



STEM



intelitek

Crossing the Chasm to Mainstream STEM Education

Implementing STEM to Solve
Today's Educational Challenges

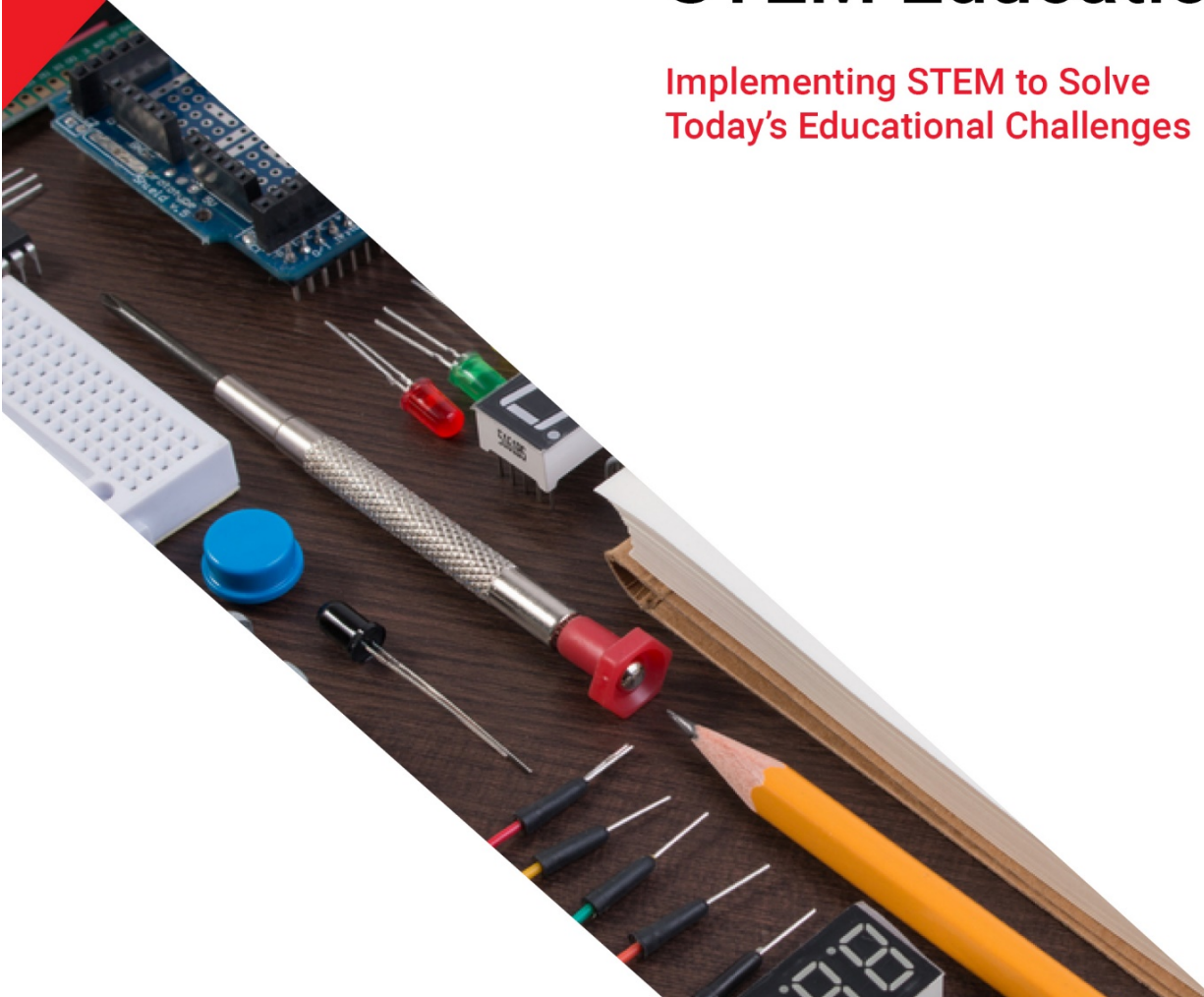


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Crossing the Chasm to 21st Century Learning

