produce high quality text-type content. Usually, they are shown on paper media. However, they should be shown on a tablet such as an iPad in the future. Generally students tend to keep them a long time as compared with simple print-type content. It is the same with real textbooks. Students have access to the text-type contents again and again. When they feel that something in the contents is important, they can easily refer to it. Also text-type content is suitable for large classes. However, this type of content has some demerits as follows.

#1: The class would be unidirectional in most cases. Students are passive but can learn something passively.

#2: Usually the text-type content is boring so the students can not enjoy the learning. That might distract students' motivation and concentration, so that the learning outcomes would be kept at a lower level.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
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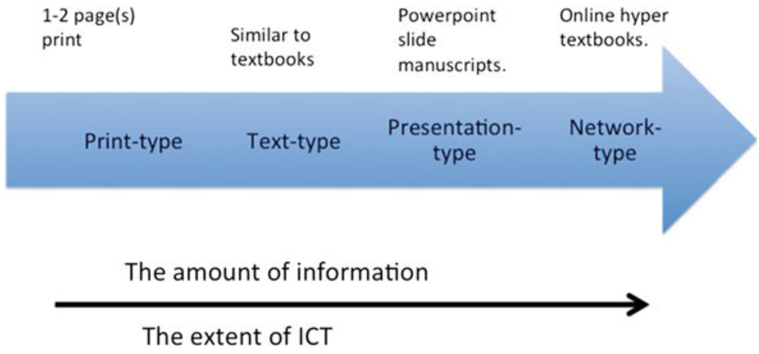


Fig. 9.1 The change of contents in the STEM class

#3: It is difficult for students to survey something further developmentally and expansively from the text-type contents.

From the viewpoint of STEM, the important factor might be missing: positive, active, and enjoyable learning.

As of recently, presentations containing the contents are often used. In such a case, teachers usually prepare slide shows for their classes. PowerPoint, Keynote, and some other presentation office applications can be printed out as paper media in various ways. Then the students can use them in classes. When they listen to teachers' slide shows, they may have difficulty following the teacher's lesson. This is usually because the presentation rate is too fast to follow. However, printed handouts could help students follow the lecture. Also the students can use them as notes about the material.

Being compared with the three types of content, the network type of content is the most advanced. It is basically shown as electronic files on computers and written by hypertext. Hypertext is the system where texts and components are usually linked and related to each other as a reference. The link is called a hyperlink. Usually the contents are written by using HTML language and are shown on The World Wide Web. The characteristic of hypertext is that students can refer something to others very easily. From the viewpoint, the type of the text is developmental. This tendency is accelerated more, when the computer showing the content has an access to the Internet. The network type text can be realized by the Internet. Since students can easily refer to others through hypertext contents, they can rearrange and reintegrate the knowledge on their own. These students could learn positively and actively, and concentrate on learning more. The most remarkable characteristic is that students can build a new relationship and rearrange the contents on their own. The efficiency for learning seems to be very high. This is very suitable for STEM education and can be realized using the Internet. This type of text can be used to make the class a student-centered one instead of teacher-centered.

One of the impacts by the Internet is to change the hierarchical structure of society to the lateral one where any persons and participants at any places and at any levels

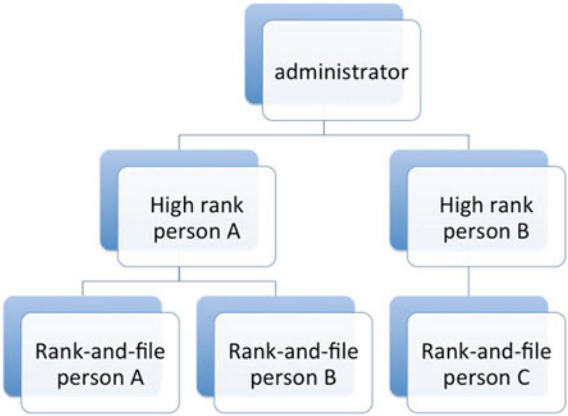


Fig. 9.2 Hierarchical social structure

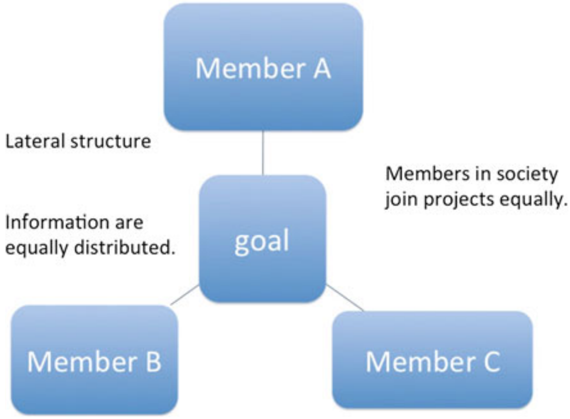


Fig. 9.3 Lateral social structure

can join equally (Figs. 9.2, and 9.3). The drastic change of social structure can be recognized for any organization, since the information generally determines the effective structure of an organization and society [2]. The Internet makes information distributed equally and laterally. Therefore, the vertical structure is inevitably changed to a lateral and horizontal one. Thus, the position and relationship between teacher and student can be also changed in the classroom of the Internet age.

Web technology was invented in 1989. Since then, it has been developed drastically. However, the relationship between a teacher and the students was just unilateral like the conventional text-type based classroom shown in Fig. 9.4.

Tim O'Reilley proposed the concept of Web 2.0 in 2005. According to his concept, the teacher and students could communicate mutually as shown in Fig. 9.5. Students can tackle with educational content more positively.

Recently the new concept called Web 3.0 was proposed so the relation between teachers and students is going to change again [3]. According to the concept,

Fig. 9.4 The concept of Web 1.0 for STEM

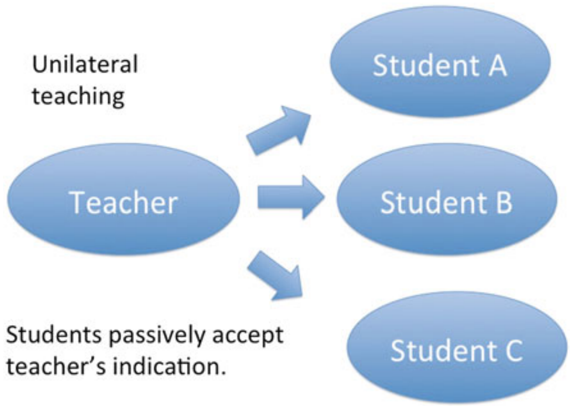


Fig. 9.5 The concept of Web 2.0 for STEM

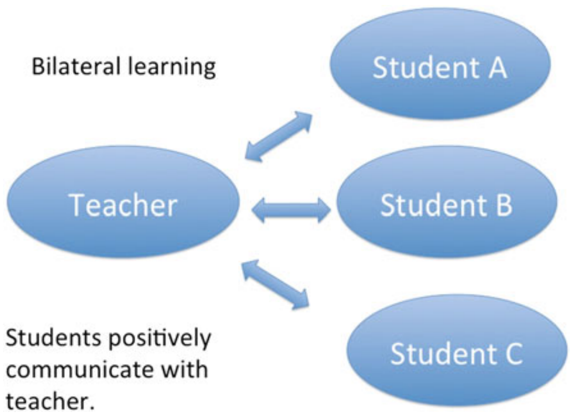
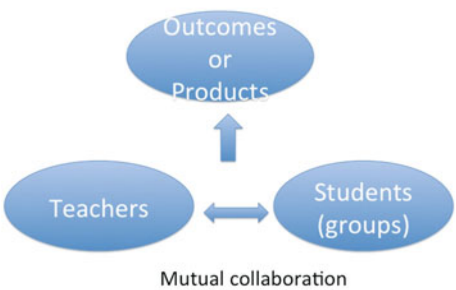


Fig. 9.6 The concept of Web 3.0 for STEM



teachers and students would collaborate to produce educational products as shown in Fig. 9.6. In this way, students would get a chance to produce textbooks and creative products, etc. on the web as part of a collaborative team.

STEM education must involve positive, active, and enjoyable learning in a student-centered class. The Internet is a powerful educational tool for STEM education for the present and the future.

References

1. Takashima, Y. (2001). Making textbooks for mathematics based on the historic investigation of mathematics. *Mathematics Education Research in Toyama, 1*, 7–12.
2. Toffler, A. (1984). *The third wave*. New York: Bantam.
3. Takasaki, H. (2010). *The future scope and problem in the age of web 3.0*, R&A of KDDI Souken, May 2010.

Chapter 10
Social Networking and STEM

Abstract In this chapter, we discuss how social networking could affect STEM education. As social networking examples, Twitter and Facebook are mentioned. Social networking opens the doors to new educational fields where many new possibilities exist for youngsters.

Since the Internet became universal, there has been a trail to utilize virtual networks for education. Particularly, when we come to think about the application to STEM education, it has the following three positive characteristics.
(1) Learning without being conscious about STEM
Joining virtual spaces very often provides satisfying and enjoyable experiences for youngsters. Therefore, students joining the virtual network don't always have to be conscious about STEM, when they learn something there. This allows youngsters not to be distracted by thinking about STEM but to focus on learning.
(2) Experience-based learning
Virtual networks often make it possible for teachers to provide students the chance for experiment-based learning. For general science education, experiences, experiments, training, etc. are very important for students. This is also true particularly for STEM education. ICT would realize this type of learning as much as possible.
(3) Mutual communication
As described in this Part 2 before, STEM education in the future needs bidirectional communication, since the type of learning is changing from teacher-centered learning to student-centered learning. Learning as a team member among students is becoming more and more important. Therefore, the bidirectional communication function is very important for STEM along with ICT.

Social networking service (SNS) is one of the networking services that private companies provide for us. Strictly speaking, it is defined as the membership community service. Ameba, Facebook, Line, Google + , Instagram, Mixi, Mobage, Pinterest, Twitter, and Skype can be mentioned as examples. Several are selected and described.

Examples: Facebook, Twitter, Youtube, etc.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
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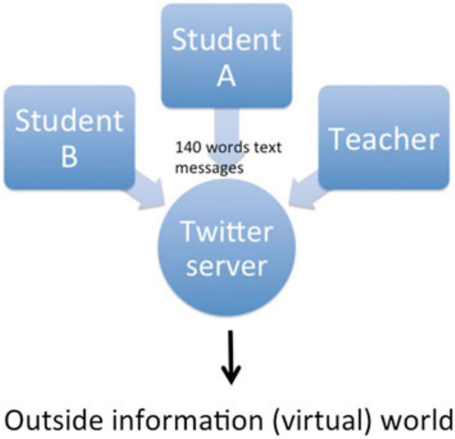


Fig. 10.1 The concept of Twitter for STEM education

Twitter is a social networking service provided by Twitter Co. Ltd. Members can submit short sentences composed of 140 characters. Twitter is headquartered in San Francisco, California, the USA. When one would submit his/her short sentences to Twitter, a moderate connection among people comes into being. From the viewpoint, Twitter can be considered a type of social networking. Regarding the utilization for education, mutual communication and discussion can take place between students among schools in different districts, states and countries. From the viewpoint, Twitter can be utilized for discussion beyond space and time. It can also be used as a source of information for learning. Even though the message is restricted to 140 characters mainly, it can contain many links by which students can collect lots of information, much more than those they could get from conventional textbooks (Fig. 10.1).

On the other hand, Facebook (FB) doesn't have any restrictions for the messages submitted by participants. It is also one of the social networking services on the Internet. Students including Mark Zuckerberg of Harvard University began the service and at first, it was restricted for use to only students in Harvard University. Nowadays, anyone over 13 years old can have the membership all over the world. Basically, the member submits his/her message based on plain text. However, many advanced functions are available on FB. Not only a desk-top PC and laptop, but also mobile terminal apparatus is available on FB. Therefore, one can have an access to FB by iPhone, iPod touch, BlackBerry, Android, iPad, etc. This service makes it possible for us to learn something at any place and also at any time. This is the same with other social networking services. In addition to the usual networking activity, there are some characteristic functions. For some other outside services, one can enter them with the authentication of Facebook. One can use a "Facebook page" as his/her homepage.

When one comes to think about the utilization of Facebook for educational activities, the following merits can be mentioned [1–3].

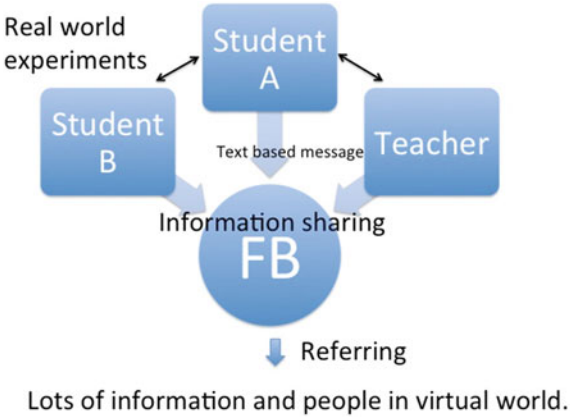


Fig. 10.2 The concept of FB for STEM education

#1: Youngsters know how to use it.
As described above, everyone over 13 years of age can have a membership. Therefore, lots of youngsters are already members and know how to handle FB very effectively. It is very natural for them to tackle with the projects on FB with much pleasure. Actually, 1.1 billion persons are already members of FB. It means that students would not have so much difficulty to begin handling it. Nowadays (March 2015), the number of members is about 1.1 billion. Therefore, the use of FB for education would not require a large initial cost.

#2: Group and sharing
Teachers and students can make a sharing space virtually where they can collaborate for something educational. They can share the information by mutual communication and discuss it with each other on FB. Using the function and characteristics, they can pursue some STEM projects on FB. Regarding this feature, students would get a chance to carry out STEM projects virtually. However, the combination with hands-on experiments in the real world is also possible as a blend e-learning STEM project (Fig. 10.2).

#3: LMS function.
Students can submit homework and reports to Facebook and teachers can grade, evaluate, and control them. That is basically a function of LMS. LMS stands for learning management system. It is just like an operating system (OS) for e-learning and the system to control for the delivery of learning contents and academic achievements. Being apart from the usual digitizing contents on a CD-ROM, the e-learning system needs to control students and to tell them apart from unknown participants without subscription. It must give students indications about content and proper learning. In addition, it has to control students' achievement and their progress (Fig. 10.3). Even though some situations might be difficult or impossible for FB, functions like the distribution of contents, report submission, etc. would be available for FB (Fig. 10.4).

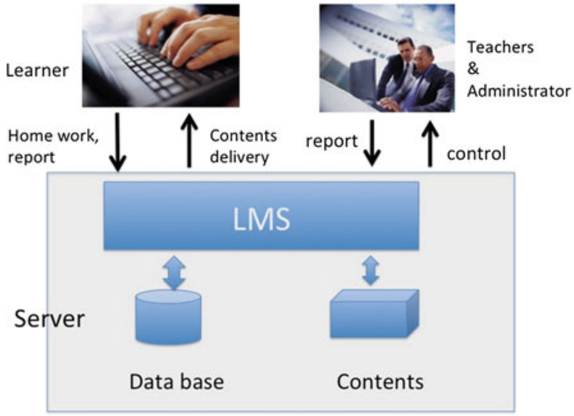


Fig. 10.3 The concept of LMS for education

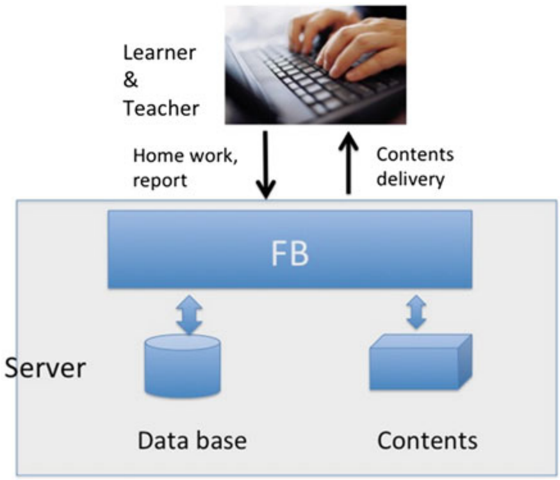
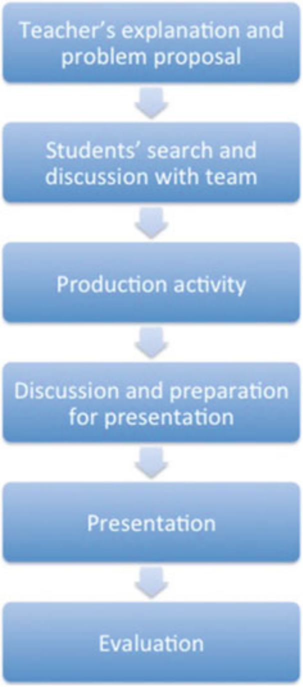


Fig. 10.4 Facebook as LMS for STEM education

#4: Virtual Presentation

Giving presentations for a plan, a progress situation, achievement, etc. is one of the essences for STEM education. It is available on FB, and it relates to #2 (Group and sharing). If the PBL process could be shown in Fig. 10.5 for STEM education, most of the process steps could be realized virtually, using FB. The only exception is the production of deliverables through discussion with the team. Regarding this, the reader can refer to Part 4 of this book, where some virtual production is described as STEM education.

