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Instructional Strategies for Integrating STEM Education in Pre Service Teacher Education Programme

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ABSTRACT

According to NCF 2005, "Good Science Education is True to the Child, True to Life and True to Science". In order to accomplish the above the theme, the present school education curriculum is based on the constructivist teaching approach. In order to attain the need of the present school education curriculum, there should occur a systematic change in the teacher education curriculum also to mould the teachers in the preparation for 21st century teaching-learning approaches. Science-Technology-Engineering-Mathematics (STEM) education is one of the innovative and very essential teaching approach in the present digital naive world. The pre service teacher preparation programme also should cater the needs of the present world. Prospective teachers should be able to get proper training on the STEM education so that they can practice it in their professional career. This paper will provide a brief possible ways of what kind of instructional practices is needed for different STEM approaches such as Silo Approach, Embedded Approach and Design based approach and how effectively the prospective teachers can implement this approaches in the normal classroom.

KEY WORDS: STEM, Instructional practices, Silo Approach, Embedded Approach, and STEM approach in Teacher Education.

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INTRODUCTION

The present science education curriculum in India should emphasis on developing the skills related to experiments, technological and problem solving. In order to accomplish the 21st century learning skills the students should be got the opportunity to experience the possible learning experiences. For that, innovative and practically possible pedagogical approaches must be followed by the present generation facilitators. Science-Technology-Engineering-Mathematics (STEM) based teaching approach is one among the innovative approach that should boost the need of 21st century learning skills among the students. In order to accomplish the benefit of any kind of innovative teaching approaches, it should be practiced in the teacher education programme, especially in the pre service programmes. So that the prospective teachers can implement that in their internship programme and also further in their professional career.

STEM is a curriculum based on the idea of educating students in four specific disciplines — Science, Technology, Engineering and Mathematics — in an interdisciplinary and applied approach. Rather than teaching the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications.

The STEM based approaches can be implement in multiple ways. Some of the approaches where STEM curriculum can successfully implemented are Silo Approach, Embedded Approach and Design based approach.

Silo Approach: The silo approach to STEM education refers to isolated instruction within each individual STEM subject Dugger, 2010 [1]. Emphasis is placed on "knowledge" acquisition as opposed to technical ability. Concentrated study of each individual subject allows the student to gain a greater depth of understanding of course content. This focused instruction stirs appreciation for the beauty of the content itself. Silo STEM instruction is characterized by a teacher-driven classroom. Students are provided little opportunity to "learn by doing", rather they are taught what to know. Morrison suggests the prevailing belief behind silo STEM instruction is to increase knowledge which generates judgment. While an instructor may choose to implement a variety of teaching strategies, in a silo classroom, the content would likely remain the focus of study. This may limit the amount of cross-curricular stimulation and student understanding of the application of what they must learn.

Embedded Approach: Embedded STEM instruction may be broadly defined as an approach to education in which domain knowledge is acquired through an emphasis on real-world situations and problem solving techniques within social, cultural, and functional contexts

STATEMENT OF THE PROBLEM

Science –Technology-Engineering-Mathematics (STEM) based education will be in the driving position in the future. By integrating STEM in to the present educational system in our country, the students will get a chance to inculcate the 21st century learning skills. To integrate in the present educational system, the best way to give proper training and orientation to the prospective teachers. In this study, the researcher tries to find out the different ways in which the integration of STEM education in the present educational system can be done and also focus about the different instructional strategies that could be appropriate for implementing the STEM education.

RESEARCH QUESTIONS

1. What are the different instructional strategies needed in pre service teacher preparation programme regarding the implementation of STEM education

OBJECTIVES

1. To find the different instructional strategies needed in pre service teacher education programme to implement about the STEM education.

EFFECTIVE PEDAGOGICAL APPROACHES TO INGRATE STEM EDUCATION

The effective pedagogical practices that have been included in promoting student engagement and achievement in STEM disciplines are inquiry-based learning, argumentation and reasoning, digital learning, and computer programming and robotics. Importantly, for STEM pedagogical practices to be effective, it is critical that teaching approaches are altered from traditional, teacher-centred pedagogies to active, student-centred pedagogies to support student teaching –learning Kennedy & Odell, 2014 [2]