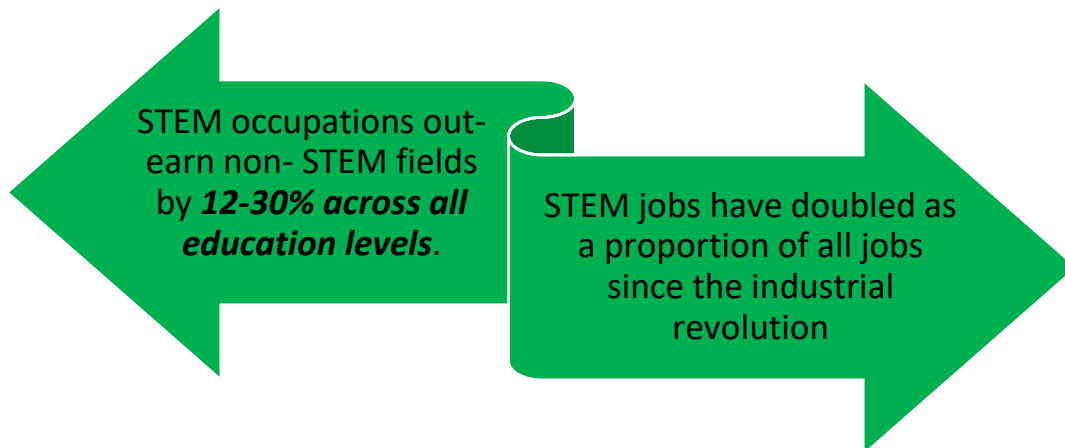
The goals of education have moved on from simple knowledge transfer. Our understanding of learning has developed, and society needs students with critical thinking skills. Given that today, where technology has become all pervasive, from digital innovation in the classroom, to the emphasis on engineering and technology in STEM subjects themselves, schools need to rethink their approaches. Educational institutions are acutely aware that they need to use and teach technology to keep up. Digital transformation is essential in order to support students to find 21st century careers and thrive as graduates in the digital workforce. All career paths, even non-STEM related, are jam-packed with technology and the modern worker must have tech literacy skills to survive. Despite widespread recognition that more than 90% of traditional teaching does not address technology, many schools and governments are struggling to cross the divide to STEM-based learning that lead to career readiness.

Instead, many schools are simply digitizing their existing teaching methods, and therefore missing the point altogether. This only perpetuates passive learning, as opposed to using technology to develop a collaborative and interactive educational setting. This deep dive into EdTech uses CoderZ as a key example of how we should be using technology and revolutionize our classrooms and teaching behaviors. It shows how with the right tools, we can create more meaningful learning opportunities for both teachers and students, and reposition our education system to become a central, self-sustaining tool for lifelong learning.

Why STEM?

Today's workforce needs STEM competencies in almost every industry. From Banking to Agriculture, and from Manufacturing to Retail, it's not just about landing a career in IT or computing; STEM skills are the future of employment. Studies show that not only are STEM careers lucrative and vital to our economy, but we are lacking the skilled workforce to fill these jobs. In fact, estimates suggest that there are 2.4 million unfilled STEM jobs available right now.¹ Finding students who are capable of filling this shortage means adopting and integrating STEM into the classroom to truly ready the next generation.

Students in every field can benefit from knowledge and understanding of technology to enable them to practice their field efficiently and use technology to advance their field as well. Teaching STEM at an early age introduces all students to a world they may never have come into contact with and opens opportunities for them



Many people believe that STEM is just Science and Math and that C.S. is for computer geeks or engineering majors. They couldn't be more wrong. STEM is all about technology and tech literacy and how technology affects our lives. STEM is a gateway to most professions and since it can be such a flexible and interdisciplinary topic, it also introduces soft skills like critical thinking and collaboration. STEM education needs to create inclusivity and equality. STEM learning must offer all students, no matter their background, visibility to the opportunity of technology in whatever field they land up. Additionally, employers need students who can not only code, but can apply coding techniques to a given field.

¹ <https://ssec.si.edu/stem-imperative>

What's Holding STEM Back?

Despite all these benefits, STEM education is not yet all-pervasive. In many cases it is not even on the roadmaps of educational institutions, severely inhibiting students from achieving meaningful learning experiences and becoming 21st century ready. This is in large part due to some common misconceptions around STEM.

- ▶▶ There is a lack of funding for STEM studies

Despite popular belief, STEM does not need a huge investment to get started. Per student, the investment does not increase to modify the curriculum to one that can benefit from STEM. There is steady funding in the US for STEM programs², as well as many private contributions to STEM classrooms. Companies such as Oracle are well known to be huge financial supporters of STEM education, as it creates workplace-ready graduates for their employment.³

- ▶▶ STEM is just Math and Science with another name

Creating more Math and Science courses is not the same as providing your students with a technological foundation in STEM. STEM is more than just Science, Technology, Engineering and Math. It is inherently interdisciplinary, as well as covering more than just the sum of its parts. Studying through the lens of STEM gives students meaningful learning experiences that include critical thinking skills, collaboration, communication and creativity. Making STEM a cornerstone of a curriculum is about creating graduates who are workplace ready in emerging fields of software, robotics and technology. But more than that, it's about creating students who understand how to learn, and can adapt and reposition themselves in multiple fields throughout their careers.