Fig. 10.5 General process for problem based learning



Of course, there are many other social networks applicable to STEM education. However, we would like to restrict the explanation only to Twitter and Facebook in this chapter. For other applications of many interesting social networking services, we would like you, the readers, to find new cases and develop them in the future.

References

1. Winkler, K. (2013, July 15). The education Foundation's Facebook Guide for Educators, EDUK WEST Europe. http://edukwest.eu/the-education-foundations-facebook-guide-for-educators/.
2. Educational technology and mobile learning, The ultimate guide to the use of Facebook in education. http://www.educatorstechnology.com/2012/06/ultimate-guide-to-se-of-facebook-in.html.
3. Curtis, S. Does Facebook really have a place in the classroom. http://www.telegraph.co.uk/technology/facebook/10926105/Does-Facebook-really-have-a-place-in-the-classroom.html.

Part III
STEM Activities in the Real World

Each activity involves Information Technology (IT), has a problem to solve, contains methods for student assessment, and includes the following four components: science, technology, engineering, and mathematics. The activities give students, especially those between the ages of 12 and 18 years, opportunities to search for lesson-related references and to design and carry out investigations (in the real world) as creative problem solvers.

Chapter 11
Amazing Airplanes

11.1 Setting the Stage

The airplane, which is truly amazing, was invented in 1903 by the Wright brothers. It has been used as a sport or hobby, for having pilots do various tricks and stunts to entertain audiences, for fighting wars, and for transporting mail (air mail) and cargo. Today airplanes serve as "buses with wings" that transport people to various locations throughout the world.

This activity provides an opportunity to design, make, and test your own airplanes.

11.2 Science/Engineering

1. Problem: Paper airplanes (of the same style and pattern) will be prepared using thick paper and thin paper.

Problem posed as a question: Will the paper airplane made out of thick paper fly a greater distance than one made of thin paper?

Students design, make, and test their own airplanes to determine which one flies the greatest distance.

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11.3 Science

2. Hypothesis: Make an educated guess about the solution to this problem. The airplane made from either thin or thick paper will fly a longer distance or maybe they will fly the same distance. Write your answer in the space provided.

____

3. Variable: What is different about the makeup of the airplanes in this activity?

____

4. Control: What will remain the same for both airplanes? (Example: The airplane style and pattern will be the same.)

____

5. Materials: thin sheets of paper (two thin sheets of white paper that are 8.5 in. by 11 in., example: printer paper for a computer), thick sheets of paper (two thicker sheets of white paper that are 8.5 in. by 11 in., example: construction paper), crayons, a ruler, a tape measure, protractor, and the Paper Airplane Flight Chart. A computer is also needed.

11.4 Technology

1. Computer Use: Do a Google search to find out about airplanes and how they fly. Also look for plane flight simulators and simulations. Write the airplane information and a brief description about your flight simulation experience in the space provided. List your references in the reference section at the end of this lesson.

Airplane Information: ____

____

____

Flight Simulation Experience: ______________________________________

____

____

11.5 Engineering

2. Identify Design Requirements: Make a pattern for your paper airplane. Draw a sketch or diagram of your airplane in the space provided.

3. Communicate the Selected Design: In order to share the airplane pattern with others, write a step by step procedure for making the airplane in the space provided. Hint: If your plane requires special folds (example: Fold to the left after measuring one inch from the right edge of the lengthwise sheet of paper), then use a ruler to ensure proper folding and directions. Use a protractor to determine folding angles.

Procedure

1. ____
2. ____
3. ____
4. ____
5. ____

4. Implement the Design: Use this pattern to make two paper airplanes (one with thin paper and one with thick paper). Color and label these planes.

5. Test the Products: Test Fly the Planes.

11.6 Mathematics

1. Measurement

a. Use a ruler to determine the length of the airplanes (from the outermost nose section of the airplane to the end of the plane's tail section) in inches and centimeters (1 in. = 2.5 cm). Write this data in the space provided.

Length of thin paper airplane:_______________

Length of thick paper airplane: ______________

b. Use a tape measure to determine the greatest number of feet and inches that each plane travels. Carry out three trial flights for each airplane. After an airplane lands, then use the outermost nose section of the airplane to measure the final distance traveled. Record all of this information on the Paper Airplane Flight Chart. Also calculate the average distance traveled for each airplane and write these values on the chart. Hint: Add the three values together and divide by three to obtain the average distance traveled.

11.6.1 Airplane Flight Instructions

A starting position (for flying the airplanes) must be setup in the classroom. Each student will stand at this position when flying his/her airplane. A tape measure (beginning at the start position) should be stretched out on the floor in the classroom. The students will fly their airplanes three times (Trial 1, Trial 2, and Trial 3 for each airplane). After an airplane lands, then use the outermost nose section of the airplane to measure the final distance traveled. All data should be recorded on the Paper Airplane Flight Chart.

11.7 Engineering

6. Modify the Design: Change the airplane design (pattern) to improve the plane and increase the distance it flies. Draw a sketch or diagram of your modified airplane in the space provided.

7. Communicate the Modified Design: In order to share the modified airplane pattern with others, write a step by step procedure for making this airplane in the space provided. Hint: If your plane requires special folds (example: Fold to the left after measuring one inch from the right edge of the lengthwise sheet of paper), then use a ruler to ensure proper folding and directions. Use a protractor to determine the folding angles too.

Procedure

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

8. Implement the Design: Use this new pattern to make two paper airplanes (one with thin paper and one with thick paper). Color and label these planes.

9. Test the Products: Test Fly the Planes.

11.8 Mathematics

2. Measurement

a. Use a ruler to determine the length of the new airplanes (from the outermost nose section of the airplane to the end of the plane's tail section) in inches and centimeters (1 in. = 2.5 cm). Write this data in the space provided.

Length of new/modified thin paper airplane: ______________

Length of new/modified thick paper airplane: _______________

b. Use a tape measure to determine the greatest number of feet and inches that each new plane travels. Follow the airplane flight instructions that you used before. Carry out three trial flights for each airplane. After an airplane lands, then use the outermost nose section of the airplane to measure the final distance traveled. Record all of this information on the Paper Airplane Flight Chart. Also calculate the average distance traveled for each new airplane and write these values on the chart. Hint: Add the three values together and divide by three to obtain the average distance traveled.

11.9 Science

6. Analysis

a. Based on the results, would you say that paper thickness affects the distance that an airplane flies?____________ Explain.____________________________

____

____

b. Was your hypothesis correct? _______________. Explain.____________

____

____

c. Look at the Paper Airplane Flight Chart. Which airplane flew the greatest distance?__________________ How far did it fly? _____________________
Was this airplane made from the original design (pattern) or from the modified design (pattern)? ____

d. Compare the flights of the paper airplanes made using the original design (pattern) to those made using the modified design (pattern).______________

____

____

e. Did the length of your original and modified airplanes differ? _____________.
If you answered yes, then do you think length affects the distance that an airplane flies? ____________________. Explain. _______________________

____

____

7. Conclusion

a. Based on your overall results, write a brief description of how to make the best paper airplane for distance flying.______________________________

b. If you had an opportunity to design another paper airplane, what would you do differently?______________________________

11.10 Paper Airplane Flight Chart

PLANE	DISTANCE TRAVELED (in feet & inches)	AVERAGE DISTANCE TRAVELED (in feet & inches)
Original Plane (of thin paper)	**Trial 1:** ______ **Trial 2:** ______ **Trial 3:** ______	**average:** ______
Original Plane (of thick paper)	**Trial 1:** ______ **Trial 2:** ______ **Trial 3:** ______	**average:** ______
New Plane (of thin paper)	**Trial 1:** ______ **Trial 2:** ______ **Trial 3:** ______	**average:** ______
New Plane (of thick paper)	**Trial 1:** ______ **Trial 2:** ______ **Trial 3:** ______	**average:** ______

11.11 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to design (create a pattern) a paper airplane?
2. Were the students able to use their design (pattern) to make and test airplanes made of thick and thin paper?
3. Were the students able to analyze and interpret the data?

11.12 Additional Activities

1. Compare your results and airplane designs (patterns) with those of other students in the class.
2. Continue this lesson by adding four small paperclips to each airplane. Put the paperclips in the same location for each plane without changing the design of the airplane. Determine the effect that paperclips have on the distance that an airplane flies.
3. Repeat this lesson using paper of different widths. Determine the effect of paper-width on the distance that an airplane flies.
4. Repeat this lesson using paper of different lengths. Determine the effect of paper—length on the distance that an airplane flies.
5. Repeat this lesson using different materials to make the airplanes (examples: cardboard, wax paper, aluminum foil, wood, etc.). Determine how different materials affect the distance that an airplane flies.

References

1. (Students are to list the references that they obtained while doing this lesson.)

Chapter 12
Best Beans

12.1 Setting the Stage

Green beans (also known as string beans and shi-so in Japanese) are vegetables that provide us with important vitamins and nutrients such as Vitamin K, Vitamin C, Vitamin A, manganese, and dietary fiber. Vitamin K helps stimulate blood clotting. Vitamin C boosts the immune system. Vitamin A helps one see in the dark (night vision) and in trace amounts manganese is important for our metabolism.

This activity provides an opportunity to grow green bean plants using various liquids.

12.2 Science/Engineering

1. Problem: Three green beans (from the same package of seeds) will be planted separately (all in the same way and in identical containers that are labeled). They will be taken care of in the same way, except for one difference. One will receive water, another will get a basic liquid (made by adding and stirring one teaspoon of baking soda also known as sodium bicarbonate in one cup of water), and the last one will get an acidic liquid (vinegar).

Problem posed as a question: Which bean plant will grow the best in terms of height, appearance, etc.?

Students grow green bean plants using various liquids to determine which one grows the best in regards to height, appearance, etc.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
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12.3 Science

2. Hypothesis: Make an educated guess about the solution to this problem. Either the bean watered with water or the bean receiving the basic liquid or the bean given the acidic liquid will grow the best or maybe they will grow the same, etc. Write your answer in the space provided.

____

3. Variable: What item differs in this activity?

____

4. Control: What items will remain the same during this project? (Example: The amount of liquid given to each plant.)

____

5. Materials: package of seeds (for green beans), sunlight, potting soil, 3 identical containers (for planting the seeds), 3 different liquids (water, baking soda in water, and vinegar), calibrated cylinder (to measure amount of liquid added to each plant container), ruler, tape measure, graph paper, the Plant Growth Chart, Smart Phone or digital camera, computer, and interface cables.

12.4 Technology

1. Computer Use: Do a Google search to find out about green beans and the best way to grow them. Write the green bean information and a brief description about growing them in the space provided. List your references in the reference section at the end of this lesson.

Green Bean Information:

___

___

___

Growing Green Beans:

___

___

___

2. Smart Phone/Digital Camera Use: Once the experiment begins, take a photo each week of the plants using the same smart phone or digital camera every time. If possible, then download all of the photos to a computer and save them for later use (such as plant growth comparisons).

12.5 Engineering

2. Identify Design Requirements: Determine the design requirements for this activity. (Example: the amount of liquid given to each plant per week).
In the space provided, write the design requirements necessary for carrying out this investigation. ___

___

___

3. Communicate the Selected Design: In order to share the method you designed to carry out this activity, write a detailed step by step procedure below. It should include details for planting, observing, and growing green beans using the three different liquids. Hint: If your designed experiment is communicated properly, others should be able to carry it out in a similar way.

Procedure

1. ____

2. ____

3. ____

4. ____

5. ____

4. Implement the Design: Use this procedure to plant, observe, and grow your green beans.

12.6 Mathematics

1. Measurement
   a. Observe your plants on a weekly basis for 5 weeks. Use the calibrated cylinder to help you keep track of the amount of liquid added to each plant. Be certain that this cylinder is clean each time you use it. Also use a ruler or tape measure to determine the height of each plant in inches and centimeters. (1 in. = 2.5 cm). Record all of your information on the Plant Growth Chart.
2. Graphing
   a. Make a graph for each plant to show its growth on a weekly basis. For example, the X-axis could represent the weeks (week 1, week 2, etc.), while the Y-axis could represent plant growth in centimeters.

12.7 Science

6. Analysis:

a. Based on the results,would you say that the liquids given to the plants affect their growth? ______________________ Explan?________________________

____

____

b. Was your hypothesis correct? ________________. Explain. ______________

____

____

c. Look at the Plant Growth Chart. Which bean plant grew the tallest? ______________________ How tall did it grow? ________________________

d. Look at the Plant Growth Chart and your photographs.Which bean plant has the best appearance?____
Explain. ____

7. Conclusion

a. Based on your overall results, write a brief description of how to best grow green beans.____

____

____

b. If you had an opportunity to design another procedure for carrying out this activity, what would you do differently?______________________________

____

____

12.8 Plant Growth Chart

WEEK	PLANT APPEARANCE	PLANT HEIGHT (inches /centimeters)
1.		
2.		
3.		
4.		
5.		

12.9 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to design a method (plan) for carrying out this investigation?
2. Were the students able to collect data and display it on graphs?
3. Were the students able to make a correct conclusion based on their results?

12.10 Additional Activities

1. Repeat this lesson using three different liquids such as tea, juice, and soda.
2. Repeat this lesson using a different type of seed.
3. Repeat this lesson using a different type of soil.

References

1. (Students list their references.)

Chapter 13
Eating Enough

13.1 Setting the Stage

Individuals want to lose weight, gain weight, or maintain a certain weight. Food is our fuel or source of energy. It is measured in Calories. The uppercase C indicates food Calories instead of calories with a lowercase c used for science experiments. However, sometimes the uppercase C is not used on food labels, etc. as it should be. (One Calorie is the energy needed to increase the temperature of 1 kg of water by 1 °C.) To maintain a certain body weight, a person must burn up (use) the same number of Calories that he or she consumes. The goal of this activity is to design a plan for maintaining a consistent body weight, while carrying out the same exercise routine each day.

This activity allows students to determine the number of Calories needed each day to maintain their body weight and to design a plan for keeping their weight constant. For this project the students are expected to carry out the same exercise routine (physical activities) each day.

13.2 Science/Engineering

1. Problem: How many Calories do you need to consume each day to maintain a consistent body weight, while carrying out the same exercise routine (physical activities) each day?

Students determine the number of Calories needed each day to maintain their body weight and design a plan for keeping their weight constant.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
DOI 10.1007/978-3-319-19234-5_13

13.3 Science

2. Hypothesis: Make an educated guess as to the number of daily Calories needed to maintain your body weight for this activity? Write your answer in the space provided.

____

3. Variables: List the items that change during this activity. One example is the beverage that you drink with meals. ______________________

____

4. Controls: List the items that remain the same during this lesson. Since you will weigh your self each day using the same scale, the scale is a control._____

____

5. Materials: computer, iPad, pedometer, scales (to weigh yourself and food items), labels from food item packages and drinks, graph paper, calculator, exercise equipment, Monday's Eating and Physical Activity Chart, Tuesday's Eating and Physical Activity Chart, Wednesday's Eating and Physical Activity Chart, Thursday's Eating and Physical Activity Chart, Friday's Eating and Physical Activity Chart, Saturday's Eating and Physical Activity Chart, and Sunday's Eating and Physical Activity Chart.

13.4 Technology

1. Computer Use/iPad Use: Do a Google search to obtain up to date information about the Basic Food Groups. Also find sample menus for a typical healthy breakfast, lunch, and dinner, along with the estimated Calories for each meal if possible. Get some information about healthy snacks too. Also search for websites with Calorie information about fruits (such as a medium size banana), vegetables, and 1 oz servings, etc. of fish and various types of meat. Use the Apps on an iPad to obtain additional data. Write all of the information in the space provided. List your references in the reference section at the end of this lesson.

