INFUSING BSCS 5E INSTRUCTIONAL MODEL WITH MULTIMEDIA: A PROMISING APPROACH TO DEVELOP 21ST CENTURY SKILLS

By

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ABSTRACT

The full promise of class room learning is dependent on its ability to incorporate 21st century skills in its instructional design, delivery and implementation. In this increasingly competitive global economy, it is not enough for students to acquire subject-level mastery alone. Skills like creative thinking, problem-solving, communication and analytical thinking are necessary for all levels of success. To cope with the demands of the 21st century, students need to know how to use their knowledge and skills-by thinking critically, applying knowledge to new situations, analyzing information, comprehending new ideas, communicating, collaborating, solving problems, and making decisions. If our students are going to compete successfully in the global economy, more must be done to support their acquisition of 21st century skills. This article attempts to articulate a vision for 21st century learning in schools, and identify a way in which a teaching strategy can improve outcomes for all students. The author here tries to infuse the 5E model and technology for the development of 21st century skills in science education curriculum programs and instructional practices.

Keywords: BSCS 5E Model, Multimedia, 21st Century Skills

INTRODUCTION

The full promise of class room learning is dependent, however, on its ability to incorporate 21st century skills in its instructional design, delivery and implementation. In this increasingly competitive global economy, it is not enough for students to acquire subject-level mastery alone. Skills like creative thinking, problem-solving, communication and analytical thinking are necessary for all levels of success, from entry-level jobs to engineering and technical fields. Teachers and administrators must ensure that students who learn in these environments are gaining the skills necessary to compete as citizens and workers in the 21st century. To cope with the demands of the 21st century, students need to know more than core subjects. They need to know how to use their knowledge and skills-by thinking critically, applying knowledge to new situations, analyzing information, comprehending new ideas, communicating, collaborating, solving problems, and making decisions. Yes, all students need to learn how to be good critical thinkers, communicators, and collaborators. They need to be tech savvy, globally aware, and financially intelligent, too. If our students are going to compete successfully in the global economy, more must be done to support their acquisition of 21st century skills. All citizens and workers in the 21st century must be able to think analytically and solve problems if they are to be successful—whether they are entry level employees or high level professionals. Present schools should uniquely be suited to enhance these skills because they should rely upon competency based learning models that focus on demonstrable knowledge and skills. This paper attempts to articulate a vision for 21st century learning in schools, and identify a ways in which a teaching model can improve outcomes for all students. The investigator here tries to integrate the 5E model and technology into a multimedia learning package which can be used by the teachers in the classrooms.

The paper begins with a brief summary of the 21st century skills as summarized by the National Academies (NRC, 2008). The paper then introduces the BSCS 5E instructional model and continues with its integration with technology to develop a multimedia learning package. The paper concludes with a technology based instructional model for the development of 21st century skills in science education curriculum programs and instructional practices.

21st Century Skills

The Research indicates that individuals learn and apply broad 21st century skills within the context of specific bodies of knowledge (National Research Council, 2008, 2000; Levy & Murnane, 2004). In science education, students may develop cognitive skills while engaged in study of specific science topics and concepts. Following are examples of 21st century skills.

Adaptability:

The fast tempo of knowledge generation in today's society requires that students be more adaptable in their thinking than ever before. The abilities and attitudes needed to adapt to the ever changing landscape of scientific ideas are myriad and varied. They include abilities, beliefs, attitudes, dispositions, goals, and motives, all of which present unique challenges for the developing adolescent learner. Also it includes the ability and willingness to cope with uncertain, new, and rapidly-changing conditions on the job, including responding effectively to emergencies or crisis situations and learning new tasks, technologies, and procedures. Adaptability also includes handling work stress; adapting to different personalities, communication styles, and cultures (Houston, 2007; Pulakos, Arad, Donovan, & Plamondon, 2000). Even if a teacher provides the appropriate environment to support critical scientific thinking and reasoning, students often lack the requisite background knowledge to do so effectively. The ability to reason effectively and adapt to changing situations requires rich, interconnected, domain specific knowledge. Today's curricula are often characterized as a mile wide and an inch deep (Vogel, 1996). Lack of sufficient domain-specific content knowledge makes the task of thinking critically challenging not impossible. Beyond skills and abilities, and perhaps even more important for the science learner, adaptability requires the willingness to engage in the effortful thinking necessary to consider alternative points of view.

Complex communication/social skills:

Research indicates that communication skills are extremely important in the field of science. From a Vygotskian perspective, if more sophisticated learners are going to lure their peers into their respective zones of proximal development and thus enhance cognitive growth in scientific thinking, effective communication is necessary (cf. Vygotsky, 1978). Skills in processing an interpreting both verbal and nonverbal information from others in order to respond appropriately. A skilled communicator selects key pieces of a complex idea to express in words, sounds, and images, in order to build shared understanding (Levy and Murnane, 2004). Skilled communicators negotiate positive outcomes with others through social perceptiveness, persuasion, negotiation and instructing (Peterson et al., 1999).