- ▶▶ Teachers don't understand STEM well enough to teach it

It's true that many teachers have not been given the skills to transfer knowledge in a STEM classroom. However, STEM-based learning programs recognize this from the outset. For example, CoderZ includes everything the teachers and instructors need to get started, from lesson plans and assessments, to professional development and tutorials behind the scenes. Teachers with the right training can easily become mentors and leaders in rolling out technology literacy to all students.

² <https://www.aip.org/fyi/2017/final-fy17-appropriations-stem-education>

³ [https://thejournal.com/articles/2016/12/01/oracle-pledges-\\$1.4-billion-for-computer-science-education-in-the-eu.aspx](https://thejournal.com/articles/2016/12/01/oracle-pledges-$1.4-billion-for-computer-science-education-in-the-eu.aspx)

▶▶ Not all students are STEM inclined

STEM Careers are one objective of immersing students in STEM, but not the only one. Tech literacy is the most important skill in 21st century jobs. A baker, an artist, a musician, a writer, a politician, a lawyer and almost everyone else will benefit from core understanding of how software works, how robots operate and how machines control the equipment they interact with daily. Now more than ever before, tech literacy is a must for every adult.

▶▶ STEM is a lot of hype, and not a lot of substance

It's true that STEM education is difficult to measure. What is "technology?" How do you measure critical thinking? How do you analyze collaboration? But the key areas that make up STEM studies, such as how to interpret problems and how to gather and evaluate evidence are the building blocks of 21st Century careers. That's why there are billions of dollars' worth of funding being put into STEM in the US⁴, and why President Barack Obama commented:

"[Science] is more than a school subject, or the periodic table, or the properties of waves. It is an approach to the world, a critical way to understand and explore and engage with the world, and then have the capacity to change that world..."

▶▶ STEM is not standardized

STEM topics often don't allow for your typical standardized testing. Multiple choice questions, essays and coursework of the traditional kind are usually not suitable for STEM education. But that doesn't mean you need to say goodbye to assessments. Differentiated learning is easy to implement with a cloud-based learning environment. Students can work at their own pace, starting from varied levels of knowledge or ability, and teachers can see at a glance how far they've come, and what they have achieved. In addition, computer science is becoming more pervasive in school curriculum and many states now require this to be offered at the middle and high school level.

▶▶ STEM education is expensive

Traditional STEM programs often used robotics to teach engineering and technology. While this is an excellent way to introduce students STEM, it IS expensive and so STEM programs were often focused only on small groups of tech inclined students or are more prevalent in higher income schools. Today, virtual learning, graphic simulation, and cloud-based tools can offer STEM to every student with a browser at a much lower cost and with much broader reach.

⁴ <https://www.act.org/content/dam/act/unsecured/documents/STEM/2017/STEM-Education-in-the-US-2017.pdf>

- ▶▶ There is a lack of infrastructure available to deliver STEM education.

If you identify STEM as being a robotics class, then this may be true. But if you identify STEM as the quest for digital literacy on all levels for all students, then today's cutting-edge technology makes this a moot argument.

Cloud-based learning environments help debunk this myth, too. Virtual learning, Web 2.0 tools and robotics simulations are becoming increasingly popular, allowing every student to work with technology and engineering from any desktop. The focus of technology is also not only on hardware and engineering, but also on software engineering. This is true for in school classes, as well as distance learning modules. This style of learning is low cost and low risk and gives both students and teachers hands-on STEM environments with little to no investment in infrastructure.

What Are Your Goals?

Technology is changing the way we live and learn, and education needs to be right at the forefront of this change. This does not mean implementing technology for the sake of embracing the latest fads or trends, and it doesn't mean adding digitization for the sake of checking a box that shows the world you're a 21st century ready classroom. These kinds of ventures are bound to fail and are simply a rehash of traditional teaching methods through a digital lens. Although many classrooms now include computers or tablet devices, it's a poor example of digitization for your students to simply be swapping a pencil and paper for a G-doc, or a handheld calculator for a handheld device complete with calculator app. This quote from Lee and Broadie sums up the problem with this style of digital transformation, and it's *all in the mindset*.