Inquiry-based learning: Inquiry-based approaches to learning are active pedagogical strategies that develop students' abilities to ask questions, design investigations, solve problems, interpret data and evidence, form explanations and arguments, and communicate findings. Inquiry-based approaches to learning are promoted in all STEM disciplines to enable students to engage in authentic and meaningful activities that are connected to the real world. A commonly utilised definition, provided by the National Research Council, is stated as: scientific inquiry is a set of abilities and understandings that include asking scientific questions, designing scientific investigations to answer questions, using appropriate tools to interpret and analyse data, formulating scientific explanations using evidence, and being able to communicate and defend relationships between evidence and scientific explanations NRC, 2012 [3]. The implementation of an inquiry-based science curriculum incorporates a range of scientific experiences designed to explicitly facilitate and scaffold students' engagement in inquiry practices such as planning investigations, and providing evidence for claims McNeill, Pimentel, & Strauss, 2013 [4]. Importantly, students must also be supported and encouraged to engage in scientific discourse in collaborative groups to communicate their findings, to ensure they learn to consider multiple, and often conflicting perspectives on scientific problems Clark & Linn, 2003; Linn & Hsi, 2000 [5].

Engaging students in scientific inquiry has the potential to develop 21st century competencies, including resilience, coping with uncertainty, self-reliance, and creativity; in addition to increasing interest and engagement in science and mathematics. Importantly engaging in scientific inquiry develops students' problem-solving abilities and logical thinking, enabling them to apply their knowledge to situations beyond the classroom. As recent reform efforts in science education advocate situating scientific content in real world contexts that are applicable to students' daily lives, inquiry-based approaches are critical to help facilitate this process. Embedding science in real world contexts helps narrow the gap between school knowledge and everyday knowledge, increases accessibility to students, engages students in problem-solving, and increases motivation due to enhanced student interest

Students are engaged in solving real world design problems, and incorporate reasoning processes and reflective practices. The process includes planning and design in authentic learning environments, iterative decision-making, formulating predictions, creating solutions, testing prototypes, and communicating findings Doppelt, Mehalik, Schunn, Silk, & Krysinski, 2008 [6].

The process of engineering design consists of three components: identifying the problem, including constraints and limitations; designing and evaluating solutions; testing and refining solutions, and improving the final design NRC, 2012.

Argumentation and reasoning: Closely related to inquiry-based learning approaches, argumentation and reasoning practices have been promoted in two STEM disciplines, science and mathematics, and are implicit in Design Based Learning strategies employed in technology and engineering. Engaging in the pedagogical practice of argumentation, whereby students participate in discussing evidence, considering alternative views, evaluating claims and debating ideas, is considered to be an authentic science learning experience Duschl & Grandy, 2008; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003 [7], mirroring the practices professional scientists engage in on a regular basis. Encouraging students to engage in critical thinking, discussion and debate has many benefits, including participating in scientific discourse, improved learning of scientific concepts, generating questions, formulating informed positions, and engaging in socio scientific decision-making Chin & Osborne, 2008; Erduran & Jimenez-Aleixandre, 2008; Varelas, Pappas, Kane, & Arsenault, 2008 [8]. Research conducted in science education indicates that engaging students in argumentative practices can also lead to improvements in student achievement Asterhan & Schwarz, 2009 [9]. Thus, encouraging a supportive classroom atmosphere where students feel confident to express their views on scientific issues is vital to enable argumentation-based learning to occur.

Digital learning: Digital classrooms are modern learning environments that enable students to develop their technological literacy and critical thinking skills throughout their daily learning activities. In essence, they are standard classrooms that integrate internet and mobile technologies, such as laptops, tablets and smartphones into the teaching and learning process. Students are able to use their mobile devices to access digital learning objects and resources to support the learning of relevant content Chan, 2010 [10]. The rationale for the use of mobile technologies is a pragmatic one the majority of students own and use mobile devices, and these devices have become a pervasive influence in their day to day life activities.. Thus, the Bring Your Own Device (BYOD) model is now a common feature in schools in many countries. Digital classrooms support the creation of constructivist STEM learning environments, whereby the learner is able to conveniently access, develop and share relevant knowledge on a progressive basis, with the teacher acting as a facilitator of knowledge construction. Other advantages of these classroom environments include providing students with access to a variety of learning sources and developing their ability to critically process and assimilate information from a variety of sources across the STEM disciplines Gut, 2011; Wong & Looi, 2011. [11]

Two digital learning approaches that have been found to be effective in STEM classrooms are digital game-based learning and computer simulations. Digital game-based learning is a computer-supported learning approach that has been shown to increase student motivation and facilitate learning in technology-enhanced environments Gee, 2007; Kiili, 2007; Prensky, 2001 [12]. Research indicates the majority of children and adolescents engage in digital game playing, thus providing a powerful impetus to engage them in meaningful learning with relevance to their daily lives. Many positive educational outcomes have been cited by researchers regarding the effectiveness of digital game-based approaches including: facilitating independent learning, improving information processing ability, promoting higher order thinking, developing problem-solving ability, and effectively scaffolding learning Mayer & Wittrock, 2006 [13]. As a student-centred instructional approach, digital game-based learning aligns with constructivist teaching approaches that value active learning, and student-led inquiry. It is an intrinsically motivating approach that has been shown to enhance students' motivation for learning and promote students' learning performance.