Non-routine problem solving:

A skilled problem-solver uses expert thinking to examine a broad span of information, recognize patterns, and narrows the information to reach a diagnosis of the problem. Moving beyond diagnosis to a solution requires knowledge of how the information is linked conceptually and involves metacognition— the ability to reflect on whether a problem-solving strategy is working and to switch to another strategy if the current strategy isn't working (Levy &Murnane, 2004). It includes creativity to generate new and innovative solutions, integrating seemingly unrelated information; and entertaining possibilities others may miss (Houston, 2007).

Self management/self development:

Self-management skills include the ability to work remotely, in virtual teams; to work autonomously; and to be self motivating and self monitoring. One aspect of self-management is the willingness and ability to acquire new information and skills related to work (Houston, 2007).

Systems thinking:

The ability to understand how an entire system works; how an action, change, or malfunction in one part of the system affects the rest of the system; adopting a "big picture" perspective on work (Houston, 2007). It includes judgment and decision making, systems analysis, and systems evaluation as well as abstract reasoning about how the different elements of a work process interact (Peterson et al., 1999).

The BSCS 5E Instructional Model

To successfully implement the process of inquiry in the classroom, teachers need to use a structured instructional framework. One such framework is the 5E model (Bybee et al., 2006). The 5E instructional model was developed in the 1980s by a non-profit organization named Biological Sciences Curriculum Study (BSCS) under the leadership of Robert Bybee. Unlike traditional expository models the 5E model aims to have students derive concepts and principles experimentally from scientific investigations. As a result students not only acquire content knowledge but also develop important cognitive process skills such as critical reasoning and problem solving. The model consists of a sequence of five learning phases—Engage, Explore, Explain, Elaborate, and Evaluate. Each phase has a specific function and contributes to the teacher's coherent instruction and the students' formulating a better understanding of scientific and technological knowledge, attitudes, and skills. The model has been used to help frame the sequence and organization of programs, units, and lessons. Once internalized, it also can inform the many instantaneous decisions science teachers must make in classroom situations.

Rodger Bybee, former director of Biological Sciences Curriculum Study (BSCS) made a presentation about linking the 5E model to 21st century skills, in a workshop conducted by the National Research Council (US) Board on Science Education on Exploring the Intersection of Science Education and 21st Century Skills. Bybee explained that in the 5E model, the curriculum is designed to allow students to explore scientific phenomena and their own ideas. Students are invited to explain their ideas, and explanations can also be provided by the teacher or a textbook or through the use of technology. The curriculum then helps students to clarify the key concepts targeted for instruction by engaging them in new situations in which they can elaborate and extend their learning. Finally, the curriculum invites both students and teachers to evaluate the learning that took place Bybee explained that the model reflects research on how students learn. Rather than simply requiring students to progress through a series of exercises that are sequenced to cover certain science topics within a certain number of days, the model aims to expose them to major concepts as they arise naturally in problem situations. The model calls for structuring activities in these problem situations so that students are able to explore, explain, extend, and evaluate their own progress. The model is based on findings from cognitive research that ideas are best introduced when students see a need or a reason for their use. Seeing relevant uses of the knowledge helps students to derive meaning from the activities (National Research Council, 1999, p. 127).

Bybee said that his review of the available research did not find any cases in which 21st century skills were specifically targeted as desired learning outcomes in curricula based on the 5E model. The model is aimed at developing students' mastery of science subject matter, not at development of skills. With these caveats in mind, he then discussed the available evidence on development of each of the five skills such as adaptability, complex communication, on routine problem solving, self-management/self-development and systems thinking. He found no evidence of development of adaptability, some evidence of development of complex communication/social skills (i.e., argumentation), and stronger evidence of development of three other skills: (1) non routine problem solving (i.e., scientific reasoning); (2) self-management/self-development (i.e., interest in science and science learning); and (3) systems thinking (i.e., mastery of content knowledge about complex scientific systems). Finally Bybee suggested that, the 5E model is a known quantity in the world of science education, it could serve as an excellent vehicle for developing 21st century skills, if adapted to focus on these skills.