“Since the launch of the World Wide Web in 1993, thousands upon thousands of teachers devoted millions of hours striving to provide the young the desired digital education. Many devoted their lives to the quest. The reality is that all were obliged to do so within a traditional, linear, hierarchical, Industrial Age organisational structure, with factory-like processes, mindset and culture. They were schools where the heads invariably had – and still have – little understanding of digital technology, and where the government, despite the rhetoric, attached little importance to every child growing their learning through digital means”⁵

Simply put, there is no point trying to add technology within the same Industrial-age mindset or structure. You need to turn the process on its head. Discover the ways that technology can help you change your classroom into something more, how it can empower your students to enjoy meaningful learning experiences while preparing them for the job of the future. Define the challenges that you want to solve as teachers and organizations for both yourselves and your students - and then implement your digitization strategy to support achieving those goals.

⁵ <https://educationtechnologysolutions.com.au/2017/10/failure-school-digital-education/>

21st Century Skills

One way to discover the right approach for your school is to look at the skills you want your students to graduate with.

Creating a list of the key competencies you would like your curriculum to nourish is a great way to build your technological curriculum. These don't have to be just technical skills. The right strategy should build on both hard knowledge and soft skills such as confidence, teamwork, adaptability or strategic thinking.

The emphasis of STEM however, is on technology education. For some this is awareness, for some it is literacy, for others it is immersion. All educational areas and career paths have the need to touch technology in the 21st century and in Elementary, Middle and through High School, it is the educator's role to guide students through some level of STEM expertise to ready them for their "real-lives".



The Challenges for Today's Schools

Of course, creating a wish list can feel like a pipe dream when there is so much in the way of adopting the right technology training or STEM Patchway. Enhancing what you currently do with a technologically advanced alternative can seem to be the only options within your reach. However, taking a long look at the challenges you're facing can actually help you discover the STEM education strategy that will work best for your unique environment.

Funding

Most schools struggle to stay within their budgets, and as we discussed earlier, funding is definitely one of the key barriers to embracing STEM education and technological innovation around the globe. Funding levels affect lower income students more than others, with the US Commission on Human Rights commenting that students from poor backgrounds often end up with the worst facilities, the fewest supplies, and the least intensive curricula.⁶

Technological innovation in the classroom cannot be limited to the schools or municipalities with the loosest purse strings. Essential workplace skills need to be accessible to all, and this can't happen without technology in every classroom, no matter the income of the families who send their children to that particular institution, or the wealth of the country itself in the global economy. Current STEM robotics programs are available to just 1% of the population, and technology itself needs to be finding a solution to this inequality of opportunity.

Accessibility

The funding gap is more often than not resolved by exclusivity. In order to channel the diminished funds to STEM, the programs are targeted at STEM inclined students. Most options are only offered as electives in higher grades, and only those with the predisposition to engineering careers benefit from Robotics Clubs and AP classes.

The fundamental change that is required is exposure of all students to STEM at as early an age as possible. Allowing all student to learn technology will increase the pool of STEM graduates and introduce students to a direction they never considered before.

Inclusivity

In addition to the economic equity in STEM studies, there are other areas where the playing field is unbalanced. Gender is one area that many schools are trying to work on for example. While

⁶ <http://www.latimes.com/nation/nationnow/la-na-civil-rights-schools-20180111-story.html>

STEM is undervalued in many countries, when you look at the statistics of STEM for girls and women, the results are even more dramatic. While in GK-12 education, girls perform on par with their male peers in Science and Mathematics, their interest level often changes once they enter higher education and beyond.⁷

Studies vary, but only 15%-25% of STEM careers are held by women, with some industries suffering more than others. In mechanical engineering for example, just 7.9% of engineers are female.⁸ Perhaps more worryingly, the gap is widening, and when you add issues of race and ethnicity into the mix, the ratios are even greater between men and women in non-social sciences and technology. If you cannot bring technological innovation into the classroom for both men and women, you are doing the workforce of tomorrow a disservice, and perpetuating stereotypes which keep certain industries in stasis.

Student Engagement

Today's students have far higher expectations than when their teachers were in school. Even before children enter the kindergarten classroom, many are familiar with technology and find what we see cutting edge as boring or old-fashioned. Teachers need to keep up with their students rather than feel left behind. Today's students are born with technology and teachers must take advantage of this rather than avoiding it.

Keeping students engaged means tapping into what makes young people today tick. Naturally, since pen and paper have been replaced by tablets and keyboards, the biggest successes have been seen in areas such as online learning, graphic applications, competitions and gamification, where empirical reviews have shown gamification to improve results, participation and enjoyment in the classroom.⁹ The best results have been seen when gamification can be intrinsic in the learning itself, not merely external motivation from a third-party source.