Computer simulations are computer modelling tools that present theoretical or simplified models of real-world processes and phenomena, and include visualisations, animations, and virtual laboratories Smetana & Bell, 2012 [14] . Computer simulations provide authentic contexts for learning where students are afforded immediate feedback Rose & Meyer, 2002 [15]enabling them to hone and develop their evolving ideas and take ownership of their learning. They promote active engagement in higher-order thinking and problem-solving, and facilitate the learning of more abstract concepts

Hargrave & Kenton, 2000[16]. Simulations can also provide opportunities to visualise phenomena that are too dangerous, time-consuming or complicated to interact with in the classroom or laboratory.

Computer programming and robotics: An important pedagogical approach that has received increased attention in recent years focuses on the integration of computer programming and robotics across the years of schooling Israel, Pearson, Tapia, Wherfel, & Reese, 2015 [17]. Pedagogical practices in the classroom need to shift towards activities that promote learning and creating, and computer programming and robotics have been proposed as learning technologies that can enable the development of competencies, such as problem-solving and higher-order thinking skills Fessakis, Gouli, & Mavroudi, 2013 [18].

Computer programming requires students to engage in a problem-solving process termed computational thinking. The process is multi-dimensional and iterative, and comprises a number of phases including: framing problems in a manner that enables them to be solved using computational tools; organising and analysing data; using models and simulations to represent data; implementing algorithmic thinking to automate solutions; evaluating solutions; and implementing the problem-solving process to other contexts. Engaging students in computer programming experiences has been shown to be beneficial for their learning, attitudes and motivation Lambert & Guiffre, 2009 [19] particularly with younger students.

Engaging students in robotics has also been shown to be a highly effective pedagogical practice, particularly in the area of programmable and interactive robotics. Similarly to computer programming, research has indicated that engaging younger students in robotics can facilitate effective learning. In addition to developing problem-solving skills, engagement in robotic manipulative has been shown to develop fine-motor skills and hand–eye coordination Bers, 2008 [20].

Accountable talk: Talking with others about ideas is fundamental to classroom learning. Classroom talk that promotes and sustains learning should be accountable to other learners, use accurate and appropriate knowledge, and adhere to rigor in thinking. Accountable talk responds to and further develops what others have said through relevant observations, ideas, opinions, or more information. Accountable talk draws on evidence appropriate to the content area (e.g., a proof in math, data from investigations in science, textual details in literature, and primary sources in social studies) and follows the rules of reasoning.

Cooperative learning: Students in small heterogeneous groups take roles and learn to share knowledge and tasks with one another through a variety of structures with this strategy. While different experts categorize these differently, common features of effective cooperative learning include team building, positive interdependence, group interaction, structured activity, and individual accountability.

Project-based learning: In K-12 education, project-based learning has evolved as a method of instruction that addresses core content through rigorous, relevant, hands-on learning. Projects tend to be more open-ended than problem-based learning, giving students more choice when it comes to demonstrating what they know. Different from projects that are the culmination of a learning unit, PBL projects are the learning unit, meaning that fundamental concepts and skills are learned throughout the project. Projects are typically framed with open-ended questions that drive students to investigate, do research, and construct their own solutions. Students use technology tools much as professionals do—to communicate, collaborate, research, analyze, create, and publish their own work for authentic audiences. Instead of writing book reports, for instance, students in a literature project might produce audio reviews of books, post them on a blog, and invite responses from a partner class in another city or country.

STEM based learning must be well designed and systematically so learning becomes active, student centered and provides real life problem solving experience. Self-directed learning, co-operative learning, discussion method focussing on the real life problems and topics can be enhanced. If we integrate STEM in to the normal classroom, the science class will be more interesting and enjoyable. Moreover, the overall development can be achieved, in the sense they can grow as a real human being. STEM Integration will be useful for the individual development. Students can develop thinking skills, improve their psycho motor skills, various life skills can be enhanced and promote collaboration among students.