Fusing BSCS 5E model with Multimedia: The Constructivist Multimedia Learning framework

It is been recognized that technology is, and will continue to be, a driving force in workplaces, communities, and personal lives in the 21st century. So it is important to incorporate information and communication technologies into education from the elementary grades up. The present paper tries to infuse the framework of 5E model in the design of multimedia learning package. The review of related literature prove that the 5E model provides a tangible reference for teachers to scaffold their developing expertise in structuring a learning environment that will facilitate students' interaction with a learning context in a critical, reflective and analytical way (Boddy et al. 2003). The 5 E's is an aid or organizer for the teacher to structure and sequence potential learning experiences in a systematic and synergistic way consistent with a constructivist view of teaching and learning. Such a 5E model if used for the design of a multimedia learning package can contribute positively to student's academic success, their attitude towards the lesson, their developing concepts, and development of their cognitive structures.

Most of the multimedia learning packages available now are lacking the purpose for which it is developed. Most of them are self learning packages which cannot provide situations for thinking critically, applying knowledge to new situations, analyzing information, comprehending new ideas, communicating, collaborating, solving problems, and making decisions. Hence a framework in the form of 5E model can enable the students to have opportunities for communication, collaboration and problem solving.

The investigator developed a multimedia learning package for secondary school physics of Kerala..The content of the package was designed using BSCS 5E model. The analysis for this research addressed subject matter about "light". Content for the package was adapted from Physics text of Std.IX of State syllabus (SCERT) of Kerala. The investigator took the role of the script writer. The investigator creates character, action and interactivity. The structuring of content in the content map is from simple to complex, known to unknown, concrete to abstract and also general to specific. The content map preparation was followed by the specification of appropriate instructional strategy. The investigator selected the 5E model as basis for lesson planning. In each phase the teacher provides learning experiences through multimedia and the students find solutions with the help of multimedia package.

The engage phase, starts by an entertaining and attractive presentation and some questions about the reasons of the event which will be told are asked. Here there was a question which mentally helps students to engage for the activity. During explore phase students produced new ideas to solve the problem by studying together, doing experimentations and observations with the help of multimedia learning package. These ideas are turned into abilities and ways of solutions to solve the problem after filtering of the teacher. The main point of this activity is that students are making observations and they get directly involved with the phenomena. The teacher assists the students while they are making observations and discussing about their observations. Throughout this exploration activity, students realize that they are not being tested and generally perceive the activity to be fun and not threatening. They also feel free to express their ideas and make contributions. Explain phase is an inquiry stage. In this stage each student watch the experiments related to problems again and discussed their suggested solution ways and hypothesis with their friends. After discussions, researcher did not give any theoretical information or answers to problems directly. She provides only opportunity to students' conduct discussions by asking open-ended questions. Students realized conceptual development by integrating their obtained results and findings with researches' questions. In this explanation phase students are involved in an analysis of their exploration.

During their education life pupils should learn how to think and how to suspect. They should learn that they cannot decide without thinking whether a preposition is true or not. While they think they should also suspect what they have taught. Teachers should consolidate, expand and help student thinking. This takes place during their elaboration phase. In the elaboration phase the aim is to expand the concept. Students should be fully aware of the meaning of new term by making connections to previous concepts. Novel situations are provided for the students to apply their newly-gained information and problem solving approach. The evaluation phase helps students and teachers to achieve the goal of taking hold of ideas and experiences and working to make them together as a reasonable whole.. The teacher should observe students' knowledge and/or skills, application of new concepts and any change in thinking. Students should assess their own learning. In this phase questions are prepared to encourage student's interest and to develop their thinking skills. The purpose is also to generate interest in the topic and to bring out prior knowledge.

The constructivist multimedia learning framework explained above was able to create in students critical thinking, creativity and analytical thinking. Hence a multimedia learning package designed using 5E model can be defined as an appropriate context for learning in this information age.

How 21st Century skills are acquired through the Constructivist Multimedia learning framework

The Constructivist Multimedia Learning framework was created with a goal of helping children learn science content, scientific attitude, scientific reasoning, and communication, collaboration, design, and project skills.

The Constructivist Multimedia Learning framework affords learning to be adaptive in many ways. First, students work on a variety of different groups throughout the year. They stay with a group for the duration of a unit and work with new people for the next unit. Working with a group for a considerable period means learning how to work with people with a variety of different styles, strengths, and weaknesses. One of the things learners discuss in depth early in the year and then later as it comes up is how they are making their collaborations work, e.g., how they are dividing up responsibilities among their groups.' The Constructivist Multimedia Learning framework' does not otherwise focus directly on helping children learn to cope with uncertain, new, or rapidly-changing conditions, but it does give learners enough variety in solving problems that children become able to address new issues as they arise. The performance assessments show students immediately getting down to work when confronted with a new task. The students learned with the help of the Constructivist Multimedia Learning framework know to think about constraints and criteria of a situation they are addressing, when they need more information and the value in justifying decisions with empirical evidence and science knowledge (and that opinion is not enough).