⁷ <https://ngcproject.org/statistics>

⁸ <https://nsf.gov/statistics/2016/nsb20161/#/>

⁹ https://people.uta.fi/~kljuham/2014-hamari_et_al-does_gamification_work.pdf

Professional Development

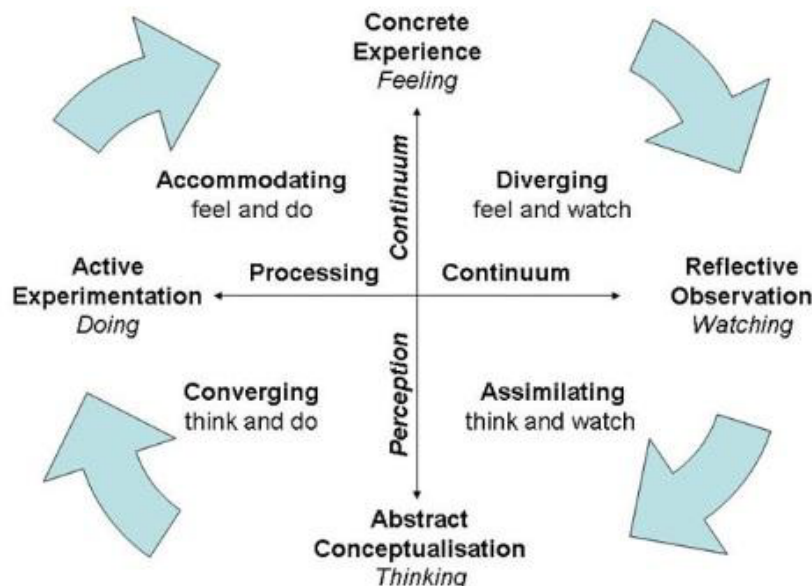
Are the teachers ready to teach STEM? It is critical for administrators to realize the level of intimidation some veteran teachers harbour for entering into the world of digitally native students.

A percentage are ready, they are Computer Science or Science grads or maybe industry veterans who migrated to education, but many are not. Providing the framework to enable teachers to facilitate without needing extensive training and to ease into STEM with the same tools and base knowledge their peers and their students have is essential to expanding the reach and breadth of STEM in schools.

The chasm is far too wide for administrators to assume the teachers can bridge it and so providing extensive access to training, peer mentoring, webinars, and support resources for teachers may be one of the most important challenges to address.

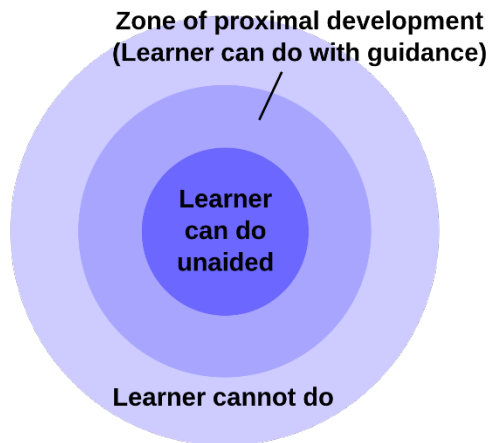
Making Learning Relevant for Students

Research has shown that if the classroom is not a learning environment that creates a learning experience, it will not succeed. The goal for experiential learning is well described by David Kolb's famous Experiential Learning Cycle. He describes a four-stage cycle of learning that focuses on experience, perception, cognition and behaviour. This holistic perspective explains how teachers and institutions can make learning relevant and intrinsic for the students they teach.



A student in an experiential learning environment, can then understand how to observe accurately, think about what is missing, and then experiment to work out solutions to complex problems. They will feel motivated by challenges that are set at the right level of difficulty, as well as believe that they are able to develop their own abilities through learning. Solutions using real-time gamified simulation like CoderZ, allows students to tangibly see what they can do today that they could not do before, and take control of their own learning.

Zone of Proximal Development - Where Students and Teachers Meet



Created by Lev Vygotsky, the Zone of Proximal Development¹⁰ is a great way to uncover one of the key goals of STEM education in classrooms, and the balance of education between teacher and student. A simple model, it's been widely used and modified since its inception, but the core meaning remains the same. The zone is the space in between what the student can do unaided, and what they cannot do. A STEM learning tool that stimulates self-learning or that provides the guidance for students to collaborate,

experiment and expand their skills supports closing the gap without requiring the "old school" teacher to be the only bridge to knowledge.