Information about the Basic Food Groups:

Menu and Calories for a Typical Healthy Breakfast:

Menu and Calories for a Typical Healthy Lunch:

Menu and Calories for a Typical Healthy Dinner:

Information about Healthy Snacks:

List of Websites with Calorie Information for Fruits, Vegetables, Fish, Meat, etc.:

13.5 Mathematics

1. Measurement
   a. In order to collect data for this activity, you need to make measurements. You will use a scale to weigh yourself each morning and to weigh portions of food such as 1 oz of chicken.
   b. You will use a pedometer or an exercise bike to measure the distance (in miles) that you walk. These items may also measure the number of Calories that you burn up while walking.
2. Calculations
   a. Use a calculator to determine the total number of Calories that you eat for each meal and daily snacks. Also use the calculator to obtain the total number of Calories that you consume each day.

13.6 Science/Engineering

6/2. Data Collection: Here is a brief description about data collection. Start by weighing yourself when you first get up on a Monday morning. Note all items (food and drinks) that you consume for breakfast, lunch, snacks, and dinner on that day. Estimate your total number of Calories for the day. This information will be recorded on your Monday data chart. Continue to keep track of your weight and the Calories that you eat each day for a week, while carrying out daily exercises (physical activities) that are essentially the same.

General Instructions

1. Begin by weighing yourself, when you first get up on Monday morning. Record this value on Monday's chart.
2. Note all items (food and drinks) that you consume for breakfast, lunch, snacks, and dinner on this Monday. Also weigh the serving size (in ounces) for the fish or meat products, etc. that you eat. Then estimate the total number of Calories for this day. Look at the labels on food items and drink containers to find out the number of Calories per serving. Use the websites that you found on the Internet to approximate the number of Calories in fruits, vegetables, and in various amounts of fish, meat, etc. Then use a calculator to determine the total number of Calories for each meal and snacks. Finally add these values together to get the total number of Calories consumed for the day. Record all of this information on Monday's data chart.
3. List your physical activities (such as walking 1 mile) for Monday on Monday's chart.
4. Repeat steps 1, 2, and 3 each day for a week (a total of 7 days). Weigh yourself each morning using the same scale. Also note the food/drink items that you have for breakfast, lunch, snacks, and dinner each day. Follow the procedure used in

instruction number 2 to obtain the total number of Calories consumed (for each meal, for daily snacks, and for each day of the week). Record all of this information on the appropriate chart. In addition, keep track of your daily physical activities (exercises), which should be consistent for the week. List them on your charts.

13.7 Technology

2. Use of Scales: You used scales to weigh yourself each morning and to weigh serving sizes of various food items such as 1 oz of chicken (in order to estimate its Calorie content). This data should be recorded on your charts.

3. Use of a Pedometer: You used a pedometer to determine the number of miles that you walked each day. (Some pedometers also show the number of Calories burned up by walking.) This data should be recorded on your charts.

4. Use of Exercise Equipment: Maybe you used exercise equipment such as an exercise bike. If so, then it determines the number of miles that you walk each day. It may also provide you with additional information. This data should be recorded on your charts.

13.8 Mathematics

3. Graphing

a. Prepare 2 graphs. One graph should display your body weight versus the day of the week for 7 days. Also prepare a graph to show the number of Calories that you consumed daily during the one week period.

13.9 Science

7. Analysis

a. Take a close look at your data and charts for the week. At what meal did you consume the most Calories? ______________________________

b. Are you gaining weight, losing weight, or keeping a constant weight? ____. Explain.
____

13.10 Engineering

3. Design a Plan (to maintain a constant body weight while carrying out the same exercise routine each day): Hint: In order to maintain a constant body weight, one must burn the same amount of Calories that he or she eats. Write the steps for your creative plan in the space provided.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

4. Test Your Plan for 1 Week

13.11 Science

8. Results

a. Was your original hypothesis correct? __________. Explain. __________

____

9. Conclusion

a. Were you able to design a plan for maintaining a constant body weight? ____ Explain. ______________________________

13.12 Eating and Physical Activity Charts

MONDAY'S EATING & PHYSICAL ACTIVITY CHART

	Food Items / Drinks & Amounts	Calories (Estimated)
Breakfast	______________	__________
	______________	__________
	______________	__________
	______________	__________
Lunch	______________	__________
	______________	__________
	______________	__________
	______________	__________
Snacks	______________	__________
	______________	__________
	______________	__________
	______________	__________
Dinner	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________

OTHER INFORMATION

Your Weight: ____________
Total Number of Calories that You Had for Breakfast: ________________
Total Number of Calories that You Had for Lunch: __________________
Total Number of Calories that You Had for Snacks: _________________
Total Number of Calories that You Had for Dinner: _________________
Total Number of Calories that You Had for the Day: ________________
List Your Physical Activities (exercises) for the Day: ______________

Additional Information: ___________________________________

TUESDAY'S EATING & PHYSICAL ACTIVITY CHART

	Food Items / Drinks & Amounts	Calories (Estimated)
Breakfast	______________	__________
	______________	__________
	______________	__________
	______________	__________
Lunch	______________	__________
	______________	__________
	______________	__________
	______________	__________
Snacks	______________	__________
	______________	__________
	______________	__________
	______________	__________
Dinner	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________

OTHER INFORMATION

Your Weight: _____________
Total Number of Calories that You Had for Breakfast: ________________
Total Number of Calories that You Had for Lunch: ___________________
Total Number of Calories that You Had for Snacks: __________________
Total Number of Calories that You Had for Dinner: __________________
Total Number of Calories that You Had for the Day: _________________
List Your Physical Activities (exercises) for the Day: _________________

Additional Information: _____________________________________

WEDNESDAY'S EATING & PHYSICAL ACTIVITY CHART

	Food Items / Drinks & Amounts	Calories (Estimated)
Breakfast	______________	__________
	______________	__________
	______________	__________
	______________	__________
Lunch	______________	__________
	______________	__________
	______________	__________
	______________	__________
Snacks	______________	__________
	______________	__________
	______________	__________
	______________	__________
Dinner	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________

OTHER INFORMATION

Your Weight: ____________
Total Number of Calories that You Had for Breakfast: __________________
Total Number of Calories that You Had for Lunch: __________________
Total Number of Calories that You Had for Snacks: __________________
Total Number of Calories that You Had for Dinner: __________________
Total Number of Calories that You Had for the Day: __________________
List Your Physical Activities (exercises) for the Day: __________________

Additional Information: ___________________________________

THURSDAY'S EATING & PHYSICAL ACTIVITY CHART

	Food Items / Drinks & Amounts	Calories (Estimated)
Breakfast	______________	__________
	______________	__________
	______________	__________
	______________	__________
Lunch	______________	__________
	______________	__________
	______________	__________
	______________	__________
Snacks	______________	__________
	______________	__________
	______________	__________
	______________	__________
Dinner	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________

OTHER INFORMATION

Your Weight: _____________
Total Number of Calories that You Had for Breakfast: _______________
Total Number of Calories that You Had for Lunch: __________________
Total Number of Calories that You Had for Snacks: __________________
Total Number of Calories that You Had for Dinner: __________________
Total Number of Calories that You Had for the Day: _________________
List Your Physical Activities (exercises) for the Day: _________________

Additional Information: ______________________________________

FRIDAY'S EATING & PHYSICAL ACTIVITY CHART

	Food Items / Drinks & Amounts	Calories (Estimated)
Breakfast	______________	__________
	______________	__________
	______________	__________
	______________	__________
Lunch	______________	__________
	______________	__________
	______________	__________
	______________	__________
Snacks	______________	__________
	______________	__________
	______________	__________
	______________	__________
Dinner	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________

OTHER INFORMATION

Your Weight: ____________
Total Number of Calories that You Had for Breakfast: ________________
Total Number of Calories that You Had for Lunch: ________________
Total Number of Calories that You Had for Snacks: ________________
Total Number of Calories that You Had for Dinner: ________________
Total Number of Calories that You Had for the Day: ________________
List Your Physical Activities (exercises) for the Day: ________________

Additional Information: __________________________________

SATURDAY'S EATING & PHYSICAL ACTIVITY CHART

	Food Items / Drinks & Amounts	Calories (Estimated)
Breakfast	______________	__________
	______________	__________
	______________	__________
	______________	__________
Lunch	______________	__________
	______________	__________
	______________	__________
	______________	__________
Snacks	______________	__________
	______________	__________
	______________	__________
	______________	__________
Dinner	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________

OTHER INFORMATION

Your Weight: ____________
Total Number of Calories that You Had for Breakfast: ________________
Total Number of Calories that You Had for Lunch: ________________
Total Number of Calories that You Had for Snacks: ________________
Total Number of Calories that You Had for Dinner: ________________
Total Number of Calories that You Had for the Day: ________________
List Your Physical Activities (exercises) for the Day: ________________

Additional Information: ____

SUNDAY'S EATING & PHYSICAL ACTIVITY CHART

	Food Items / Drinks & Amounts	Calories (Estimated)
Breakfast	______________	__________
	______________	__________
	______________	__________
	______________	__________
Lunch	______________	__________
	______________	__________
	______________	__________
	______________	__________
Snacks	______________	__________
	______________	__________
	______________	__________
	______________	__________
Dinner	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________
	_______________	__________

OTHER INFORMATION

Your Weight: ____________
Total Number of Calories that You Had for Breakfast: ______________
Total Number of Calories that You Had for Lunch: ______________
Total Number of Calories that You Had for Snacks: ______________
Total Number of Calories that You Had for Dinner: ______________
Total Number of Calories that You Had for the Day: ______________
List Your Physical Activities (exercises) for the Day: ______________

Additional Information: ___________________________________

13.13 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to use a computer, etc. to obtain information for this activity? (Hint: Check their list of references at the end of this lesson.)
2. Were the students able to make measurements in order to obtain data?
3. Were the students able to design a plan to maintain a constant body weight while carrying out the same exercise routine each day?

13.14 Additional Activities

1. If you had an opportunity to repeat this activity, what would you do differently? Carry out this lesson using your modified plan.
2. Repeat this activity with an emphasis on the use of physical activities to maintain a constant body weight. For instance if you seem to be gaining weight, then increase your daily physical activities to burn up more Calories. Try to keep your daily Calorie intake somewhat constant for the week, just as you kept your daily physical activities essentially the same in the previous lesson.
3. Carry out a similar activity. Only this time design a creative plan to lose weight. (Hint: First decide how much weight you want to lose.)

References

1. (Students list their references.)

Chapter 14
Possible Planets

14.1 Setting the Stage

The Solar System consists of planets that revolve around the Sun. The Sun is the star closest to Earth. The order in which some of the planets revolve around the Sun is as follows. Mercury is closest to the Sun, followed by Venus, Earth, and Mars.

This activity provides an opportunity to create new planets.

14.2 Science/Engineering

1. Problem: Obtain as much information as possible about the planets Earth and Mars. Then create new planets that could exist between them in our Solar System.

Problem posed as a question: What do these new planets (between Earth and Mars) look like? (The description should include information such as planet size, life forms, and the presence of gases, minerals, water, and Moons.)

14.3 Science

2. Materials: books and magazine articles about Earth and Mars, iPhone/iPad with apps about Earth and Mars (Example: Mars Globe app), computer, calculator, Creative Planet Chart, drawing paper, pencils, crayons, protractor, ruler, and compass.

Students create new planets that are located between the planets of Earth and Mars.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
DOI 10.1007/978-3-319-19234-5_14

14.4 Technology

1. Computer Use: Do a Google search to find information about the planets Earth and Mars. Write this information in the space provided and use it for your Creative Planet Chart. List your references in the reference section at the end of the lesson.

Planet Earth Information:

____

____

____

Planet Mars Information: ____

____

____

2. iPhone/iPad Use with Apps: Use an iPhone/iPad with apps about Earth and Mars to obtain pictures and more information about these planets. Write the additional information in the space provided and use it for your Creative Planet Chart.

Planet Earth Information: ____

____

____

Planet Mars Information: ____

____

____

14.5 Engineering

2. Identify Design Requirements: Determine the design requirements for this activity. (Example: The new planet must be located between the orbits of Earth and Mars.) In the space provided, write any design requirements necessary for carrying out this investigation. ————

____

____

3. Identify Design Limits: (Examples: **a**. The new planet could be as close to Earth's orbit around the Sun as possible as long as it is still between the orbits of Earth and Mars. **b**. Another new planet could be as close to Mars' orbit around the Sun as possible as long as it is still between the orbits of Earth and Mars. **c**. Also a new planet could be equal distance between the orbits of Earth and Mars.)

Write other design limits in the space provided. ____________________

____

____

14.6 Mathematics

1. Calculations

a. Record all of the information (that you obtained about Earth and Mars) on the Creative Planet Chart. Then take a close look at it. Use a calculator to perform some calculations with the data. Do this to help decide the characteristics of your three creative planets listed on the Creative Planet Chart. For example, here is one way to make an educated guess for the Orbit Period (in Earth Days) of the creative planet equidistant between Earth and Mars. First add the Orbit Periods for Earth and Mars together and then divide the sum by two.
b. Make additional calculations to estimate the diameter, possible temperatures, atmosphere components, the presence of Moons and volcanoes, and other characteristics for your three possible creative planets. Add your answers to the Creative Planet Chart.

14.7 Engineering

4. Generate Possible Solutions to the Problem

a. Name and draw a sketch of the three planets that you created. Use the space provided below.

b. Briefly describe each new planet in the space provided.

Planet closest to Earth: ____________________________

____

____

Planet closest to Mars: ______________________________

____

____

Planet equidistant between Earth and Mars: __________

____

____

14.8 Science

3. Conclusion

a. After completing this lesson, please write (in the space provided) any concluding thoughts that you have about the existence of other possible planets.

____

____

____

14.9 Creative Planet Chart

DATA	PLANETS		CREATIVE PLANETS		
	Earth	**Mars**	**Closest to Earth**	**Closest to Mars**	**Equidistant between Earth & Mars**
Moons	1	2			
Diameter In Miles					
Temperatures					
Main Atmosphere Components					
Volcanoes					
Orbit Period In Earth Days	365.25	686.98			
Other Information					

14.10 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to use a computer, etc. to obtain information about the planets Earth and Mars? (Hint: Check their Creative Planet Chart.)
2. Were the students able to use mathematics (along with their obtained information) to estimate the diameter, possible temperature, and other characteristics for the three possible creative planets?
3. Were the students able to generate possible solutions to the problem (draw a sketch and write a description for three possible planets existing between Earth and Mars)?

14.11 Additional Activities

1. Continue this lesson by creating planets different distances between Earth and Mars. For example, create a planet existing two-thirds the distance between Earth and Mars (but closer to Mars).
2. Repeat this activity using two different planets such as Venus and Earth.

References

1. (Students list their references.)

Chapter 15
Going Green

15.1 Setting the Stage

We live on the planet Earth. Each person needs to be concerned about the well-being of our planet and to do his/her part to preserve it for future generations. Everyone should participate in Green (environmentally friendly) activities that include reducing the use of resources, recycling materials (such as paper, metal, and glass), and reusing items like those made of plastic, etc.

This activity provides an opportunity for students to design (create) plans to help their household and local school Go Green (become environmentally friendly).

15.2 Science/Engineering

1. Problem: The students will discuss and carry out activities that involve recycling and the reusing of materials as well as conserving resources like trees and water. They will design plans to help their household and local school Go Green (become environmentally friendly).

Problem posed as a question: What plan did you design to help your household become environmentally friendly (Go Green)? What plan did you design to help your local school become environmentally friendly (Go Green)?

Students create a plan to help their household and local school to become environmentally friendly.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
DOI 10.1007/978-3-319-19234-5_15

15.3 Science

2. Materials: computer, iPad, calculator, access to classroom garbage can for one week, access to household garbage for one week, protective gloves to wear while handling garbage, safety glasses, labeled containers to hold the various types of garbage (one container for paper, one for glass, one for metal, etc.), lids for each labeled container if desired, Going Green Chart for School, and the Going Green Chart for Home.

15.4 Technology

1. Computer Use/iPad Use: Do a Google search to find out information about reducing the use of resources (example: conserving water), about recycling materials like plastic, and about reusing items such as paper. Write your answers in the space provided. List your references in the reference section at the end of this lesson.

Information about Reducing the Use of Resources: ______________________

____

____

____

Information about Recycling Materials: ______________________________

____

____

Information about Reusing Items: __________________________________

____

____

____

15.5 Science/Engineering

3/2. Data Collection: A goal for Going Green (becoming environmentally friendly) is to reduce the amount of garbage (amount of waste) that is generated. This can be done by decreasing the amount of food that we put on our plates at meal time, the amount of paper that we use, and the amount of plastic items that we buy, etc. For example, at some buffets in Malaysia, people are charged for the amount of food that they waste. We must conserve food, especially because people in many parts of the world (example: Africa) are starving.

