

The National Academies of SCIENCES • ENGINEERING • MEDICINE

With sponsorship from the National Science Foundation, the National Academies of Sciences, Engineering, and Medicine is convening a public symposium to explore ambitions for the future of undergraduate STEM education and identify steps for achieving them.

Prior to the symposium, the National Academies held an idea competition to engage stakeholders with diverse perspectives. Entrants submitted a statement or video addressing some aspect of the symposium's focus: *What should undergraduate STEM education look like in 2040 and beyond to meet the needs of students, science, and society? What should we do now to prepare?*

Entries were evaluated based on their potential to contribute to and advance discussion at the symposium. Entries were also judged on originality and future orientation. Below is one of the winning submissions.

"Athena—An Adaptive Socially Conscious AI Mentor for your Future STEM Selves"

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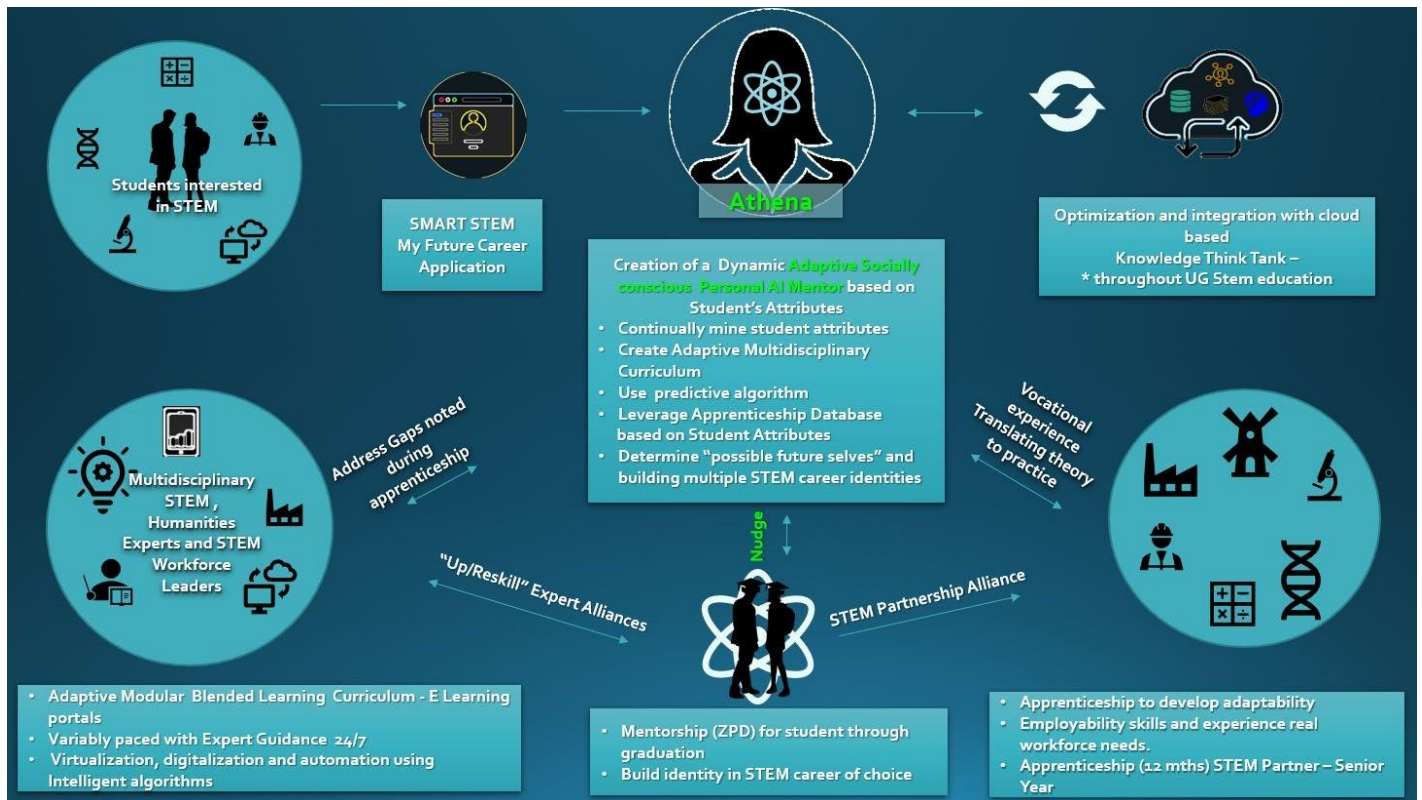


Figure 1: Athena, an AI based Career Mentorship Program.