The Role of the Teacher in Motivating Students for Success

It's important to consider this tool when training educators to become STEM leaders. For many teachers and instructors, introducing technology into their classrooms can feel like more of a threat than a supportive tool for success. The upsurge in automation and digital learning can make many teachers feel superfluous, especially if they are used to the traditional methods of

¹⁰ https://en.wikipedia.org/wiki/Zone_of_proximal_development

knowledge transfer. If your student can look up any information they need from their mobile phones – what is the point of a teacher in today’s classroom?

This attitude needs to change. Technology gives teachers the opportunity to move from the traditional model of information transfer from one person to another, to become something much more relevant and exciting. With technology taking on a lot of the tasks like grading, fact checking, keeping track of student progress and even reports, teachers can build real relationships with their pupils. In this age, teachers are needed for guidance and mentorship, encouraging their students and helping them relate to what they are learning, problem solve and establish creative thinking skills.

Teachers move from traditional chalk and talk methods, to being valuable resources for their students, identifying weaknesses and challenges, and encouraging the students to unravel information, think of solutions and feel empowered for success. As a facilitator, the teacher is far more valuable than a mere figurehead at the front of a classroom. Gamified, personalized learning environments like CoderZ enable teachers to focus on defining challenges, motivating students and clarifying the long-term objectives of their learning.

Flipped classrooms are another great example to consider. The model involves students accessing information and facts from home before the lesson, in their own time. They then come into school armed with the knowledge for the class and discuss it in person with guidance from the class teacher. This is the exact inverse of homework, where the teacher gives over information, and it is reinforced with at home repetition. The information transfer is no longer necessary, and for many is seen as a waste of time and skills. Instead, let digital media and the internet take the place of handing over knowledge, and empower teachers with the tools to encourage students and build soft skills like confidence, collaboration, teamwork, time management, and problem solving, and guide students to the right areas of learning for their aptitude.

This change may seem huge and cannot take place overnight. Many teachers are resistant to technological innovation and in some cases STEM education, or innately distrust it altogether. Most schools and institutions believe they don’t have the time or funding to implement new ways of working or wouldn’t know where to begin. Off the shelf educational solutions are badly needed that can be quickly deployed and include the end-to-end tools necessary for successful digitization.

The CoderZ Difference

Supporting STEM, Supporting Diversity, Offering Access to All

CoderZ is an example of a solution designed to address these challenges head on. One of its unique differentiators is the cloud-based framework. While architectural changes are slow and expensive to make, Software-as-a-Service (SaaS) has revolutionized almost every industry, including education. Employing a cloud-based solution for learning means that many of the issues of cost, inclusivity, accessibility and diversity become irrelevant, as the content can be accessed from anywhere on any computer.



CoderZ also levels the playing field, working equally well for beginners or experienced coders alike by offering personalized paths and self-paced learning. As CoderZ uses both Blockly, a unique visual approach to coding for beginners and Java, text-based coding for experienced students, it's suitable for all experience levels, and can help individuals start from the ground up. The advantage of a learning environment based on a Visual Programming language is that this lowers the barriers to students who are English Language Learners or students with Learning Differences such as Dyslexia. Students can focus their learning on concepts such as flow and conditional logic without being impeded by syntax.

In some regions, states or countries, educators are looking for an entry point to coding and robotics for their students and teachers, many of whom have never worked with robots before, or have a low experience level in STEM topics. Integrating classroom management, teacher guides, pacing guides, tutorials and professional development support the teachers in introducing STEM to their classes.

Preparing Teachers for Success

The CoderZ learning environment also guides and encourages teachers to make the move from traditional teaching methods of instruction to becoming mentors, embrace the zone of proximal development and provide valuable support to their classrooms. The cloud-based solution can host unlimited classes and takes a lot of the administrative work off the hands of staff. No IT

support is needed for software updates which allows for continuous improvement of the learning environment.



Teachers are empowered with the information and tools they need to excel in their own professional development, as well as keep on top of student and class progress at a glance. Studies on teacher empowerment have shown that when teachers are empowered, this has a strong effect not only on teacher commitment, but also on student achievement,¹¹ With 8% of teachers leaving the profession annually before retirement age, it's clear how essential this is to consider when introducing STEM to our schools.¹²

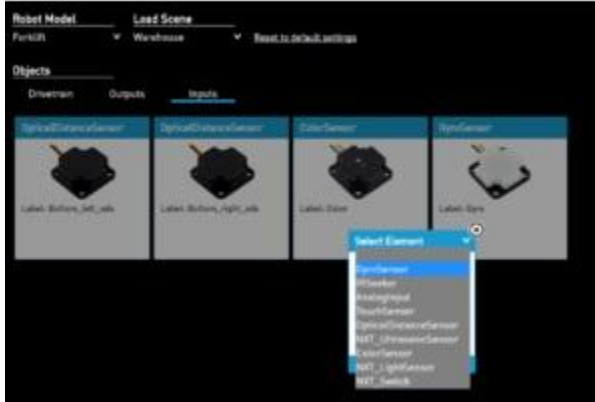
CoderZ encompasses classroom management, teacher training, tutorials, professional development, a knowledge base, and class tools like pacing guides, mission solutions, and assessments.