General Instructions

1. Each day for a week (5 day school week) check the contents of the garbage can in your classroom at school. At the same time check the garbage generated in your home on a daily basis for a week (7 day week).
2. Wear safety glasses and protective gloves while handling the garbage. The garbage should be categorized under 6 different headings such as paper, food scraps, metal, plastic, glass, and other items. Place each type of garbage in appropriately labeled containers. For example, paper should be placed in the container labeled paper. You need 2 sets of labeled containers: one for school and one set for home.
3. Estimate the number of items (by counting them) for each category on a daily basis for a week for both the school classroom and your home. Record all of the information on your Going Green Charts.

15.6 Mathematics

1. Calculations

a. Use a calculator to determine total sums and percents. Start with the data on your Going Green Chart for School. Add the number of items in each category to obtain the total number of these items per school week. Write these values on your chart. Then add all of the sums (of each category for the week) to obtain the total number of all items for the school week. Write your answer in the space provided and on your chart.

   Total Number of Items (sum of all categories for the week) and representing the "Whole" in our equation: ________________

   Use the following equation to determine the percent for the total number of items in each category for the school week. Record all of your data on the Going Green Chart for School.

   Percent of Whole = Part

Let's look at an example. Pretend that the sums for each separate category for the week are as follows.

Paper	Food Scraps	Plastic	Glass	Metal	Other Items
50	30	5	5	8	2

For this example the Whole is 100 items and the paper category is 50 items. Using our equation we find out that paper made up 50 % of the garbage.

Percent of Whole = Part

100 50

50 divided by 100 and then multiplied by 100 gives us 50 %

0.50 times 100 = 50 %.

b. Use a calculator to determine total sums and percents for the data in the Going Green Chart for Home. Add the number of items in each category to obtain the total number of these items per week (a regular 7 day week). Write these values on your chart. Then add all of the sums (of each category for the week) to obtain the total number of all items for the week. Write your answer in the space provided and on your chart.

Total Number of Items (sum of all categories for the week) and representing the "Whole" in our equation: ——————

Use the following equation to determine the percent for the total number of items in each category for the week. Refer to the example in section a. Record all of your data on the Going Green Chart for Home.
Percent of Whole = Part

15.7 Engineering

3. Generate Possible Solutions to the Problem: In the space provided generate 5 possible solutions to each posed problem.

How Can Individuals Reduce the Use of Resources?

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

How Can Individuals Recycle Materials?

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

How Can Individuals Reuse Items?

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

4. Design a Going Green Plan for Your Classroom: Using your Going Green Chart for School and your other information design a Going Green Plan for your classroom. Write the procedure in the space provided.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

5. Design a Going Green Plan for Your Home: Using your Going Green Chart for Home and your other information design a Going Green Plan for your household. Write the procedure in the space provided.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. Implement the Design in Your School: Try to get all of the classrooms in your local school to implement (use) your plan for Going Green (becoming environmentally friendly).

7. Implement the Design in Your Home: Try to get all members of your household to implement (use) your plan for Going Green (becoming environmentally friendly).

15.8 Going Green Charts

GOING GREEN CHART (SCHOOL)

GARBAGE CATEGORIES
(with number of items in each one)

	Paper	Food Scraps	Plastic	Glass	Metal	Other Items
School Week						
Day 1	________	________	________	________	________	________
Day 2	________	________	________	________	________	________
Day 3	________	________	________	________	________	________
Day 4	________	________	________	________	________	________
Day 5	________	________	________	________	________	________
Total number of Items for the week						
% of this item's Total for the week Compared to the sum Of all items for the Week	________	________	________	________	________	________

Sum of all Items for
The Week (the Whole) ______________________

GOING GREEN CHART (HOME)

GARBAGE CATEGORIES
(with number of items in each one)

	Paper	Food Scraps	Plastic	Glass	Metal	Other Items
Regular Week						
Day 1	________	________	________	________	________	________
Day 2	________	________	________	________	________	________
Day 3	________	________	________	________	________	________
Day 4	________	________	________	________	________	________
Day 5	________	________	________	________	________	________
Day 6	________	________	________	________	________	________
Day 7	________	________	________	________	________	________
Total number of Items for the week	________	________	________	________	________	________
% of this item's Total for the week Compared to the sum Of all items for the Week	________	________	________	________	________	________

Sum of all Items for
The Week(the Whole) ________________________

15.9 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to collect data (about the contents of generated garbage) for a week at school and at home? (Hint: Check the Going Green Charts for School and Home.)
2. Were the students able to design a plan to help their school become environmentally friendly? (Hint: Did the plan include ways to reduce the use of resources, recycle materials, and reuse items?)
3. Were the students able to design a plan to help their household become environmentally friendly? (Hint: Did the plan include ways to reduce the use of resources, recycle materials, and reuse items?)

15.10 Additional Activities

1. Repeat this activity by using a balance or scale to weigh (instead of count) the amount of garbage (waste) collected in each category (such as metal, plastic, food scraps, etc.) for a week.
2. Design and implement a plan for your household to conserve as much energy as possible.

References

1. (Students list their references.)

Chapter 16
Building Bridges

16.1 Setting the Stage

A bridge is a structure built over a river, etc. to connect one shore to another. The simplest bridge is a beam bridge. Other bridge types include truss, arch, and suspension. A truss bridge uses a series of triangles (trusses) for support.

This activity provides an opportunity to design, make, and test your own bridges.

16.2 Science/Engineering

1. Problem: Each team of at least two students will design and build a bridge (made of unbendable plastic straws) with a span of 6.5 in. (16.25 cm) that will hold as much weight as possible. Washers will be added to a small plastic container (placed in the center of the bridge) until the bridge collapses or bends at least 1 in. from its original position (whichever comes first).

Problem posed as a question: What type of bridge will you design and build to hold as many washers as possible?

16.3 Science

2. Hypothesis: Make an educated guess as to the number of washers that your bridge will hold. Write your answer in the space provided.

___

Students design, build, and test their own bridges to determine which one can support the most weight.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
DOI 10.1007/978-3-319-19234-5_16

3. Materials: 15 non bendable plastic straws (at least 8 in. long), tape, scissors, ruler, balance, washers, plastic container (example: plastic cup), graph paper, computer, iPad, camera, iPhone, and Bridge Design Chart.

16.4 Technology

1. Computer Use: Do a Google search to find out about the different types of bridges and how they work. Write this information in the space provided. List your references in the reference section at the end of this lesson.

Beam Bridge Information: ______________________________

____

____

____

Truss Bridge Information: ______________________________

____

____

____

Suspension Bridge Information: ______________________________

____

____

____

Other Bridge Information: ______________________________

____

____

____

2. iPad Use: Use the Google Earth App on the iPad to locate and observe in detail various bridges such as the Golden Gate Bridge in California. Write the useful information (that you obtained) in the space provided.

Useful Bridge Information: ______________________________

____

16.5 Engineering

2. Identify Design Requirements

The bridge must span at least 6.5 in. (16.25 cm).

The bridge cannot be taped to a support structure (examples: table, books).

The bridge must have a spot in its center to hold a small plastic container (for the added washers).

Washers will be added to the bridge until it bends 1 in. from its original position or collapses, whichever comes first. The depth of bending can be measured with a ruler.

Materials are limited for this activity. No additional straws will be provided.

3. Design the Bridge: Make a pattern for your bridge. Draw a sketch or diagram of your bridge in the space provided. Use graph paper to draw a side, top, and bottom view of your bridge. Add dimensions (such as length and height) to your drawings.

4. Communicate the Selected Design: In order to share the bridge design with others, write a step by step procedure for making your bridge in the space provided. Keep in mind that you can cut the straws to desired lengths using scissors. Also you can connect straw sections together using tape.

Procedure

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

5. Implement the Design: Use the pattern to build the bridge.

6. Test the Product: Test the bridge.

16.6 Technology

3. Camera or iPhone Use: Use a camera or an iPhone to take photos of your bridge.

16.7 Mathematics

1. **Measurement**

   a. When building bridges, engineers must consider loads (which are weights and forces) that a structure must withstand. The dead load is the weight of the structure itself. Use a balance to determine the dead load (weight of the bridge). Record this value which can be expressed in ounces, pounds or Newtons. One Newton is about 0.22481 1b. Record this value on the Bridge Design Chart. The live load is the weight that is added to the bridge. For this activity it would be the weight of the plastic container and the added washers. Use a balance to determine the live load for your bridge. Add this value to the Bridge Design Chart.
   b. Count the number of washers that your bridge held and record this value on the Chart.

2. **Calculation**

   a. Determine the success of your bridge by solving the following equation.

      PERCENT OF WHOLE EQUALS PART

      (dead load) (live load)

      In other words:

      LIVE LOAD DIVIDED BY DEAD LOAD AND THEN MULTIPLIED BY 100 IS THE PERCENT OF THE BRIDGE WEIGHT THAT THE BRIDGE COULD HOLD (AS ALIVELOAD).

      Write your answer in the space provided. ______________________

16.8 Science

4. Analysis:

a.Was your hypothesis correct? ________________. How many washers did your bridge hold? ____________. Enter this value ony our Bridge Design Chart. Complete the Bridge Design Chart.

5. Conclusion:

a. Based on your overall results, write a concluding statement (in the space provided) about the success of your bridge. __________________________

____

____

b. If you had an opportunity to design another bridge, what would you do differently? ____

____

____

16.9 Bridge Design Chart

Type of bridge built: ______________________

Number of straw sections used for bridge: ______________________

Number of triangles included in the bridge: ______________________

Hypothesis (estimated number of washers held bybridge): ______________________

Actual number of washers held by bridge: ______________________

Dead Load(in ounces, pounds, or Newtons) ______________________

Live Load (in ounces, pounds, or Newtons) ______________________

QUESTIONS:

1. Did you build a successful bridge? ___________. Explain. ____________

____

2. Bridges are subject to stress. The download force (of the weight of the bridge itself) creates a stress called compression, which pushes a material together. Asecond type of stress is called tension, which pulls a material apart. How does the use of triangle sections affect the stress on a bridge? ___________

____

16.10 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to use a computer, etc. to obtain information about different types of bridges? (Hint: Check their list of references at the end of this lesson.)
2. Were the students able to design a bridge with a span of 6.5 in.?
3. Were the students able to build a successful bridge? (Hint: Did the bridge hold zero washers, a few washers, or many washers?)

16.11 Additional Activities

1. Repeat this activity by designing, building, and testing a modified and improved bridge.
2. Repeat this activity using different materials to make the bridge (examples: spaghetti, toothpicks).
3. More advanced students can calculate the internal force in truss bridge members that are arranged in interconnected triangles. They need to use vectors and concepts from Trigonometry.

References

1. (Students list their references.)

Chapter 17
Weather Watchers

17.1 Setting the Stage

Weather is the outside conditions at a given time and place in regards to temperature, moisture, wind, etc. A meteorologist is a scientist who studies the atmosphere. He or she makes observations and uses special tools to get data for making accurate weather forecasts.

This activity allows students to determine the weather conditions in their local community for a 4 week period. It also gives them an opportunity to design a creative weather map that displays their information.

17.2 Science/Engineering

1. Problem: What are the weather conditions for your local community during a 4 week period?

17.3 Science

2. Materials: Computer, iPad, iPhone, television, calculator, thermometer, barometer, rain gauge, Predicted Weather Data Chart, Actual Weather Data Chart, graph paper, colored pencils, markers, and poster board for the weather map.

Students determine the weather conditions in their local community for a 4 week period and design a creative weather map that displays their information.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
DOI 10.1007/978-3-319-19234-5_17

17.4 Technology

1. Computer Use: Do a Google search to find out information about the following weather tools and terms. Write your answers in the space provided. List your references in the reference section at the end of this lesson.

Information about Thermometers: ____________________________________

____

____

____

Information about Barometers: ____________________________________

____

____

Information about Rain Gauges: ____________________________________

____

____

Information about Anemometers: (Hint: You may also find simple instructions for making one.) ____

____

____

____

Information about Weather Maps: ____________________________________

____

____

Information about Clouds: Three general groups of clouds are cirrus, cumulus, and stratus. Cirrus clouds are highest in the sky. They appear wispy and thin and are mostly made of ice crystals. Stratus clouds are closest to the ground. They make the day look overcast and are mostly made of water droplets. Cumulus clouds are in the middle layers of the atmosphere and look like large patches of cotton. These clouds contain ice crystals and water vapor and are mostly associated with rain.

Other Cloud Information: ____

____

____

Information about Weather Fronts: Various weather fronts exist. Two of them are as follows. A Cold Front is a front in which cold air is replacing warm air at the surface. A Warm Front is a front in which warm air replaces cooler air at the surface.

Other Weather Front Information: _____________________________________

____

____

____

2. Television Use: Watch the Weather Channel on television to obtain a 7 day weather forecast for your local community. Do this each week for 4 weeks and record the temperatures and other information on your Predicted Weather Data Chart.

3. iPhone/iPad Use: Use the weather Apps on your iPhone/iPad to obtain a 7 day weather forecast for your local community. Do this each week for 4 weeks and record the temperatures and other information on your Predicted Weather Data Chart.

17.5 Science/Engineering

3/2. Data Collection: You have already obtained and recorded some weather forecast information on your Predicted Weather Data Chart. Now you must make some measurements and observations (of your own) each day for a 4 week period. (Try to make your measurements and observations at about the same time each day for the 4 week time period.) Record all of the information on your Actual Weather Data Chart.

General Instructions

1. Place a thermometer at a convenient location outdoors so that you can easily see it each day of the week for a 4 week period. Check the thermometer at the same time each day and record all of the temperatures (either in degrees C or F) on your Actual Weather Data Chart.
2. Place a rain gauge at a convenient location outdoors so that you can easily see it each day of the week for a 4 week period. If you do not have a rain gauge, then use a graduated cylinder or a calibrated container. Check the rain gauge (or your other calibrated item) at the same time each day. Record the type and amount of precipitation (either in fluid ounces, milliliters, or inches) on your Actual Weather Data Chart.
3. Use a barometer to obtain the barometric pressure (example: in millibars) each day of the week for a 4 week period. Check the barometer at the same time each day and record the data on your Actual Weather Data Chart.
4. Make observations each day of the week for a 4 week period. Ask yourself some questions like the following. Are there clouds in the sky? Is it windy? Is the Sun shining?

17.6 Mathematics

1. Calculations

a. Use a calculator to determine total sums and averages. Look at the predicted temperatures (from the television weather channel) for Week 1 on your Predicted Weather Data Chart. Then add the seven values together and divide the sum by 7 to determine the average (predicted) weekly temperature. Record the sum and the average weekly temperature for Week 1 on this Data Chart. Use the same calculations for Week 2, Week 3, and Week 4. Record the new sums and averages on the same Data Chart. Repeat this activity using the predicted temperatures (from the iPhone/iPad Apps).

b. Use a calculator to determine total sums and averages for data on your Actual Weather Data Chart. Use the same procedure described in **section a** to calculate the sums and weekly averages (Week 1, Week 2, Week 3, and Week 4) for the temperature, air pressure, and amount of precipitation. Add these values to this Data Chart.

2. Graphing

a. Make a graph showing the actual daily temperatures that you obtained during the 4 week period. The X-axis could represent the days (28 days during the 4 week period). The Y-axis could represent the temperature in either degrees F or C.

17.7 Science

4. Analysis

a. Look at both Data Charts. How do the predicted temperatures and information compare to the actual observations and measurements that you made?____

____

____

____

b. Look at your Actual Weather Data Chart. Which week had the most precipitation? ______________. Explain. ___________________________

____

____

5. Conclusion

a.Write a concluding statement about the weather conditions in your local community during the 4week period. ____________________________

____

____

17.8 Engineering

3. Design a Creative Weather Map to Display all of Your Actual Data Collected during the 4 Weeks: Write the procedure for designing your weather map in the space below. (Hint: Use the poster board and colored pencils and markers. Also include a key with symbols for your map.)