The experimental students who used the Constructivist Multimedia Learning framework for learning are constantly making presentations to each other, and because they need the results of each other's investigations and recognize the value of their peers' ideas, critiques, and recommendations, they get into the habit of listening and asking questions. The clarifications peers ask for early on in the year serve to help learners identify what is important to present so others can understand what they have to offer, and the group get better over the year at presenting in a productive way. They also get experience with the back and forth communication needed to make sense of each other's ideas; our evidence shows learners becoming more confident and competent over a school year at engaging in such dialog – both within small groups they work in and as a class. Moving from small-group to whole-class work on a regular basis allows those who are good at such communication to model it for others; it also gives everyone a chance to try out such communication in their small groups (3 or 4 members) before participating in such communication in front of the class which will be useful for the shy and not-as-confident learners.

Learning to solve problems in a variety of ways is afforded in constructivist multimedia learning environment through working on problems that might have many good answers and the frequent sharing of ideas. Children see that they and their peers might be coming up with different solutions; they get experience judging the goodness of solutions; and they articulate to their peers how they came up with their solutions. Also, throughout a year, they work on a variety of design challenges; each requires different variations of the reasoning they are doing, and each might require a different kind of investigation.

Self-management is a key in constructivist multimedia learning environment. Here nothing is spoon-fed, and the children who get the most out of the units are those who make the effort. All students tend to participate. Teachers note that they have many fewer discipline problems because students want to engage. The combination of asking students to learn in the context of engaging problems, exploring information helping them learn what is expect of them, explicitly discussion of the how-to's of what they are doing in addition to explicit discussion of the content they are learning, and giving them opportunities to teach and learn from each other, believe, are essential to growing self-management skills.

Several of the problems in the multimedia package unit require understanding good solutions. This requires judgment and decision-making, systems analysis, systems evaluation and reasoning. Student text introduces learners to representations they can use to help with this reasoning. The keys here are (i) to give learners practice thinking in a context in which they need to do it well for success and (ii) to provide the support the learners need to be able to get started with and then get better at systems thinking. The variety of presentations done in the Constructivist Multimedia Learning framework is a real help in promoting systems thinking in the same way it helps in promoting concept learning and learning of other skills. Students report their experiences and results to each other and debug together whatever is not working well. In the process, they hear others using the skills and content, they have a chance to experience its good use, and they have a chance to question what they do not understand.

The vision of how 21st Century skills play out in classrooms is closer to multimedia-based science rather than to laboratory–based science environments (in which "hands-on" activity often shapes the organization of teaching and learning). By multimedia based science the researcher means that the primary focus of student work is to solve complex problems, and that multiple forms of learning activities by students (gathering relevant information, collecting data, testing models, learning new concepts needed to understand the problem, etc.) is always in the service of producing an evidence-based solution to a problem. The constructivist multimedia learning approach is characterized by a focus on a few key science ideas, purpose-driven group work, student ownership of problems and problem-solving approaches, the on-going public vetting of multiple solutions and models as they are being developed, and the use of feedback to refine ideas and solutions. The researcher come to conclusion that the constructivist multimedia learning to science learning involves students in generating and re-framing problems—a skill that is actually more fundamental than the five 21st Century skills listed.

Recommendations

1. Constructivist multimedia approach to teacher professional development -based on 21st century skills-should be adopted, both at pre-service and in-service training programs. Teachers should be given the opportunity to develop 21st century skills themselves and to experience how these skills can be brought into the classroom

2. Embed the constructivist multimedia framework into teacher preparation and professional development so as to develop 21st century skills

3. A curricular framework with a clear definition of 21st century skills and the strategies lihe constructivist multimedia learning framework to support and regulate its implementation and assessment should be developed.

4. The role of non formal and informal education contexts in supporting the acquisition of 21st century skills should be acknowledged and taken into account. Constructivist multimedia learning packages to link what is learnt in and outside the school can be developed.

5. The need for different types of new literacies - information literacy, ICT skills and technological literacy - in the knowledge society must be acknowledged. These new literacies should be embedded within and across the other 21st century skills and core subjects and could be developed by practicing constructivist multimedia framework during the teaching learning process.

Conclusion

In order for our students to be prepared to navigate this 21st century world, they must become literate in 21st century literacies, including multicultural, media, information, emotional, ecological, financial and cyber literacies. Collaborating with students from around the world in meaningful, real-life projects is a necessary tool for developing these literacies. Students can learn that through collaboration, not competition, they can work together to make the world a better place. 5E model infused with technology is a good tool for the teachers as well as students to bring in the 21st century skills. Technologies are not an end in themselves; technologies are tools students use to create knowledge and to create personal and social change.

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