Meaningful Learning Experiences for Students

The CoderZ learning environment seamlessly employs the very gamification tools that have been shown to increase engagement, participation and motivation. Realistic simulations allow students to solve challenges and move through levels, increasing their knowledge along the way. The 3D simulations are fun to play and beautifully designed, featuring real-world problems that get progressively more difficult as you move through the courses. Differentiation for teachers becomes seamless, as all students can work at their own pace, with no one being left behind or unchallenged while others 'catch up.' The program also celebrates their success, as students ask questions, their peers are able to help their friends and gain confidence in their own abilities. The intrinsic learning comes from the experiential model of study and gives students the knowledge that they will not fail.

¹¹https://www.researchgate.net/publication/305272998_The_Effects_of_Teacher_Empowerment_on_Teacher_Commitment_and_Student_Achievement

¹² https://www.huffingtonpost.com/entry/where-are-all-of-the-teachers-going_us_596b7e10e4b06a2c8edb474c?guccounter=1



The 3D simulation itself is a cutting-edge hands-on experience that motivates and engages students. Using simulated robots, all students have the chance to work with their very own virtual robot, which can be configured to link to physical robots in the classroom. Each student can build and test their own programs, before downloading them to see them work in practice. The learning environment really takes robotics to the ‘other 99%’.

The Student’s Perspective

“CoderZ changed the way that I feel about robotics and coding because it introduced me to what it is like to put the code together and seeing how the robot goes”

“CoderZ has changed the way I see STEM programs, before I didn’t really like programming, but now I am more into coding because I see the connection better”

“I always looked at STEM programs as things we had to do in class and kinda boring. But CoderZ has been fun!”

“It is not difficult to get girls into STEM programs, with CoderZ it’s super-easy and fun to do”

“I liked using CoderZ because it breaks down all the steps in creating a program and makes it easier to understand”

“I like I because it’s like a video game, it’s fun while I study and learn”

CoderZ’s gamified interface and level orientation is integrated into the learning program and students are engaged and motivated to progress which requires learning new engineering, math, science and coding skills.

Recognizing What to Measure: Monitoring Student Progress and Failure

The cloud-based environment gives another benefit which is less obvious; that of monitoring every aspect of student activity, achievement and progress.

For instructors, objective data removes the issue of perception in grading and reporting on students, giving unbiased facts about progress and performance. Teachers can highlight emerging issues or trends that are happening in their classroom, identifying the root cause of repeat problems and troubleshooting proactively to ensure they are solved before they result in

more student anxiety or failure. Looking at a particular student's progress in real time and in granular detail gives teachers the ability to suggest personalized streams of learning or point them in the direction of the right resources for support and follow their progress to see what difference the help has made. Personalized learning can be modified to support a student's own strengths, culture, ambitions, or desired skills.

Continuous feedback is also a huge benefit for the students themselves, who have a real-time view of their performance and tools to develop the cycle of experimentation and correction. CoderZ for example uses a Heads-Up Display, which gives an accurate representation so that students can examine and amend their own work. Rather than complete a project and then wait for feedback, students can self-assess, repeating tasks until they achieve success. Studies have shown that self-assessment can be just as effective as instructor feedback, as well as having the added benefit of growing the learner's confidence and skills.¹³

Metrics are extremely powerful and can help instructors to build relationships with their students, as well as customize learning for each student.

