Advanced STEM in the Classroom

Competency

Educator uses advanced STEM topics in the classroom to engage students and support twenty-first-century learning.

Key Method

Educator uses a range of tools and pedagogical strategies to teach students about key advanced STEM topics

Method Components

What is "advanced STEM"?

While the inclusion of STEM topics like coding have become increasingly prevalent in curricula around the world, technology has continued to advance at a rapid pace. To support student success in the 21st century, it is important to recognize that coding is only the beginning, not the end, of student's introduction to STEM.

However, many teachers feel that they have barely grasped coding. The thought of integrating more advanced topics like artificial intelligence, blockchain, and big data into the classroom can feel overwhelming. To put it simply, we define advanced STEM as comprising of the emerging technologies that are shaping our present and future. From artificial intelligence to data science, blockchain to machine learning, these technologies are wide-ranging but connected by their immense impact on our lives and societies.

Why should students learn about these topics and technologies?

One of the reasons most often shared for why students should have more experience with STEM in school is "to prepare them for the jobs of the future." This is a worthwhile goal; jobs in STEM fields are growing at a rate of close to 8%, compared to just 3.7% for non-STEM jobs. Over 70% of jobs in STEM are actually computing jobs or use computer science in a major way (US Bureau of Labor Statistics, 2021). As a result, learning the fundamentals of a range of advanced STEM topics can be a valuable skill in the workforce.

However, there are still many students who will not end up in a STEM field. Nevertheless, these students should still learn about these advanced STEM topics!

While learning about these topics can be inherently enjoyable for many, one of the goals of twenty-first-century education should be to move students from being digital consumers to digital creators. That is to say, rather than being passive users of technology, students should have a deeper understanding of how technology is shaping their lives and societies and how they, in turn, can use technology to make a positive impact in the world. To truly understand how technology works, one must begin to understand how these emerging and advanced technologies are evolving our experiences of and interactions with the technology of our everyday lives and experiences.

Furthermore, incorporating advanced STEM topics into the classroom is an important and effective way for students to learn key twenty-first-century skills such as communication, collaboration, critical thinking, and creative problem solving.

Foundations of Effective STEM Instruction

While introducing STEM in the classroom has increasingly become a stated priority of schools and governments across the globe over the last decade, understanding how to effectively integrate advanced STEM topics in the classroom at the K-12 level often goes undiscussed.

Based on research by the Computer Science Teachers Association and other best practices, the 5 foundations of effective instruction in the incorporation of advanced STEM topics are:

1. **Demonstrate thorough knowledge and skills**

No, you do not need to be an expert in order to integrate advanced STEM topics in the classroom. However, educators do need to experience these technologies themselves and build their skills in order to effectively teach these topics to to K–12 students.

Educators should have a solid understanding of fundamental advanced STEM technologies and core terms and principles, and also have the ability to recognize common student misconceptions and areas of difficulty.

By taking this time to familiarize themselves with the foundations of advanced STEM topics, educators will be both better equipped and more confident in their abilities to bring high-quality instruction into their classroom.

2. **Implement evidence-based practices as responsive classroom practitioners**

Every classroom is unique, but there are general principles and evidence-based practices that should guide all educators in bringing high-quality instruction to their students, including:

1. *Hands-on learning.* While there are fundamental theoretical concepts underpinning advanced STEM topics, students need hands-on experience to truly understand and develop the skills they need.
2. *Troubleshooting.* When it comes to exploring advanced STEM topics, it is not a matter of *if* you will make a mistake, but *when*. On top of learning the fundamental principles and getting hands-on experience, students also need explicit instruction and practice with troubleshooting strategies.
3. *Multiple pathways.* There is almost always more than one way to achieve a given outcome when working within advanced STEM topics. Effective educators account for this inherent flexibility when assessing student work while valuing the learning process over the final product.

3. **Design learning experiences using pedagogical content knowledge**

While many pre-made lessons and activities exist to support educators in bringing advanced STEM instruction to their classroom, educators must be able to evaluate and modify these resources as well as create their own original learning experiences in order to meet the needs of their unique group of students.

4. **Continuously develop knowledge, practice, and professional identity**

It can be tempting for an educator beginning their journey with advanced STEM topics in the classroom to stay within their comfort zone with simple and familiar lessons and activities. However, students may quickly advance past these learning experiences and require more advanced and novel experiences.

Therefore, effective instruction means the learning is never done! Educators should be continuously evolving their own skills and looking for ways to engage students in increasingly complex learning.

5. **Advocate for equity and inclusion in the classroom**

Educators must recognize that the world of STEM has not been equitable in the past and remains so. Women/girls, racialized people, people with disabilities, and other marginalized

groups remain deeply underrepresented in the world of STEM, and especially in fields related to emerging technologies.

These problems will not fix themselves. Cultural biases about who belongs in the world of STEM exist in us all, even at a subconscious level. Beyond merely teaching about advanced STEM topics, educators must take an active role in promoting equity and inclusion in their instruction and overall classroom environment in order for all students to achieve success and recognize their potential.

Supporting Rationale and Research

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Resources

Standards
International Society for Technology in Education (ISTE) Student Standards.
https://www.iste.org/standards/iste-standards-for-students

Lesson Plan Template
https://dl.dropbox.com/s/hur3xcbcvbxnkkz/Advanced%20STEM_Lesson%20Plan%20Template.docx?dl=0

Key Terms:

Emerging Technologies: Technologies whose development and/or practical applications are not yet fully realized and are likely to significantly change the status quo. These technologies are often entirely new, but also include evolutions of older technologies.

Artificial Intelligence: Creating the capacity for computers to do tasks that would normally require human intelligence.