1. ____

2. ____

3. ____

4. ____

5. ____

6. ____

7. ____

8. ____

17.9 Weather Data Charts

PREDICTED WEATHER DATA CHART

	Temperature From TV	Other Info From TV	Temperature (FromiPad / iPhone)	Other Info

Week1

Monday____

Tuesday____

Wednesday____

Thursday ____

Friday ____

Saturday ____

Sunday ____

Sum: ____

Weekly Average: ____

Week 2

Monday ____

Tuesday ____

Wednesday ____

Thursday ____

Friday ____

Saturday ____

Sunday ____

Sum:____

Weekly Average:____

PREDICTED WEATHER DATA CHART

	Temperature From TV	Other Info From TV	Temperature (FromiPad /	Other Info iPhone)

Week3

Monday____

Tuesday____

Wednesday____

Thursday ____

Friday ____

Saturday ____

Sunday ____

Sum: ____

Weekly Average: ____

Week 4

Monday ____

Tuesday ____

Wednesday ____

Thursday ____

Friday ____

Saturday ____

Sunday ____

Sum:____

Weekly Average:____

ACTUAL WEATHER DATA CHART

Temperature **Air Pressure** **Precipitation** **Observations**

Week 1

Monday____

Tuesday____

Wednesday____

Thursday ____

Friday ____

Saturday ____

Sunday ____

Sum: ____

Weekly Average: ____

Week 2

Monday ____

Tuesday ____

Wednesday ____

Thursday ____

Friday ____

Saturday ____

Sunday ____

Sum:____

Weekly Average:____

ACTUAL WEATHER DATA CHART

Temperature **Air Pressure** **Precipitation** **Observations**

Week 3

Monday ______________________________

Tuesday ______________________________

Wednesday ______________________________

Thursday ______________________________

Friday ______________________________

Saturday ______________________________

Sunday ______________________________

Sum: ______________________________

Weekly Average: ______________________________

Week 4

Monday ______________________________

Tuesday ______________________________

Wednesday ______________________________

Thursday ______________________________

Friday ______________________________

Saturday ______________________________

Sunday ______________________________

Sum: ______________________________

Weekly Average: ______________________________

17.10 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to collect data during the 4 week period?
2. Were the students able to analyze their collected data in order to write a concluding statement about the weather conditions in their local community during the 4 week period?
3. Were the students able to design a weather map to display all of their collected data during the 4 week period?

17.11 Additional Activities

1. For a 2 week period make daily measurements and observations for your local community like you did in the previous activity. Then closely analyze the data and information that you collected. Next forecast (predict) the daily weather conditions in your local community for the next 2 weeks. Finally compare your weather forecasts to the actual weather conditions during those 2 weeks.
2. Repeat this activity during a different season of the year.

References

1. (Students list their references.)

Chapter 18
Delicious Drinks

18.1 Setting the Stage

People worldwide consume drinks on a daily basis. It may be a glass of water, milk, soda, tea, or some other beverage to complement a meal or quench a thirst. Some drinks are nutritious, while others contain lots of sugar and calories.

This activity provides an opportunity for students to design (create), make, and test their own drinks.

18.2 Science/Engineering

1. Problem: Each team of at least two students will obtain, wash, analyze, and use their senses to characterize 10 different fruits (oranges, lemons, pineapples, grapefruits, bananas, peaches, blueberries, strawberries, grapes, and coconuts) in terms of appearance, smell, taste, health benefits, etc. (If some of these fruits are not available, substitute them with fruits of your own choice.) Then ask the students to prepare some juice for each fruit using a juicer and a blender. Finally have them design (create) their best tasting nutritious drink by combining specific amounts of one or more of their already prepared fruit juices.

Problem posed as a question: What is the recipe for your best tasting nutritious drink?

Students design, prepare, and test their own drinks to determine the best tasting nutritious drink.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
DOI 10.1007/978-3-319-19234-5_18

18.3 Science

2. Hypothesis: Make an educated guess as to the types of fruit juices you will combine to make your delicious nutritional drink. Write your answer in the space provided.

____

3. Materials: 10 different fruits (oranges, lemons, pineapples, grapefruits, bananas, peaches, blueberries, strawberries, grapes, and coconuts), juicer, blender, strainer, labels and containers with covers for each juice type, measuring cups and measuring spoons of various sizes, regular spoon, plastic knife, box of small paper cups, computer, iPad, the Fruit Analysis Chart, the Fruit Juice Analysis Chart, and the Combined Fruit Juice Analysis Chart. Also if coconuts are used the instructor will need safety glasses, a screwdriver, hammer, and nail, in order to obtain the coconut juice (water).

18.4 Technology

1. Computer Use/iPad Use: Do a Google search to find out the health benefits and other information about the different fruits. You may also use the Apps on an iPad to obtain some data. Write all of the information in the space provided. List your references in the reference section at the end of this lesson.

Information about Oranges: ____

____

____

____

Information about Lemons:____

____

____

Information about Pineapples: ______________________________________

____

____

Information about Grapefruits: ______________________________________

____

____

Information about Bananas: ______________________________________

____

____

Information about Peaches: ______________________________________

____

____

Information about Blueberries: ______________________________________

____

____

Information about Strawberries: ____

____

____

Information about Grapes: ____

____

____

Information about Coconuts: ____

____

____

18.5 Science/Engineering

4/2. Data Collection: Start by obtaining and washing all of the fruit samples. Then use your senses to characterize the fruits in regards to appearance, smell, taste, etc. Record all of the information on your Fruit Analysis Chart.

Next prepare a juice for each fruit. Pour a small sample of each juice type into a paper cup. Label all of the cups. Then characterize each fruit juice in regards to appearance, smell, taste, etc. Record all of the information on your Fruit Juice Analysis Chart.

General Instructions for Preparing Fruit Juices

1. Wash all fruit before starting this activity.
2. Have containers with covers and labels available for identifying and storing each juice. If juices are to be kept for a period of time, then they should be refrigerated.
3. Do the following to make grapefruit, orange, and lemon juice. First cut the fruit in half. Then remove the seeds. Finally squeeze by hand using a plain juicer. The fruit half is placed over the top of the juicer and squeezed by hand. Prepare and save as much juice as needed.

4. If the coconut is to be used as one of the fruits, then the instructor should wear safety glasses, be cautious, and do the following. First place the coconut on a hard, non slippery surface, such a wood. Then puncture two of the eyes of the coconut with a screwdriver. If the screwdriver does not work, then use a hammer and nail. Tap and rotate the coconut while its juice pours into a container. Obtain and save the desired amount of coconut juice (water).

18.6 Technology

2. Use of a Blender: Use a blender to prepare banana, peach, blueberry, strawberry, pineapple, and grape juice. Start by washing the fruit and by removing stems (from the berries, grapes, etc.), pits (from the peaches), and skins (from the bananas and pineapples). Make each fruit juice separately. To make banana juice place 1 banana with 1 cup of water into a blender and blend at the medium setting for about 1 min. For the other fruit juices, place small pieces of fruit (cut with a plastic knife) into the blender with about one-half cup water. Blend at the medium setting for 1–3 min as needed. If desired, pour each juice through a strainer to remove the skins (for example, from the grapes and peaches) and to make the drink less chunky. Prepare and save as much of each juice that is needed.

18.7 Engineering

3. Identify Design Requirements

The designed (newly created) drink must be prepared by combing specific amounts of one or more of the already prepared fruit juices.

The designed (newly created) drink must be delicious.

The designed (newly created) drink must be nutritious.

4. Generate Possible Solutions to the Problem: Start by closely looking over the data on your Fruit Analysis and Fruit Juice Analysis Charts. Then decide on three different possible fruit juice combinations for your best tasting nutritious drink. Also estimate the amounts to be used for each component of your three possible fruit juice combinations. For example, one possibility might include 50 % orange juice and 50 % strawberry juice. Write the information for your three possible solutions (of fruit juice combinations) in the space provided.

Information about the First Possible Fruit Juice Combination Drink:__________

____

____

Information about the Second Possible Fruit Juice Combination Drink: ________

____

____

____

Information about the Third Possible Fruit Juice Combination Drink: ________

____

____

18.8 Mathematics

1. **Measurement**

a. Use the calibrated measuring spoons and cups, etc. to prepare your three possible best tasting nutritious drinks (from the existing fruit juices that you have already prepared). Use a regular spoon that is clean to thoroughly stir each possible best drink. Store each of your 3 drinks in a covered container that is labeled. Record the components and the amounts of each (used to prepare your 3 possible best tasting nutritious drinks) on your Combined Fruit Juice Analysis Chart.

18.9 Engineering

5. Evaluate the Alternatives: Pour a small sample of the 3 potential best drinks into separate paper cups. Label each cup. Use your senses to characterize the 3 potential best drinks in regards to appearance, smell, taste, etc. Record this information on the Combined Fruit Juice Analysis Chart.

6. Select the Best Approach (design for creating the best tasting nutritious drink): In the space provided write the recipe for making your best tasting nutritious drink.

____

____

____

18.10 Science

5. Analysis

a. Was your hypothesis correct? ________________. Explain. ______________

____

____

6. Conclusion

a. Based on your overall results, write a concluding statement to describe your best tasting nutritious drink. ____

____

b. If you had an opportunity to design (create) another best tasting nutritious drink, what would you do differently? ____

____

18.11 Analysis Charts

FRUIT ANALYSIS CHART

FRUIT	APPEARANCE	SMELL	TASTE	OTHER INFORMATION
Orange				
Lemon				
Pineapple				
Grapefruit				
Banana				
Peach				
Blueberry				
Strawberry				
Grape				
Coconut				

FRUIT JUICE ANALYSIS CHART

FRUIT JUICE	APPEARANCE	SMELL	TASTE	OTHER INFORMATION
Orange				
Lemon				
Pineapple				
Grapefruit				
Banana				
Peach				
Blueberry				
Strawberry				
Grape				
Coconut				

COMBINED FRUIT JUICE ANALYSIS CHART

Juice Combination & the Amount of Each Juice in Ounces or Milliliters	Appearance	Smell	Taste	Other Information
First Potential Best Tasting Nutritious Drink				
Second Potential Best Tasting Nutritious Drink				
Third Potential Best Tasting Nutritious Drink				

18.12 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to use their senses (smell, taste, etc.) to characterize the various fruits and fruit juices? (Hint: Check their Analysis Charts.)
2. Were the students able to generate three possible solutions to the problem (preparing the best tasting nutritious drink)?
3. Were the students able to write the recipe to make their best tasting nutritious drink?

18.13 Additional Activities

1. Repeat this activity by using different fruits.
2. Repeat this activity by using different vegetables to create the best tasting nutritious vegetable juice.

References

1. (Students list their references.)

Chapter 19
Personal Project

19.1 Setting the Stage

For this activity you can be creative and solve a problem that is of interest to you. Start by brainstorming to come up with some interesting topics and ideas. If more ideas are needed, then search the Internet and look at books and magazines, etc. Select your favorite topic and decide what you want to know about it. Then form a question to answer, which is actually the problem that you want to solve. Be certain that the needed materials and resources are available to carry out the investigation. Get approval from your instructor, who should check your setup before you begin this activity. Be safe and follow the instructor's safety rules.

Below is a sample topic and problem to solve.

Sample Topic: Music
Sample Problem: How can water be used to make musical sounds?

This activity provides students with an opportunity to select and solve a problem that is of interest to them.

19.2 Science/Engineering

1. **Problem:** Write the problem that you want to solve in the form of a question. Use the space provided. ____

____

Students select and creatively solve a problem that is of interest to them.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
DOI 10.1007/978-3-319-19234-5_19

19.3 Science

2. Hypothesis: If you are able to make an educated guess for the answer to your problem, then write the answer in the space provided.

____

3. Materials: List all of the materials, resources, equipment, etc. needed to carry out your investigation. ______________________________________

____

____

19.4 Technology

1. Computer Use/iPad Use: Search the Internet and use Apps on your iPad, etc. to obtain useful information to help solve your problem. Write it in the space provided.

List your references in the reference section at the end of this lesson.

Useful Information: ____

____

____

____

____

____

____

19.5 Mathematics

1. Measurement

a. In order to collect data you need to make some measurements. Describe (in the space provided) the types of measurements that you will make during this activity. ____

____

____

____

2. Calculations

a. At some point during this lesson you will make some calculations like determining sums, averages, percents, etc. Describe (in the space provided) the types of calculations thatyou will make during this investigation. ____

____

____

____

19.6 Science/Engineering

4/2. Data Collection: In order to solve the problem you need to collect data during your investigation. Record this information on a labeled Data Chart. Draw a labeled sketch of your Data Chart in the space provided.

Labeled Data Chart Sketch

19.7 Engineering

3. Design a Creative Plan (for carrying out the investigation): Write the steps for your plan in the space provided.

1. ____

2. ____

3. ____

4. ____

5. ____

4. Implement the Design (your creative plan): Use this creative plan to carry out your investigation.

19.8 Science

5. Results:

a. Was your hypothesis correct? ______________. Explain. __________

____

6. Conclusion:

a. What can you conclude after carrying out this investigation?

____

____

____

Additional Information

If you have more information to share, then write it in the space provided. ____

19.9 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to select a problem to solve?
2. Were the students able to design a plan or model for carrying out their investigation?
3. Were the students able to collect data? (Hint: Check their Data Chart.)

19.10 Additional Activities

1. If you have an opportunity to repeat this activity, what would you do differently? Get the approval of your instructor and then carry out your modified investigation.
2. If you could select another topic and problem to solve, what would they be? Get approval from your instructor and then carry out your new investigation.

References

1. (Students list their references.)

Part IV
STEM Activities in the Virtual World

The format for each activity in this section differs from those carried out in Part III (the real-world activities). They all involve information and communication technology (ICT), have a problem to solve, contain methods for student assessment, and include science, technology, engineering, and mathematics. The activities give students, especially those between the ages of 16 and 20 years, opportunities to design and carry out investigations (in the virtual world) as creative problem solvers. This part of the book also discusses STEM Education in video-sharing websites and online courses for STEM Education, based on Massive Open Online Courses (MOOCs).

Chapter 20
Mars Simulation Mission

20.1 Setting the Stage

Mars, the Red Planet, is the most Earth-like of the planets. It has inspired authors and composers and motivated scientists to search for life there. In the Mars Exploration Rover Mission, two rovers (named Spirit and Opportunity) landed on Mars in 2004 to search for clues about past water activities. Later a rover called Curiosity landed on Mars in 2012. These rovers carry cameras and equipment to gather samples of rocks and soil.

This activity provides an opportunity to launch a rocket and land a spacecraft (at a previously selected position) on Mars, a virtual terrain. Students carefully control and move their rovers across the surface of Mars to avoid crashing into boulders. Also they obtain information (based on data from real Mars Missions) about the Martian soil, rocks, and atmosphere by using instruments and cameras aboard their rovers.

20.2 Science/Engineering

1. Problem: Each student (or team of two individuals) will start this activity by launching a rocket and landing a spacecraft at a selected position on Mars, virtual terrain. Then they will move their rovers across the planet's surface and use the cameras and instruments on board to obtain information about the Martian soil, rocks, and atmosphere.

Students launch a rocket and then strategically land his or her spacecraft (at their own previously selected position) on Mars, a virtual terrain. They carefully control and move their rovers across the surface of Mars to obtain information about the Martian soil, rocks, and atmosphere, by using instruments and cameras aboard their rovers.

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Problem posed as a question: What did you find out about the Martian soil, rocks, and atmosphere?

20.3 Science

2. **Hypothesis:** Make an educated guess about the types of soil, rocks, and atmosphere on Mars. Write your answer in the space provided. ___________

____

3. Materials: Computer, special software, iPad, map of Mars (that displays latitude and longitude), and the Mars Mission Data Collection Chart.

Note: This activity (which is based on Space Explorers' Mars Simulation Mission) was performed by students in the United States and Japan [1–4]. They used special software available at the Space Explorers' website (www.space-explorers.com). Classes can use this website or do a Google search to find other available Mars Mission Simulations. Procedures may vary depending on the chosen simulation.

20.4 Technology

1. Computer Use/iPad Use: Use a computer and virtual terrain for the Mars Mission Simulation. If you are not involved with the Space Explorers' Program, then do a Google search (using a computer or iPad) to locate other available Mars Mission Simulations. List their websites in the space provided. Then select one and participate in a Mars Mission Simulation.

Websites for available Mars Mission Simulations: ______________________

____

____

____

20.5 Mathematics

1. **Measurement**

   a. Select coordinates in advance for your spacecraft's special landing site on Mars. Use a map of the planet that displays latitude and longitude. Note the name or close proximity of this location on Mars. Write this information in the space provided and the Mars Mission Data Chart.

   ____

   ____

   b. You will measure the amount of energy used to move your rover over the surface of Mars. It might be expressed in Sols, Solar days.
   c. You will use instruments aboard the rover to measure the amounts of gas and other chemicals encountered in the Martian environment. Remember to record all information on the Mars Mission Data Collection Chart.