The World Economic Forum predicts that the fourth industrial revolution will fundamentally alter the future of the STEM workforce. Business growth will be dependent on 4 key advances – global high-speed mobile Internet; Artificial Intelligence (AI); widespread adoption of big data analytics; and cloud technology. AI is for the Fourth Industrial Revolution what electric power was to the second. People will work collaboratively with AI employees and education must produce AI Natives.

Athena, an adaptive, socially conscious AI mentor is the future of STEM education, providing the power to personalize and support a meaningful and robust educational experience over the long-term. Students, in the role of mentee, collaborate with **Athena** to evaluate and choose curriculum elements, support services and career opportunities based upon projected possible ‘Future STEM Selves’, which are dynamic personal embodiments of successful long-term career participation. **Athena**’s mentoring is based upon predictive algorithms applied to big data integration from the diverse systems that contain pertinent information. Behind the scene, these algorithms continuously cluster, prioritize, and sequence elements based on new data. Each mentee’s “My Future STEM Selves” profile will be self-adaptive and self-evolving throughout their undergraduate experience, with **Athena** seamlessly and continuously curating an adaptive socially conscious curriculum.

Athena will emerge from a multidisciplinary effort using a **strong AI platform** involving a coalition of stakeholders such as STEM thought leaders from industry and experts from STEAM fields (i.e. including education, the humanities and arts). This collaboration will enable Athena to “think” and respond intelligently, consciously and ethically. Curriculum elements will be mapped for each possible Future STEM Self with complementary electives supporting long-term employability skills. With this curriculum, students can confidently learn through trial and error, including several advanced skills such as developing intelligent design, supply chain management workflow, predictive analysis concepts and optimization strategies.

STEM education requires innovation and creativity, a noted missing element of current practice. As novices, students generally have difficulty **translating mathematical/scientific meaning to real-world conditions**, representing it from a design perspective or mathematically deciding what needs to be solved and then how to solve the problem. Furthermore, many students are reliant on rote memorization or applying a standard recipe or formula to respond to all types of questions rather than recognizing the nature of the question and context. **Athena** will use a machine learning approach to encourage experiences that fit within their mentee’s zone of proximal development; neither too demanding or too unsatisfying. Mentees will be encouraged to formulate questions and to translate and apply conceptual frameworks to real-world situations. By being continually encouraged to think creatively, Athena’s mentees will be able to quickly assess the current state of a problem or challenge, represent it from a design perspective, then critically determine solutions that resolve real world contextual needs.

Athena embodies the expert mentor persona. Experts grasp the bigger picture due to their mental model of the subject, including the sociocultural expectations, and use this model to check logic,

expectations, results and context as they go. To overcome the issues that students face, Athena will evaluate their knowledge gaps and nudge them by introducing alternatives, examples and advice, then subsequently assess depth of understanding based on an adaptive decision tree. This will enable variably paced learning, which prioritizes the individual students' strengths and weaknesses.

Current instructional methods have seen relative success in conveying concepts through traditional pedagogical methods. Unfortunately, these methods do not provide the opportunity for students to “see” how experts apply techniques to real world situations. The resultant inertia results in a loss of confidence or failure to use resources available to tackle these issues as they arise. Incorporating apprenticeship experience that lasts at a minimum for 12 months in the senior year provides the vocational experience (skill-based training) combined with on the job training. **This experiential approach also is heavily dependent on establishing and sustaining a strong STEM Alliance to foster apprenticeship opportunities for the mentee(s).** For experienced mentees, **Athena** can also assist in evaluating their work quality, minimizing the amount of time needed for on the job training. Figure 2 below illustrates the culmination of attributes the future STEM graduate will possess through the mentoring and tools provided with **Athena**.