CONCLUSION

STEM teaching approach can be used for concretizing abstract concepts in science. It will provide a drastic change in the school education. Eradication of rote learning will occur and promotes the real meaningful learning. By giving proper orientation to the prospective teachers, the STEM based approach can be implemented in all levels of education. The effective Pre-service teacher training will bring the huge difference in the need of the present world.

REFERENCES

1. William E. Dugger, Jr., Evolution of STEM in the United States.
2. Kennedy, T. K., & Odell, M. R. L. Engaging students in STEM Education. Science Education International. 2014; 25(3):246-258.
3. NRC, National Research Council. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC: The National Academies Press. 2012.
4. McNeill, K. L., Pimentel, D. S., & Strauss, E. G. The impact of high school science teachers' beliefs, curricular enactments and experience on student learning during an inquiry-based

urban ecology curriculum. International Journal of Science Education, 2013;35(15): 2608-2644.

5. Clark, D., & Linn, M. C. Designing for knowledge integration: The impact of instructional time. The Journal of the Learning Sciences, 2003; 12(4): 451-493.
6. Linn, M. C., & Hsi, S. Computers, teachers, peers: Science learning partners. Routledge. 2000.
7. Doppelt, Y., Mehalik, M. M., Schunn, C. D., Silk, E., & Krysinski, D. Engagement and achievements: A case study of design-based learning in a science context. 2008.
8. Duschl, R. A., & Grandy, R. E. Reconsidering the character and role of inquiry in school science: Framing the debates. Teaching. 2008.
9. Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R.). What" ideas-about-science" should be taught in school science? A Delphi study of the expert community. Journal of research in science teaching, 2003; 40(7) : 692-720
10. Chin, C., & Osborne, J. Students' questions: a potential resource for teaching and learning science. Studies in Science Education, 2008;44(1): 1-39.
11. Erduran, S., & Jiménez-Aleixandre, M. P. Argumentation in science education. Perspectives from classroom-Based Research. Dordre-cht: Springer. 2008.
12. Varelas, M., Pappas, C. C., Kane, J. M., Arsenault, A., Hankes, J., & Cowan, B. M. Urban primary-grade children think and talk science: Curricular and instructional practices that nurture participation and argumentation. Science Education, 2008; 92(1): 65-95.
13. Asterhan, C. S., & Schwarz, B. B. Argumentation and explanation in conceptual change: Indications from protocol analyses of peer-to-peer dialog. Cognitive science, 2009; 33(3): 374-400.
14. Chan, T. W. How East Asian classrooms may change over the next 20 years. Journal of Computer Assisted Learning, 2010; 26(1): 28-52.
15. Wong, L. H., & Looi, C. K. What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. Computers & Education, 2011; 57(4) : 2364-2381.
16. Prensky, M. Fun, play and games: What makes games engaging? Digital game-based learning, 2001; 11-16.
17. Mayer, R. E., & Wittrock, M. C. Problem solving. Handbook of educational psychology, 2006; 2: 287-303.
18. Smetana, L. K., & Bell, R. L. Computer simulations to support science instruction and learning: A critical review of the literature. International Journal of Science Education, 2012; 34(9): 1337-1370.

19. Rose, D. H., & Meyer, A. Teaching every student in the digital age: Universal design for learning. Association for Supervision and Curriculum Development, 1703 N. Beauregard St., Alexandria, VA, 2002.
20. Hargrave, C. P., & Kenton, J. M. Pre instructional simulations: Implications for science classroom teaching. Journal of Computers in Mathematics and Science Teaching, 2000; 19(1): 47-58.
21. Israel, M., Pearson, J. N., Tapia, T., Wherfel, Q. M., & Reese, G. Supporting all learners in school-wide computational thinking: A cross-case qualitative analysis. Computers & Education, 2015; 82: 263-279.
22. Fessakis, G., Gouli, E., & Mavroudi, E. Problem solving by 5–6 years old kindergarten children in a computer programming environment: A case study. Computers & Education, 2013; 63: 87-97.
23. Lambert, L., & Guiffre, H. Computer science outreach in an elementary school. Journal of Computing Sciences in colleges, 2009; 24(3):118-124.
24. Bers, M. U. Blocks to robots: Learning with technology in the early childhood classroom New York: Teachers College Press, 2008; 154.
25. NCERT. National curriculum frame work. New Delhi 2005