20.6 Science/Engineering

4/2. Data Collection

a. Control and carefully move your rover over the virtual terrain (of Mars) that contains soil and large boulders. Conserve energy because you will have a limited amount of fuel. Note the number of times that you refuel the rover and determine the total amount of energy (fuel) consumed. Write these values on the Data Chart.
b. Use the camera, various spectrometers, and other available instruments (aboard the rover) to obtain data about the Martian rocks, soil, and atmosphere. For example, the Thermal Emission Spectrometer provides temperature profiles of the Martian atmosphere and the Alpha Particle X-Ray Spectrometer analyzes the abundance of elements that make up rocks and soils. Record all of the information on your Mars Mission Data Collection Chart. Complete the Chart and closely examine its contents.

20.7 Science

5. Analysis:

a. Was your hypothesis correct? _______. Explain. _______________

____

6. Conclusion:

a. Based on your overall mission experience, write (in the space provided) a description of Mars that includes information about the Martian soil, rocks, and atmosphere.

____

____

____

20.8 Mars Mission Data Collection Chart

1. Coordinates (latitude & longitude values) for rover's landing site on Mars: __

2. Name of rover's landing location (ex. Gale Crater) on Mars: ______________

3. Number of times that your rover was refueled: _________________

4. Total amount of fuel consumed by rover during the Mars Mission Simulation: _______

5. For this section list the instruments used during the simulation and the information obtained from them.

Instrument Used	**Data Obtained**
a. _________________	_____________________________________
b. _________________	_____________________________________
c. __________________	______________________________________
d. __________________	______________________________________
e. __________________	______________________________________
f. ___________________	______________________________________
g. ___________________	______________________________________

6. List information about the Martian soil. _______________________________

____

7. List information about the Martian rocks._____________________________

____

8. List information about the Martian atmosphere. _______________________

____

9. List additional information that you obtained during the mission simulation. ________

____

20.9 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to land their rovers at the predetermined location on Mars?
2. Were the students able to control and move their rovers over the Martian surface?
3. Were the students able to use instruments aboard their rovers to obtain information about the soil, rocks, and atmosphere of Mars? (Hint: Check their Mars Mission Data Collection Charts and Conclusions.)

References

1. Kanematsu, H., & Barry, D. M. (2008). Creative Space Exploration Project for Engineering Design. In *Proceedings of the JSEE Annual Conference, the International Session, Kobe, Japan* (August, 2008).
2. Kanematsu, H., Shibagaki, K., & Barry, D. M. (2008). Space Explorers Project and Engineering Design. In *The Education Report of National Colleges Subcommittee*, Tokai Association of Engineering Education, No. 2 (pp. 31–32).
3. Kanematsu, H., & Barry, D. M. (2007). World First Marslink Mission as Educational Material for Design Skills—as a PBL Class. In *Conference Proceedings paper of Japan's Society for Engineering Education,* 250.
4. Barry, D. (2005). World first marslink mission participants learn and enjoy science. *The Science Education Review, 4*(3).

Chapter 21
Eco Car Problem-Based Learning Project in Second Life

21.1 Setting the Stage

Problem-Based Learning (PBL) is important for engineering education as well as for creative engineering design. It provides students with challenging, ill-structured problems that relate to their daily lives. The students receive guidance from their instructors and work cooperatively in a group to seek solutions to the problems. PBL has been used to successfully carry out many experiments in the real world and is beneficial in the virtual world too. The virtual world is especially desirable for solving problems that are too dangerous, too time consuming, and too expensive for the real world. For example, it is ideal to use with a class project that requires the designing and building of safe, economical cars (eco cars) of the future. Student teams from the United States and Japan separately tackled this problem. They managed to design and build eco cars in Second Life (a three-dimensional virtual community) by using virtual objects called primitives [1–3].

This activity provides an opportunity for students to design and build cars, that are safe and energy efficient, by using primitives in Second Life (SL).

21.2 Science/Engineering

1. Problem: Each team of at least two students will design and build a safe, economical car (eco car) of the future in SL using primitives (three-dimensional virtual objects such as cubes). Participants will communicate with each other (through their avatars) by using the speech and/or chat functions available in SL. Also they will perform various other functions so that their avatars can carry out

Students design and build cars, that are safe and energy efficient, using primitives in Second Life (SL).

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
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required tasks on behalf of them. In computing, an avatar is generally a figure representing a particular person or a graphical representation of the user.

Problem posed as a question: What type of car will you design and build in Second Life as your safe, economical car (eco car) of the future?

NOTE: This investigation requires students to have registered avatars for SL and to perform various functions so their avatars can carry out tasks on behalf of them. Tutorials are available in SL as well as special locations to practice making prims (which are also called primitives). The ideal situation for instructors is to have virtual classrooms (resembling those in real life with tables and chairs, etc.) for lectures and brainstorming sessions. However, if these are not available, then modify this activity to complement the learning environment that you have.

Students need to complete the Eco Car Information Chart!

21.3 Science

2. Materials: computer, special software for SL, microphones, headsets, Bamboo Fun (pen and touch tablet) by Wacom, and the Eco Car Information Chart.

21.4 Technology

1. Computer Use: The computer provides an electronic learning environment. To start, the participants' avatars (of both students and instructors) meet in a designated area of SL to discuss the project. They communicate by using the speech and/or chat functions available there. The speech option requires that a microphone and headset be hooked up to each personal computer. The chat function is similar to writing text messages.

The teacher poses the following problem to the student teams. What type of car will you design and build in Second Life as your safe, economical car (eco car) of the future? Then he or she gives a short lecture about existing car types such as solar and fuel cell cars. The students also do a Google search to obtain additional information about various cars in regards to safety, energy efficiency, and ecological friendliness.

They should write this information, along with the websites, in the space provided and add it to the Eco Car Information Chart.

Solar Car Information:____

____

____

____

Fuel Cell Car Information: ____

____

____

Other Car Information: ____

____

____

The student teams, with guidance from their instructor(s), hold several brainstorming sessions in the virtual world to decide what car type is the best and how to build it. Then specific tasks are assigned to each participant. Their avatars also travel to special locations in SL (such as Natoma and the Ivory Tower) to practice making primitives, which are needed for constructing virtual cars.

21.5 Engineering

2. Identify Design Requirements:

What type of eco car will you build? ____________________________

What are the required dimensions of your eco car in inches?

Length: _________________

Width: _________________

Height: _________________

Are there other design requirements? ____________ . Explain. ____________

____

21.6 Engineering/Technology

3/2. **Design the Eco Car**: Make a sketch of your eco car by using the special pen and tablet (that attaches to your computer) along with the Bamboo software. If they are not available, then prepare the drawing on a piece of paper or graph paper. Be certain to include a scale that represents your car's dimensions such as length and height. Draw a simple sketch or diagram of your eco car in the space provided.

Eco Car Sketch

4/3. **Communicate the Selected Design**: Share the sketch of your eco car at a website that is common to all participants. You might need to scan it first and then save it as a pdf or png file.

5/4. **Implement the Design**: Refer to the sketch as you and your team build the eco car with primitives in a designated area of SL.

21.7 Mathematics/Technology

1/5. **Measurement**: Each team member has already been assigned certain tasks for building the eco cars in SL with prims (primitives). Primitives are three dimensional virtual objects that can have different shapes (example: cubes), color, sizes, textures, etc. Measurements are made in this electronic learning environment to determine the length, height, and width of each prim. Record your information in the space provided.

2/6. **Calculations**: Mathematical calculations are made to prepare primitives (using tools available in SL) with unique shapes, color, textures, etc. These special primitives are then used to build the creative eco cars of the future. In the space provided describe the mathematical calculations made to prepare primitives for building your eco car.

____

____

____

____

21.8 Technology

7. **Camera Use in SL**: Use the camera available in SL to take photos of your virtual car (eco car). Then email the photos to yourself and save them as jpeg files. Print out some hard copies too.

21.9 Science

3. **Conclusion**

a. What are the benefits of the eco car that you designed and built in the virtual world? ____

____

b. If you had an opportunity to design another eco car, what would you do differently? ____

____

NOTE: Complete the Eco Car Information Chart.

21.10 Eco Car Information Chart

(Answer all of the questions below.)

1. Where did you carry out the eco car activity in SL? ____________________

____

2. Did you communicate in SL by using speech, chat, or both functions? _____

3. Did your avatar travel to various locations in SL to practice making prims? __________ If your answer is yes, then list the places in the space provided. ____

4. List the car types that you considered for your eco car.

List the benefits of each.

______________________	____________________
______________________	____________________
______________________	_____________________
______________________	_____________________

5. Write a brief description of your eco car built in SL. Include dimensions, color, texture, primitive shapes used, etc. Also list the benefits of this car in terms of safety, energy efficiency, and ecological friendliness. ___________________

____

____

6. What was the easiest function to carry out in SL? Select one of the following. Communication, Avatar Movement (like walking), Teleporting Avatars to places in SL, or Making Prims (primitives) : ___________________________

7. What was the most difficult function to carry out in SL? Select one of the following. Communication, Avatar Movement (like walking), Teleporting Avatars to places in SL, or Making Prims (primitives): ____________________

8. What are the advantages of performing this activity in SL instead of using the real world? ____

21.11 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to perform various functions in SL so that their avatars could carry out tasks on behalf of them?
2. Were the students able to communicate effectively in SL?
3. Were the students successful at designing and building eco cars in SL by using prims (primitives)? Hint: Check their sketches and their finished products (the virtual cars).

References

1. Barry, D.M., Kanematsu, H., Fukumura, Y., Kobayashi, T., Ogawa, N., & Nagai, H. (2014). Problem-based learning activities in second life. *International Journal of Modern Education Forum, 3*(1).
2. Kanematsu, Hideyuki, Kobayashi, Toshiro, Ogawa, Nobuyuki, Barry, Dana M., Fukumura, Yoshimi, & Nagai, Hirotomo. (2013). Eco car project for Japan students as a virtual PBL class. *Procedia Computer Science, 22*, 828–835.
3. Barry, D.M., Kanematsu, H., Fukumura, Y., Kobayashi, T., Ogawa, N., & Nagai, H. (2012). Problem based learning for US and Japan students in a virtual environment. In T. Watanabe et al. (Eds.), *Intelligent Interactive Multimedia Systems & Services, SIST 14* pp. 479–488. Berlin: Springer.

Chapter 22
International Discussions Held in Second Life Using One's Native Language

22.1 Setting the Stage

Second Life (SL) is a virtual environment where synchronous e- learning and international discussions can take place. It is a three-dimensional virtual community provided by Linden Research, Inc. in San Francisco, California. Students communicate with each other there (through avatars) by using the speech and/or chat functions available. Also they perform other functions so their avatars can carry out required tasks on behalf of them. In computing, an avatar is generally a figure representing a particular person or a graphical representation of the user. See Fig. 22.1 [1].

Second Life provides a virtual setting where individuals from different countries can meet and hold discussions. Their hardest obstacle is the language barrier.

Students from Japan, Korea, and the United States, met in SL and successfully communicated with each other in their own language (Japanese, Korean, and English) by using special translation software [2–4]. Before carrying out this project, virtual classrooms were built in SL on an island owned by Nagaoka University of Technology, Japan. Each room included the chat function (text messages), recording systems, and web-coupled functions for storing and displaying chat conversations. Also a language grid system was incorporated into the virtual environment so that students could communicate with each other in their own language by using a translation system. The language grid is a multi-lingual service infrastructure, where people can share language resources such as dictionaries.

This international project included instructors (from each country) who served as facilitators. It also involved three teams, each with one student from Japan, Korea, and the United States. The three-member teams met in separate classrooms (on

Students from Korea, Japan, and the United States use special software in SL that allows them to chat with each other about various topics using their own languages: Korean, Japanese, and English.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
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Fig. 22.1 A group of avatars conversing with each other in SL

Japan's virtual island in SL) to discuss different topics. One group discussed music, another talked about sports, while the third team chatted about movies. The students sat in special chairs (containing translation software) to communicate with each other in their own language by using the chat function. Green chairs were used by students from the U.S., Korean students sat in red chairs, and the Japanese students occupied the yellow ones. The three languages were translated simultaneously. For example, when a Japanese student spoke, his/her words were translated into Korean and English. All three languages were displayed on the computer screen at the same time. This was a successful and enjoyable activity in SL. Students from Japan, Korea, and the United States learned about each country's favorite sports, songs, and movies, by communicating in their own language.

NOTE: Because the Asian countries are about 14 h ahead of the United States, the U.S. students entered the virtual classrooms at about 6.00 p.m., while the Japanese and Korean students arrived at about 8:00 a.m. their time the next morning.

This activity provides an opportunity for students from different countries to communicate with each other in SL by using their own language.

22.2 Science/Engineering

1. Problem: Each team of at least two students (from different countries) will meet in SL and discuss various topics using their own language.

Problem posed as a question: Will students from different countries be able to communicate with each other in SL by using their own language?

NOTE: This investigation requires students to have registered avatars for SL and to perform various functions so their avatars can carry out tasks (such as walking and communicating) on behalf of them. Tutorials are available in SL. The ideal situation for instructors is to have virtual classrooms (resembling those in real life with tables and chairs) for discussions. Also translation software is needed so students from different countries can communicate by using their own language. However, if these are not available, then modify this activity to complement the learning environment that you have.

Students need to complete the International Discussion Chart!

22.3 Science

2. **Materials**: computer, special translation software for SL, systems for recording, storing, and displaying chat conversations, and the International Discussion Chart.

22.4 Technology

1. **Computer Use**: The computer provides an electronic learning environment. To start, the participants' avatars (of both students and instructors) gather in a designated area of SL to discuss the project. They communicate there by using the chat function, which is similar to writing text messages. Then the instructor(s) divides the students into groups. Each group contains one representative from every participating country. Next the groups are assigned separate places to meet and one of the following discussion topics: movies, music, sports, and food. The teachers (from each participating country) act as facilitators and encourage the group members to introduce themselves and to discuss the assigned topic as it relates to their country. For example, in the category of sports, students from Japan and the U. S. might talk about baseball. A goal of this activity in SL is for the participants to learn about each other's country by communicating in their own language. Please allow about 45 min for the group discussions.

NOTE: This activity requires the use of translation software. If it is not available, then another option is to have the international students communicate in English.

22.5 Mathematics

1. Calculations:

Record the total number of student participants for this activity (for all groups): ____________, for just your group: ________

Record the total number of participating male students (for all groups): ______, for just your group: _______________
Record the total number of participating female students for this activity (for all groups): ____, for just your group: _____________

Use the following formula to calculate percent.
Percent times the total number equals the part.
% of total = part

a. What percent of all the student participants were female? ______________
b. What percent of all of the student participants were male? ______________
c. What percent of all the female participants (students) were in your group? ______________

d. What percent of all the male participants (students) were in your group? ______________

22.6 Science

3. Conclusion:

a. Were you able to communicate with the members of your group in SL by usir your own language? _________ Explain. _____________

b. Did you learn anything about another country? _______. Explain.

____

____

NOTE: Complete the International Discussion Chart.

22.7 International Discussion Chart

(Answer all of the questions below.)

1. What countries were represented in your group? ______________________

____

2. What percent of all the female participants (students) were in your group?

____

3. What percent of all the male participants (students) were in your group?

____

4. What languages were used for your group discussion in SL?
a. ____
b. ____
c. ____
d. ____

5. What topic did your group discuss? ___________________

6. Were you able to communicate effectively in SL (with the group members) while using your own language? ____________. Explain. ___________

7. Did you learn anything about another country through your discussion in SL? ________________

Explain. ____

8. If you had a choice, what countries would you include in the group discussion? ____

9. If you had a choice, what topic would you talk about in your group discussion?

____

10. What is your overall reaction to this activity in SL? _____________________

22.8 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to perform various functions in SL so that their avatars could carry out tasks on behalf of them?
2. Were the students able to communicate effectively in SL with the group members by using their own language? (Hint: Did they contribute to the group discussion?)
3. Did the students learn about another country by communicating in SL with group members using their own language? (Hint: Check their answers on the International Discussion chart.)

References

1. Hyacinthe, L. (File: Second Life 11th Birthday Live Drax Files Radio Hour). CC BY–SA 3.0. It is available in Wikimedia Commons in the category of *Avatars from Second Life*.
2. Kanematsu, H., Fukumura, Y., Barry, D. M. Sohn, S. Y., & Taguchi, R. (2010). Multilingual Discussion in Metaverse among Students from the USA, Korea, and Japan. In *KES 2010, Part IV, LNAI 6279,* (pp. 200–209). Berlin: Springer.
3. Kanematsu, H., Fukumura, Y., Barry, D. M. Sohn, S. Y., Taguchi, R., & Arturo, N. R. R. (2010). Conversation Analysis of PBL in Metaverse for Students from the USA, Korea, and Japan. In *Proceedings of the International Conference on Engineering Education ICEE-2010,* Gliwice, Poland (July 2010).
4. Kanematsu, H., Fukumura, Y., Barry, D. M. Sohn, S. Y., Taguchi, R., & Sahar Farjami (2010). Virtual Classroom Environment for Multi-Lingual Problem-Based Learning with US, Korean, and Japanese Students. In *Proceedings of 2010 JSEE Annual Conference*, Tohoku, Japan (Aug 2010).