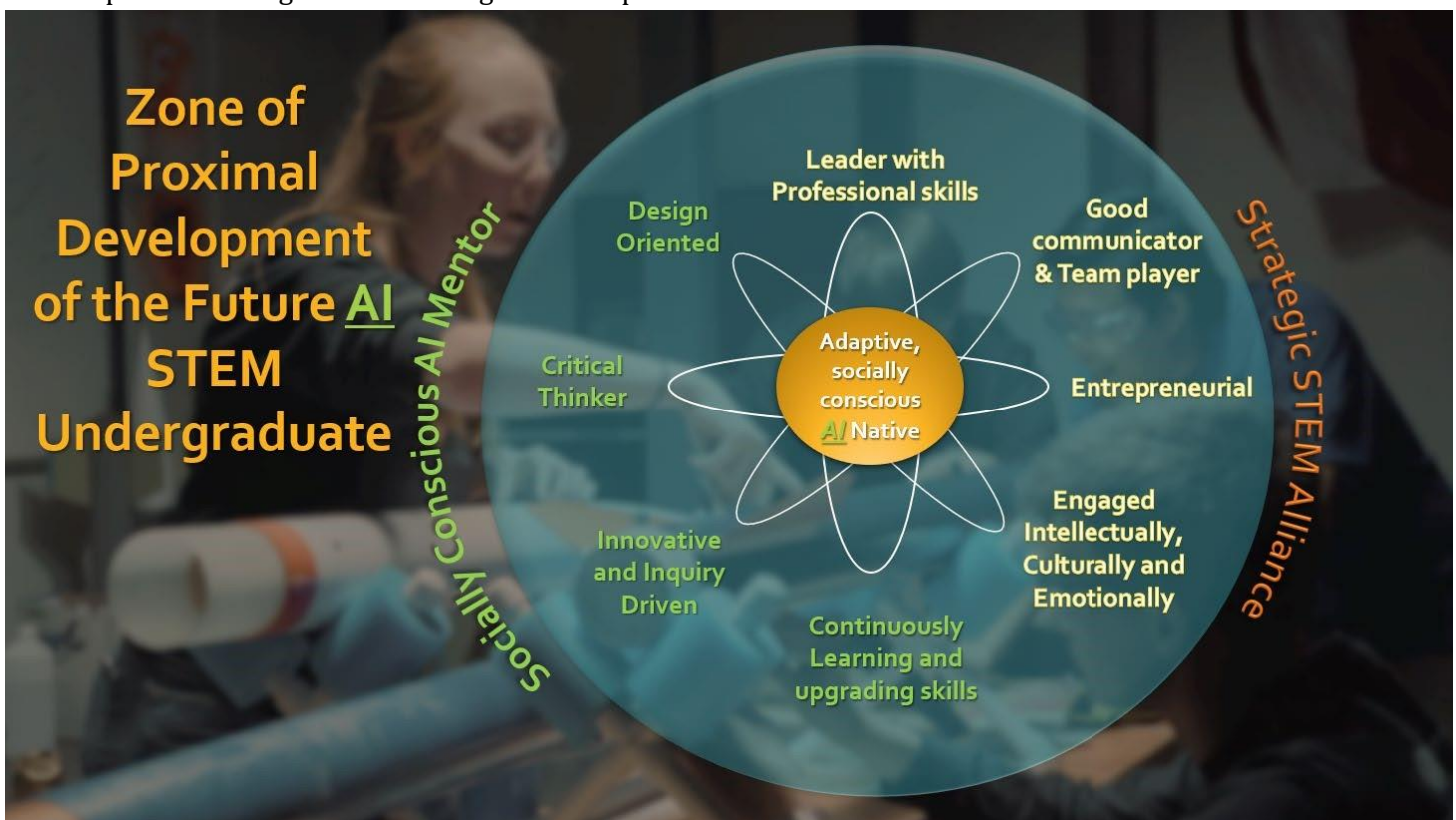


Figure 2: The AI STEM graduate attributes

This future approach to Undergraduate STEM education is explicitly designed for the mosaic of students that reflect the current cultural diversity in our society. **Innovation begets innovation;** therefore, it is imperative that we help students develop into responsible AI natives who are quickly able to adapt to future trends with an agile mindset. Realizing the vision of **an Adaptive Socially Conscious AI Mentor AI mentor like Athena** requires a commitment from educators, employers, policy makers and regulators to invest in the development of this innovative vision.



SMART STEM
My Future Career
Application



Creation of a Dynamic **Adaptive Socially conscious Personal AI Mentor** based on Student's Attributes

- Continually mine student attributes
- Create Adaptive Multidisciplinary Curriculum
- Use predictive algorithm
- Leverage Apprenticeship Database based on Student Attributes
- Determine "possible future selves" and building multiple STEM career identities



Optimization and integration with cloud based
Knowledge Think Tank –
* throughout UG Stem education



Address Gaps noted during apprenticeship

Vocational experience
Translating theory to practice



"Up/Reskill" Expert Alliances

STEM Partnership Alliance



- Adaptive Modular Blended Learning Curriculum - E Learning portals
- Variably paced with Expert Guidance 24/7
- Virtualization, digitalization and automation using Intelligent algorithms

- Mentorship (ZPD) for student through graduation
- Build identity in STEM career of choice

- Apprenticeship to develop adaptability
- Employability skills and experience real workforce needs.
- Apprenticeship (12 mths) STEM Partner – Senior Year

Zone of Proximal Development of the Future AI STEM Undergraduate

Socially Conscious AI Mentor