Machine Learning: Machine learning describes the methods used to get machines to learn—that is, to find patterns and make predictions—from data without being explicitly being programmed to do so. Machine learning is a subset of artificial intelligence that focuses on learning from data.

Big Data: Extremely large data sets that can be analyzed to reveal patterns, trends, and associations, especially relating to human behavior and interactions. Big data can be the combination of several large data sources to help understand more about the information contained within the data.

Blockchain: A system in which a record of transactions (often made in Bitcoin or another cryptocurrency) are maintained across several computers that are linked in a peer-to-peer network.

Cryptography: The practice and study of techniques for secure communication, especially to protect against interception from adversaries.

Internet of Things: The large and growing network of devices that are connected to the internet and to each other.

Submission Guidelines & Evaluation Criteria

To earn the micro-credential, you must receive a passing evaluation for Parts 1 and 3 and a "Yes" for Part 2.

Part 1. Overview Questions

Please write your responses below (1000-word limit for the 5 questions in total).

1. Describe your role in education. What grade and subject or content area do you teach? What should we know about you and your classroom?

2. What is your current level of experience and confidence with teaching advanced STEM topics?
3. Identify at least one asset and one barrier you anticipate to integrating advanced STEM topics into your classroom.
4. Why do you believe it is important to teach students about advanced STEM topics?
5. What are you hoping to gain through this micro-credential?

Passing: Response provides reasonable and accurate information that outlines the prior experience of the educator and the context of their classroom/teaching. Educator specifies a learning goal that describes what they hope to gain from this experience. Educator outlines their current mindset and experience when it comes to teaching advanced STEM topics in sufficient detail.

Part 2. Work Examples/Artifacts/Evidence

To earn this micro-credential, submit the following three artifacts.

Artifact 1: Certificates of Completion

1. Certificate of completion for a STEM Minds Teacher Professional Development Workshop related to your STEAM Hub course (see Artifact 2, below)
2. Certificate of completion for ONE of the following STEAM Hub courses:
    a. Intro to Cryptography
    b. Intro to Blockchain
    c. Intro to Machine Learning
    d. Intro to Big Data
    e. Intro to Internet of Things (IoT)
    f. Intro to Artificial Intelligence
    g. Intro to Databases
    h. Intro to Networks

Artifact 2: STEAM Hub Course Final Project

For the STEAM Hub course you selected above, please submit a copy of your final project. It must include:

- the full project file (please do not submit screenshots)
- any relevant share settings appropriately set to allow anyone to view the project

Artifact 3: Lesson Plan

Submit a lesson plan showing how you will bring this advanced STEM experience to your classroom. This lesson may be a “stand alone” lesson or may be one in a larger unit. Please indicate this context for the lesson somewhere in the lesson plan. You may choose to use your own lesson plan template or may use the suggested template in the Resources section. Your lesson plan must include the following information:

1. What core concepts you plan to introduce to students and how you plan to do so
2. What project(s) students will be asked to create, and how they will have the opportunity to test and refine them
3. How you intend to foster an inclusive and collaborative culture in your classroom, with a focus on historically underrepresented groups instead (including girls/women, students with disabilities, ELL students, etc.)

4. How you plan to address common student misconceptions/areas of difficulty
5. What troubleshooting strategies you intend to introduce to students (please also include *how* and *when* you plan to introduce these strategies)
6. What opportunities students will have to communicate about advanced STEM topics
7. How you intend to assess and evaluate student work (with a focus on process over product)

Part 2. Scoring Guide

Artifact	"Yes"	"Almost"	"Not Yet"
Artifact 1: Certificates of Completion	The certificate of completion for both the course and the professional development workshop were provided.	N/A	One or both of the certificates are missing.
Artifact 2: STEAM Hub Course Final Project	The project provided meets the expectations as outlined in the project rubric within the STEAM Hub course at a level of 80% or higher.	The project provided meets the expectations as outlined in the project rubric within the STEAM Hub course at a level of less than 80%.	The project was not provided.
Artifact 3: Lesson Plan	The lesson plan includes all of the following: 1. Core concepts to be addressed 2. Project description 3. Inclusion and collaboration strategies 4. Anticipated student misconceptions/ areas of difficulty 5. Troubleshooting strategies to be taught 6. Opportunities for student communication 7. Assessment and evaluation plan	The lesson plan includes some of the following: 1. Core concepts to be addressed 2. Project description 3. Inclusion and collaboration strategies 4. Anticipated student misconceptions/ areas of difficulty 5. Troubleshooting strategies to be taught 6. Opportunities for student communication 7. Assessment and evaluation plan	The lesson plan includes only one or two of the following: 1. Core concepts to be addressed 2. Project description 3. Inclusion and collaboration strategies 4. Anticipated student misconceptions/ areas of difficulty 5. Troubleshooting strategies to be taught 6. Opportunities for student communication 7. Assessment and evaluation plan

Part 3. Reflection

Please write your responses below (1000-word limit for the 5 questions in total).

1. Throughout this experience, what steps did you take to foster an inclusive and collaborative culture in your classroom? What impact did this have on you and your students?

2. How did this micro-credential process influence how you teach advanced STEM topics and/or other subjects?
3. What were the most common issues your students faced in their learning? How did you address these challenges?
4. In what ways did your students engage with collaboration, communication, critical thinking, and creative problem-solving through this experience?
5. How would you describe your students' overall experience with advanced STEM topics? If you had to do it again, what would you do differently? What would you do the same?
6. What are your next steps for growth as an educator in this area?

Passing: Response provides reasonable and accurate information that outlines their approach to inclusivity in teaching advanced STEM topics. Educator explores how the experience influenced their teaching and their next steps for growth. The response outlines the impact on the students and their experience in sufficient detail.