Chapter 23
Virtual House of the Future During the Global Warming Era

23.1 Setting the Stage

Problem-Based Learning (PBL) is important for engineering education as well as for creative engineering design. It provides students with challenging, ill-structured problems that relate to their daily lives. The students receive guidance from their instructors and work cooperatively in a group to seek solutions to the problems. PBL has been used to successfully carry out many experiments in the real world and is beneficial in the virtual world too. The virtual world is especially desirable for solving problems that are too dangerous, too time consuming, and too expensive for the real world. For example, it could be used as a location for designing and building structures such as bridges, large buildings and houses. Student teams from the United States and Japan separately tackled the following problem. What will the typical house look like in the near future during the Global warming period? They managed to design and build their houses in Second Life (a three-dimensional virtual community) by using virtual objects called primitives [1–3].

This activity provides students with an opportunity to design and build houses (that are energy efficient and environmentally friendly) using primitives (prims) in Second Life (SL).

23.2 Science/Engineering

1. Problem: Each team of at least two students will design and build the typical house of the future in SL using primitives (three-dimensional virtual objects such as cubes). Participants will communicate with each other (through their avatars) by

Students design and build environmentally friendly houses for the future using primitives in SL.

H. Kanematsu and D.M. Barry, *STEM and ICT Education in Intelligent Environments*, Intelligent Systems Reference Library 91,
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using the speech and/or chat functions available in SL. Also they will perform various other functions so that their avatars can carry out required tasks on behalf of them. In computing, an avatar is generally a figure representing a particular person or a graphical representation of the user.

Problem posed as a question: What type of house (for the future during the Global warming period) will you design and build in Second Life?

NOTE: This investigation requires students to have registered avatars for SL and to perform various functions so their avatars can carry out tasks on behalf of them. Tutorials are available in SL as well as special locations to practice making prims (which are also called primitives). The ideal situation for instructors is to have virtual classrooms (resembling those in real life with tables and chairs, etc.) for lectures and brainstorming sessions. However, if these are not available, then modify this activity to complement the learning environment that you have.

Students need to complete the Virtual House Information Chart!

23.3 Science

2. Materials: computer, special software for SL, microphones, headsets, Bamboo Fun (pen & touch tablet) by Wacom, and the Virtual House Information Chart.

23.4 Technology

1. Computer Use: The computer provides an electronic learning environment. To start, the participants' avatars (of both students and instructors) meet in a designated area of SL to discuss the project. They communicate by using the speech and/or chat functions available there. The speech option requires that a microphone and headset be hooked up to each personal computer. The chat function is similar to writing text messages.

The teacher poses the following problem to the student teams. What type of house will you design and build in Second Life as the typical house of the future during the Global warming period? Then he or she gives a short lecture about ways to conserve energy, like using solar panels on houses. The students also do a Google search to obtain additional information about conserving energy and environmentally friendly approaches for building houses.

They should write this information, along with the websites, in the space provided and add it to the Virtual House Information Chart.

The Use of Solar Panels on Houses :
____

____

____

____

Other Information:______________________________________

____

____

____

____

The student teams, with guidance from their instructor(s), hold several brainstorming sessions in the virtual world to decide what type of house is the best and how to build it. Then specific tasks are assigned to each participant. Their avatars also travel to special locations in SL (such as Natoma and the Ivory Tower) to practice making primitives, which are needed for constructing virtual houses.

23.5 Engineering

2. Identify Design Requirements:

What type of virtual house will you build? ______________________________

What are the required dimensions of your virtual house in inches?

Length: __________________

Width: ___________________

Height: ___________________

Are there other design requirements? ________________. Explain. _________

____

23.6 Engineering/Technology

3/2. **Design the Typical House of the Future**: Make a sketch of your typical house of the future by using the special pen and tablet (that attaches to your computer) along with the Bamboo software. If they are not available, then prepare the drawing on a piece of paper or graph paper. Be certain to include a scale that represents the dimensions of your house such as length and height. Draw a simple sketch or diagram of your virtual house in the space provided.

Sketch of Virtual House

4/3. **Communicate the Selected Design**: Share the sketch of your virtual house at a website that is common to all participants. You might need to scan it first and then save it as a pdf or png file.

5/4. **Implement the Design**: Refer to the sketch as you and your team build the typical house of the future with primitives in a designated area of SL.

23.7 Mathematics/Technology

1/5. **Measurement**: Each team member has already been assigned certain tasks for building the virtual houses in SL with prims (primitives). Primitives are three dimensional virtual objects that can have different shapes (example: cubes), color, sizes, textures, etc. Measurements are made in this electronic learning environment to determine the length, height, and width of each prim. Record your information in the space provided.

____

____

____

2/6. **Calculations**: Mathematical calculations are made to prepare primitives (using tools available in SL) with unique shapes, color, textures, etc. These special primitives are then used to build the energy efficient houses of the future. In the space provided describe the mathematical calculations made to prepare primitives for building your house of the future.

____
____
____
____

23.8 Technology

7. **Camera Use in SL**: Use the camera available in SL to take photos of your virtual house. Then email the photos to yourself and save them as jpeg files. Print out some hard copies too.

23.9 Science

3. **Conclusion**

a. What are the benefits of the house that you designed and built in the virtual world? ______________________________________

____

b. If you had an opportunity to design another house, what would you do differently? ____

____

NOTE: Complete the Virtual House Information Chart.

23.10 Virtual House Information Chart

(Answer all of the questions below.)

1. Where did you carry out this activity in SL?___________________

____

2. Did you communicate in SL by using speech, chat, or both functions? _____________

3. Did your avatar travel to various locations in SL to practice making prims?__ If your answer is yes, then list the places in the space provided._________

____

4. List the house types that you considered for your typical house of the future.	List the benefits of each.
_______________________	_____________________
_______________________	_____________________
_______________________	_____________________

5. Write a brief description of your typical house of the future built in SL. Include dimensions, color, texture, primitive shapes used, etc. Also list the benefits of this house in terms energy efficiency, and environmental friendliness.

____

____

____

6. What was the easiest function to carry out in SL? Select one of the following. Communication, Avatar Movement (like walking), Teleporting Avatars to places in SL, or Making Prims (primitives):__________________

7. What was the most difficult function to carry out in SL? Select one of the following. Communication, Avatar Movement (like walking), Teleporting Avatars to places in SL, or Making Prims (primitives): __________________

8. What are the advantages of performing this activity in SL instead of using the real world?____

23.11 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to perform various functions in SL so that their avatars could carry out tasks on behalf of them?
2. Were the students able to communicate effectively in SL?
3. Were the students successful at designing and building typical houses of the future in SL by using prims (primitives)? Hint: Check their sketches and their finished products (the virtual houses).

References

1. Barry, D. M., Kanematsu, H., Fukumura, Y., Kobayashi, T., Ogawa, N., & Nagai, H. (2014). Problem-Based Learning Activities in Second Life. In *International Journal of Modern Education Forum, 3*(1).
2. Barry, D.M. & Kanematsu, H. (2010). International collaboration: Creative engineering design program between the US and Japan. In *Innovations 2010.* International Network for Engineering Education and Research.
3. Barry, D. M., Kanematsu, H., Fukumura, Y., Ogawa, N., Okuda, A., Taguchi, R., & Nagai, H. (2009). Problem Based Learning Experiences in Metaverse and the Differences between Students in the US and Japan. In *Proceedings of the JSEE Annual Conference, the International Session*, Nagoya, Japan (August 2009).

Chapter 24
Lessons About Nuclear Energy and Safety Held in Second Life

24.1 Setting the Stage

Nuclear energy is a very important form of energy. It is released from nuclear reactions (like fission) and used to generate electricity. However, if serious problems occur, then radiation from nuclear reactors can cause much damage. Consider the huge earthquake that hit the East part of Japan on March 11, 2011. Accompanying it was the worst nuclear disaster ever for Japan, the tragic events at the Fukushima nuclear power plants. What could be done to stop the spread of radiation? What processes could be used for recovery and restoration? From the viewpoint of engineering education, engineers must be prepared to address and answer questions such as these.

Problem-Based Learning (PBL) is important for engineering education. It provides students with challenging, ill-structured problems that relate to their daily lives. The students receive guidance from their instructors and work cooperatively in a group to seek solutions to the problems. PBL has been used to successfully carry out many experiments in the real world and is beneficial in the virtual world too. Students from the United States and Japan learned about nuclear energy and safety through e-learning classes in Second Life, a three-dimensional virtual community [1–4]. The U.S. and Japan teams met separately in virtual classrooms that contained walls, a roof, tables, chairs, podiums, and whiteboards for displaying and sharing information. Their instructors gave them Power Point presentations (in the virtual building) and encouraged them to ask questions and discuss the material. The students also made mathematical calculations and managed to solve the following problem. What kinds of metals can effectively protect human beings from radiation?

Students learn about nuclear energy and its safe use through lessons held in SL.

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Participants used avatars to carry out tasks in the virtual world. The U.S. team communicated by speaking and the Japan group used the chat function, which requires an exchange of text messages. Both forms of communication are available in Second Life (SL).

This activity provides an opportunity to learn about nuclear energy and its safe use through e-learning classes in SL. Also students are asked to solve the following problem. What kinds of metals can effectively protect human beings from radiation?

24.2 Science/Engineering

1. Problem: Each team of at least two students will learn about nuclear energy and safety through e-learning in SL. Then they will be asked to solve a problem. They need to determine what kinds of metals effectively protect human beings from radiation. Participants will communicate with each other (through their avatars) by using the speech and/or chat functions available in SL. Also they will perform other functions so their avatars can carry out required tasks on behalf of them. In computing, an avatar is generally a figure representing a particular person or a graphical representation of the user.

Problem posed as a question: What kinds of metals can effectively protect human beings from radiation?

NOTE: This investigation requires students to have registered avatars for SL and to perform various functions so their avatars can carry out tasks (such as walking and communicating) on behalf of them. Tutorials are available in SL. The ideal situation for instructors is to have virtual classrooms (resembling those in real life with tables, chairs, and whiteboards, etc.) for lectures and brainstorming sessions. However, if these are not available, then modify this activity to complement the learning environment that you have.

Students need to complete the Nuclear Safety Information Chart!

24.3 Science

2. Materials: computer, special software for SL, microphones, headsets, Bamboo Fun (pen & touch tablet) by Wacom, calculators, and the Nuclear Safety Information Chart.

24.4 Technology

1. Computer Use: The computer provides an electronic learning environment. To start, the participants' avatars (of both students and instructors) meet in a virtual classroom or a designated area of SL to discuss the project. They communicate by using the speech and/or chat functions available there. The speech option requires that a microphone and headset be hooked up to each personal computer. The chat function is similar to writing text messages.

Then the teacher gives a lecture (or Power Point presentation) in the virtual classroom if one is available. His/her talk should include information about nuclear energy, protection from radiation, and types of radiation including their penetrating power. Short examples are provided for these topics.

Nuclear Energy: This energy is released from nuclear reactions (like fission) and used to generate electricity. An atom contains protons and neutrons in its nucleus. In fission, the nucleus splits by either radioactive decay or because it has been bombarded by other subatomic particles. Controlled fission is used to release energy within nuclear power plants. Uranium—235 is important for this purpose. It decays naturally by alpha radiation. Also it can undergo induced fission. When a free neutron is fired into the uranium—235 nucleus, the nucleus absorbs the neutron and becomes unstable. It splits immediately and releases lots of energy.

Protection from Radiation: Radiation consists of gamma rays and subatomic particles such as neutrons, electrons, and alpha particles. Some forms of it (like gamma rays) can penetrate the human body and cause cancer to develop. Ultraviolet radiation from the Sun causes burns and skin cancer. Individuals should wear protective clothing and sunscreen for protection from the Sun. Radiation exposure can also be managed by reducing the amount of time of exposure, which in turn reduces the dose of radiation that one receives. Increasing the distance between an individual and the radioactive source reduces the dose too. In addition, shielding can be used to reduce the radiation to a level safe for humans. Shields are made of materials (such as metals of a specified thickness) that inhibit the penetration of radiation. They are placed between the radiation source and the region to be protected.

Types of Radiation and Their Penetrating Power: An alpha particle is like a helium nucleus with an atomic number of 2 and a mass of 4. Alpha particles are produced during alpha decay and can be stopped by a sheet of paper. Beta particles are high energy electrons produced by beta decay. They have more penetrating power than alpha particles and can be stopped by a thin metal plate such as aluminum. Gamma rays have lots of energy and are able to kill living cells. They can be stopped by lead and a thick iron plate. Neutrons can be stopped by water and concrete.

At the end of this lecture, the students should answer the questions related to it on their Nuclear Safety Information Chart.

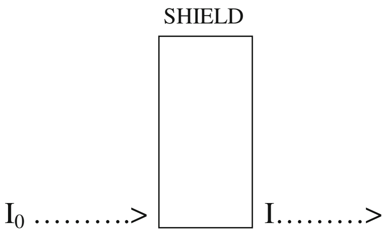
24.5 Mathematics/Technology

1/2. Calculations: While in the virtual environment, the instructor gives the students an equation for determining radiation penetration. He/she discusses this equation and relates it to the use of shields (for protection from radiation). Then the teacher and participants do a sample problem together. Students are encouraged to use calculators and the Wacom touch tablets for their mathematical work.

The equation and sample problem are provided.

$$I = I_0 e^{-ub}$$

I = transmitted x-ray intensity
I_0 = incident x-ray intensity
u = coefficient of decay (1/cm)
b = thickness of the shield (cm)



Sample Problem: Determine the percent of transmitted radiation through a copper shield that is 0.1 cm thick. The decay coefficient for copper is 1.98 and I_0 is 1.0.

Substitute these values into the equation and solve for I. Then multiply the final answer by 100 to obtain the percent of transmitted radiation.

$$I = I_0 e^{-ub}$$
$$I = 1\ e^{-1.98\,(0.1)}$$
$$I = 1e^{-0.198}$$
$$I = 0.82$$
$$0.82 \times 100 = 82\%\ \text{transmitted radiation}$$

This lesson's problem is posed for the students to solve. What kinds of metals can effectively protect human beings from radiation?

In order to solve this problem, the student teams need to communicate and calculate the transmitted radiation values for protective shields made of various metals. For this lesson only copper and aluminum shields will be investigated.

The students determine the amount of radiation transmitted (I) for copper shields that are 0.5 cm, 1.0 cm, and 2.0 cm thick. Refer to the sample problem for assistance. Once again, multiply each answer by 100 to obtain the percent of radiation transmitted through each shield. In the same way, calculate the percent and amount of radiation transmitted for aluminum shields that are 0.5 cm, 1.0 cm, and 2.0 cm thick. NOTE: The coefficient of decay for aluminum is 0.385. All data should be recorded on the Nuclear Safety Information Chart.

24.6 Science

3. Conclusion

a. Of the metals tested, which one makes a better shield of protection from radiation? ________. Why? ________________________________

b. Does the thickness of a shield affect its ability to provide radiation protection? ______. Explain. ____

NOTE: Complete the Nuclear Safety Information Chart

24.7 Nuclear Safety Information Chart

(Answer all of the questions below.)

1. What is nuclear energy? ______________________________

____

2. List and describe three types of radiation.

a.____

b.____

c.____

3. List four ways that you can protect your self from radiation.

a. ____

b. ____

c. ____

d. ____

4. Radiation penetration of copper shields & aluminum shields

Copper Shield	Aluminum Shield
Thickness of 0.5 cm, I = _____, _____%	I = ______, _____%
Thickness of 1.0 cm, I = _____, ___%	I = ______, ______%
Thickness of 2.0 cm, I = _____, _____%	I = ______, ______%

5. Based on this activity, which metal better serves as a protective shield? ______________________. Explain. _________________________________

____

6. What effect does thickness have on a shield's ability to provide protection from radiation?____

____

24.8 Assessment

In order to successfully carry out this activity the students must perform certain tasks, which we refer to as Performance Goals. The students will be assessed on how well they meet these goals. The three main Performance Goals for this lesson are provided.

Three Main Performance Goals

1. Were the students able to perform various functions in SL so that their avatars could carry out tasks on behalf of them?
2. Were the students able to communicate effectively with the teacher and with each other in SL? (Hint: Did they contribute to the class discussion or ask questions about the lecture?)
3. Were the students able to use calculators and the provided equation to determine the amount of radiation transmitted for various copper and aluminum shields?

References

1. Barry, D. M., Kanematsu, H., Fukumura, Y., Kobayashi, T., Ogawa, N., & Nagai, H. (2014). Problem-based learning activities in second life. *International Journal of Modern Education Forum,* 3(1).
2. Kanematsu, H., Kobayashi, T., Barry, D. M., Fukumura, Y., Dharmawansa, A., & Ogawa, N. (2014). Virtual STEM class for nuclear safety education in metaverse. *Procedia Computer Science, 35*, 1255–1261.
3. Barry, D. M., Kanematsu, H., Fukumura, Y., Kobayashi, T., Ogawa, N., & Nagai, H. (2013). US Students carry out nuclear safety project in a virtual environment. *Procedia Computer Science*, *22*, 1354–1360.
4. Kanematsu, H., Kobayashi, T., Ogawa, N., Fukumura, Y., Barry, D. M., & Nagai, H. (2012). Nuclear energy safety project in metaverse. In T. Watanabe et al. (Eds.) *Intelligent Interactive Multimedia Systems & Services, SIST 14*, (pp. 411–418). Berlin: Springer.

Chapter 25
Video Sharing and MOOCs for STEM Education

Abstract In this chapter, we introduce the new virtual tools known as Video Sharing and MOOCs. These tools are described in terms of their benefits and effectiveness for education.

25.1 Video Sharing and STEM Education

Video Sharing sites can be one of the promising tools for STEM. Even though there are many video-sharing sites on the Internet, YouTube is obviously the most well-known. One can submit his/her moving pictures to the site and share them with other participants. The contents are basically moving pictures. Generally, there are many kinds of moving pictures.

Usually, moving pictures are encoded to digitizing data through Codec. It is a program that compresses, encodes raw data to a digitized one and decodes it to an electronic file that people can see and hear through a certain application of software. Generally the moving picture data is composed of sound and picture parts. Therefore, the encoded moving picture data is saved in a "container" basically. When the moving picture is played, the codec (used for compressing/encoding) and player software are needed to run it again.

The type of encoded files is classified into many groups. The representative types that are available for YouTube are MPEG-4, AVI, MOV, MPEGS, FLV, 3GPP and WebM. The playing of moving pictures on YouTube is done not by the usual streaming system, but by a progressive one where the file based on HTTP protocol is run while it is downloaded.

Figures 25.1, 25.2, and 25.4 show the possibilities for the application of YouTube to STEM education. Figure 25.1 is the so called Web 1.0 type education as described in Chap. 9 of Part 2. The information is transferred from the teacher to the students, bidirectionally. There are many YouTube videos where students are

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There are many video sharing sites for STEM. Some include YouTube. Also online courses for STEM Education are possible with Massive Open Online Courses (MOOCs).

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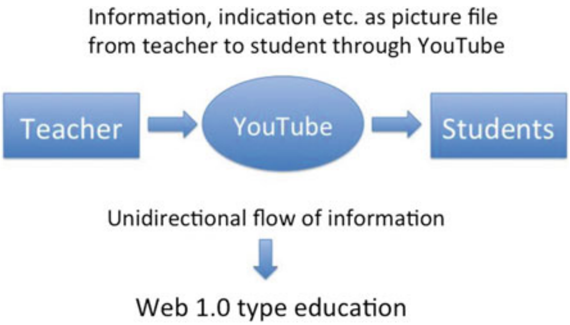

Fig. 25.1 Web 1.0 type STEM on YouTube

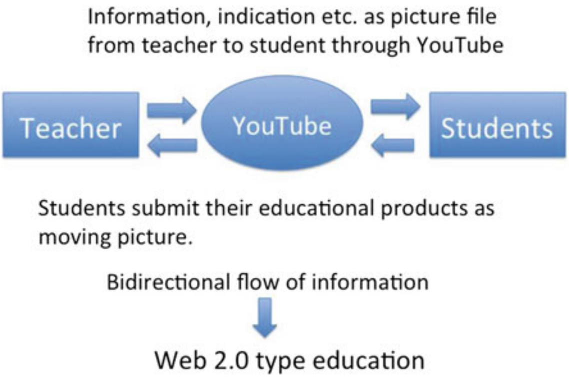

Fig. 25.2 Web 2.0 type STEM on YouTube

able to get information on how to carry out various experiments. These are just like online textbooks [1, 2] (Fig. 25.3).

Figure 25.2 shows Web 2.0 type of education with YouTube. For this type, mutual communication must be kept. As an example, the video from teachers could be an indication for report submission or an explanation for problems. To solve

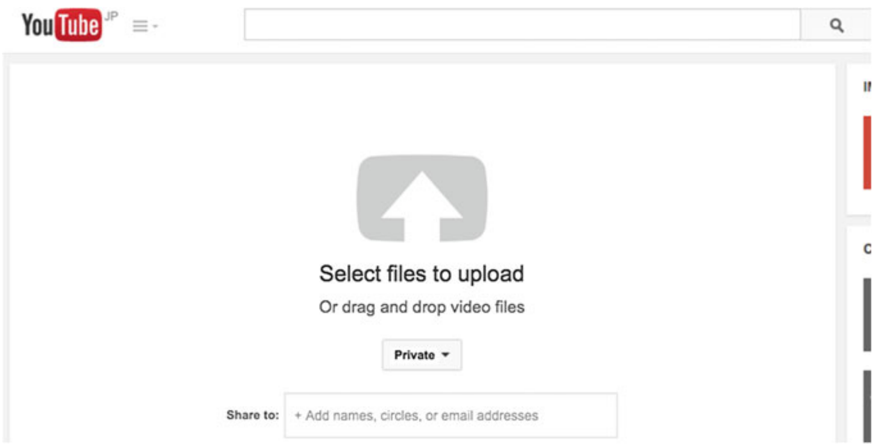

Fig. 25.3 An upload screen of YouTube for moving pictures

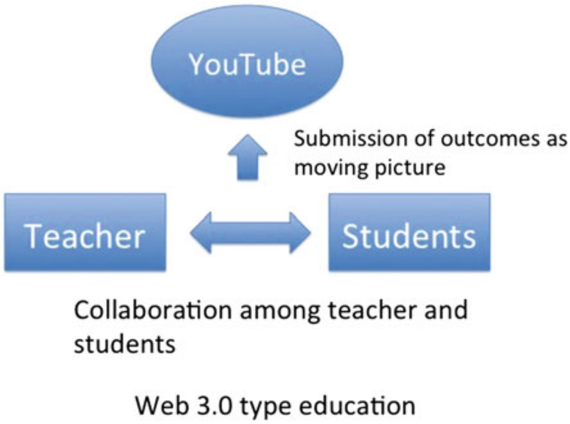

Fig. 25.4 Web 3.0 type STEM on YouTube

these problems, students could submit their results as a moving picture. Usually, the mutual process would be available for other ICT technology virtually. LMS (Learning Management System) would be one of them. Facebook might also be possible for the purpose. However, it would be possible by YouTube too. When one uses YouTube, the submission could be viewed by anyone in the world. If a submission would not be appropriate from educational viewpoints, then the educational activity could be done in a closed circle also available on YouTube. In this case, after you download a moving picture, then you will be led to the following window, as shown in Fig. 25.4.

You can see a small button entitled "Private" under the upload button. This button is changeable to "Public". If you select "Private", then the submitted files would be shared with persons in a certain closed circle composed of teachers and students. In such a way, the educational outcomes could be protected from unknown third parties.

The same process could be applied to a Web 3.0-based YouTube activity. In this type of activity, teachers and students would cooperate and collaborate with each other to produce something as a moving picture. Therefore, if they simultaneously used email, Skype, or some other services, then their activity would be much more effective.

25.2 Online Courses for Stem Education Based on MOOCs

MOOCs refer to Massive Open Online Courses. It is basically an online class on a large scale. Universities and business corporations all over the world offer their unique programs online. Each program has its learning course set up in such a way that students could learn on their own and submit their reports or answers to problems.

During learning in the course, students could discuss problems, contents, etc. and exchange information with other participants. From the viewpoint, MOOCs might be the learning not only for an individual but also for teams. The discussion is usually done on electronic message boards.

After finishing all of the contents of the course, the teacher in charge would evaluate the students' outcomes and award the deserving students with certificates.

When you would read the outline of MOOCs, you might feel that it is very similar to e-learning systems. However, MOOCs is different from the usual e-learning for some points. E-learning in higher education organizations is generally oriented toward students in the universities. Therefore, the participants must have some required qualifications. On the other hand, MOOCs does not require any qualifications or tuition from the participants. From this viewpoint, participants to MOOCs don't have to be students. Anyone can join it. On the other hand, the participants would not get any credits from universities.

There are some well-known business corporations providing online courses on MOOCs. Coursera is one of them [3]. As of August 2013, 80 universities had online courses open with a total number of about 400. The language used is not only English, but also Spanish and Chinese. In the future, online courses will be available using additional languages. Coursera exchanges contracts with universities and takes the educational content provided by universities, etc.

Udacity is another example of a company dealing with MOOCs [4]. As of August, 2013, it offered 28 online courses. The remarkable characteristic of Udacity is that it provides courses run not by educational organizations, but by the teachers themselves. This is different from Coursera.

There are some online courses about STEM. Most of them are oriented to teachers for improving their skills for STEM [5, 6]. Those courses will give teachers an opportunity to join seminars and workshops. Some courses are applicable for K-12 [7, 8]. Teachers and students might benefit more from these courses in the future.

References

1. Ejiri, A., Namiki, ed., M, Science experiments 100, https://www.youtube.com/watch?v=l3XSBuU6E-s.
2. Berkley Middle School science experiments, https://www.youtube.com/watch?v=bBYS-t2ZtP8.
3. Coursera's web page, https://www.coursera.org.
4. Udacity's web page, https://www.udacity.com.
5. An example for STEM on Coursera, https://www.mooc-list.com/course/tinkering-fundamentals-constructionist-approach-stem-learning-coursera.
6. Center for teaching, Vanderbilt University, http://cft.vanderbilt.edu/tag/moocs/.
7. MOOCs Directory, http://www.moocs.co/K-12_MOOCs.html.
8. Canvas Network: https://www.canvas.net.

Part V
Classroom of the Future

A prediction for the future classroom.

Chapter 26
For the Future

Abstract This chapter describes what the future classroom would look like. Advanced digitized facilities and equipment would change the physical appearance of classrooms. New educational content corresponding to the new situation would also appear. Also, the relationship between students and teachers would be changed drastically.

So far in Part 2, some typical features have been described about the effect of ICT on STEM education. As the final chapter of this book, we try to predict the future classroom. The characteristics were changed into three categories mainly. The first one is the change of the classroom as "space" where STEM Education is carried out. The second one is the change of contents. The final one is about personalities.

26.1 The Classroom as Learning Space [1]

The conventional classroom is composed of a blackboard at the front, the teacher standing at the podium and students (facing the teacher) sitting in chairs with a desk. The conventional situation will be changed inevitably. First of all, students will tend to share information and discuss it with each other as group work. Therefore, the teacher would not be at the center like an absolute leader or dictator. This classroom will be a student-centered one (Fig. 26.1). Such a change inevitably leads to the abolition of the blackboard. Instead, big monitors would be placed at the front and at the rear of the classroom. WiFi would be available in the classroom so the students could collect information and refer to various resources. They would get a chance to show their slides, figures, etc. on big monitors. Except for ICT facilities such as big monitors and WiFi, such a classroom type has been often proposed and realized concretely so far to carry out Problem-Based Learning (PBL). In the PBL class, the teacher is not the leader, but just provides support for the students who seek and solve problems through discussions and investigations as a team. In the same way, more than one teacher can be in the classroom to "support" the students as they obtain their solutions (team taught).

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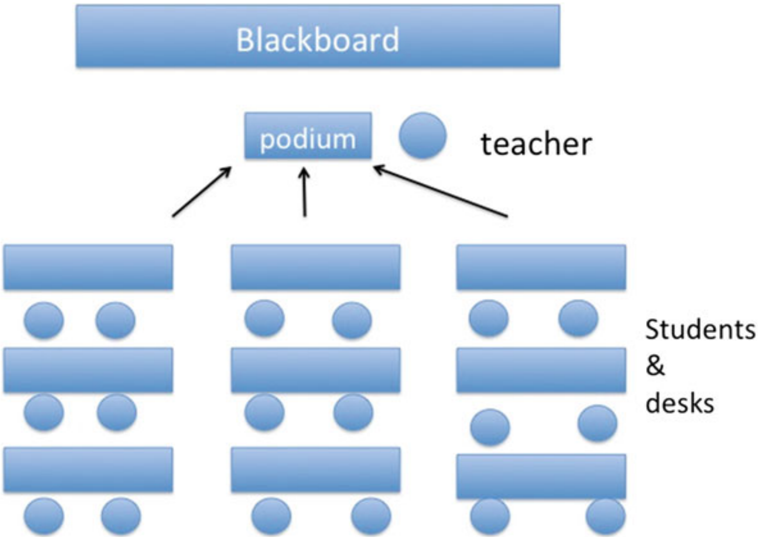

Fig. 26.1 Conventional classroom (teacher centered classroom)

However, the big difference between the conventional PBL class and the future ICT class is the mobility of students' desks. They can move freely in the classroom to seek discussions and information and share them with others from project to project (Fig. 26.2). At the four corners of ceilings in the classroom, video cameras are installed and set to capture and monitor all events including the students and

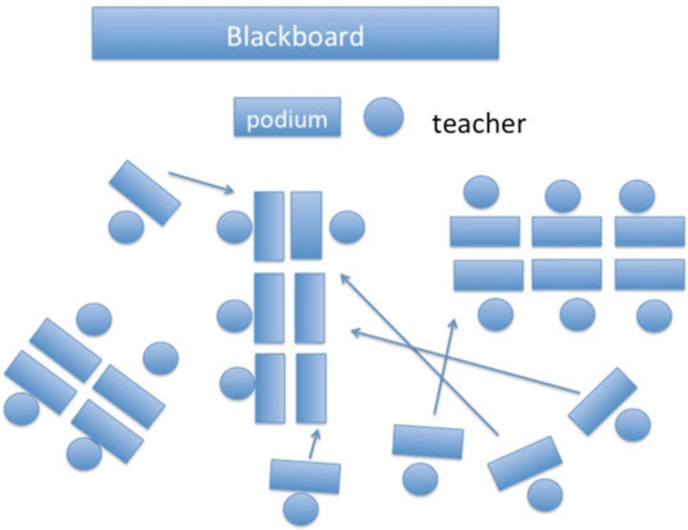

Fig. 26.2 Student centered classroom for STEM

their activities. Each mobile desk for the students has a computer (desk-top computer), microphone and headset. Using these communication devices, students would be able to freely communicate with each other in the classroom, in the school, in the country, and in the world. The computer would most likely be a tablet or it might be one that could be worn like a wrist watch, etc. It will depend on how the ICT would be developed in the future.

26.2 The Contents for Learning

The contents for learning will be changed drastically. As already mentioned in Part 2, Chap. 9, the hypertext based textbook will be very natural at least. The link on the text will take students to various interesting sites where they can learn something on the web pages with static pictures, moving ones, music, voice, etc. The students can share the information simultaneously with others by using electronic boards at the front and back of the classroom. They can move around and talk with other students inside and outside of the classroom, using microphones and videos not only by the video cameras on the ceilings, but also by those on the computers. From the viewpoint, the class in the future will be carried out without borders of time and space.

Their academic activities are controlled by LMS on the server. The system will become much more advanced. The communication with voices will be natural. Various ICT apparatuses will work collaboratively and supplementary to process and handle the information and data to provide students better opportunities for STEM education. In the future, the border between activities in real life and virtual life, (the experimental and lecture type classes), will disappear and become vague.

26.3 Teacher's Characteristics for STEM in the Future

At this point, the authors are not sure how much the prediction will be realized in fact. However, the tendency to increase ICT facilities in the classroom will be absolutely remarkable more and more. In those high tech ICT environments, how should teachers improve their skills not only on the side of hardware, but also in regards to the use of software? As for the personality and characteristics of a good teacher, it is very hard for us to easily propose an "educated guess." The authors do not have any concrete grounds on the mental side of teachers. However, even in such a future, the authors feel teachers in the future should be open-minded, flexible, creative and comfortable persons, in order to best prepare creative and motivated learners (students).

Reference

1. Eadie, G. M. (2000). *Schools for the future—The impact of ICT on schools: Classroom design and curriculum delivery*. USA, England and Hong Kong: A Study of Schools in Australia.