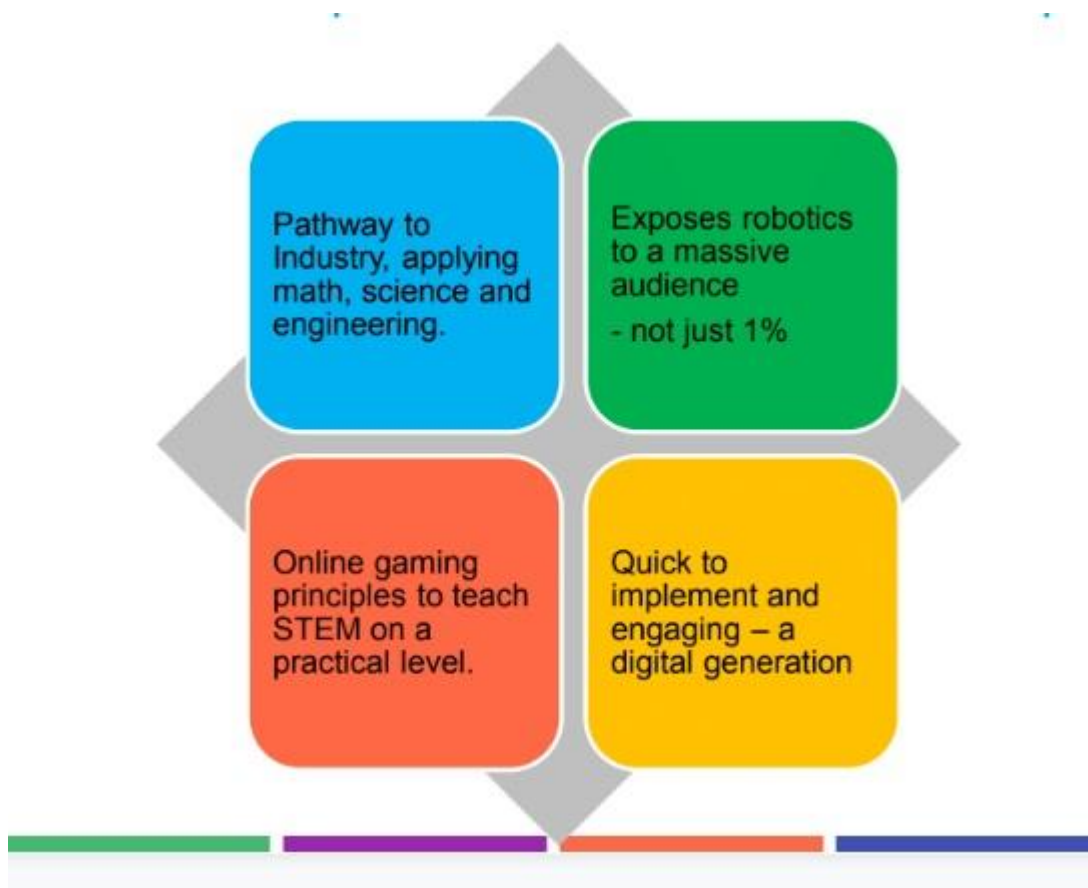
¹³ <http://journals.sagepub.com/doi/abs/10.1177/1469787416637466>

Making Technology Work for Your Environment

Teachers will never be replaced by technology. The two need to work in partnership, with technology providing the tools for teachers to facilitate the learning process, and teachers providing the guidance to students to utilize the knowledge and skills they learn, working in perfect synergy.

While CoderZ is a powerful learning platform, it is the teachers that identify the problems that need solving and support the students in making a success of STEM classrooms and study.

In order to support this synergy between learning technology and cutting-edge teaching methods, digital disruption in education needs to be more than simply replacing your existing model with its technological equivalent. In order for technology to make a real difference for both teachers and students, tech learning needs to address the benefits it brings to solve the challenges that we face today in the 21st century, as we attempt to create tomorrow's workforce.



CoderZ stands out from the crowd, because of its innovative approach, which allows anyone to access STEM learning, from wherever they have an internet connection. As it works for both novices and experts, it removes the barrier to entry which we so often see in STEM education, not only for students – but instructors too. By providing support to educators, CoderZ tackles the issue of a lack of experienced STEM teaching talent, with a learning environment that can continuously train talented staff to become mentors and educators for STEM in and out the classroom.

CoderZ's unique focus on real-world problem solving, creates pathways to STEM careers that our economy so desperately needs. Whether this is a career in engineering, software development or any other field where strategic thinking, creative learning and team-building is relevant, this technology is built for today's industry, and that of future generations.

The use of intrinsic gamification and competition is shown to be one of the best ways to promote participation, motivation and engagement in learning today, encouraging students of all ages to get involved and stay both incentivized and enthusiastic. CoderZ uses gamification to enthrall students with a taste for technology and an understanding of engineering, mechanics, math, science, geometry, trigonometry, and specifically coding.

This platform is not merely a product, it's a recipe for crossing the chasm between the traditional learning methods of yesterday, and the engaging, inclusive technology environments of tomorrow.

Checklist for Crossing the Chasm to 21st Century Skills and Careers



Engage students and keep them intrinsically motivated



Create pathways to today's STEM careers



Empower teachers and parents to feel valuable and adapt to technology



Provide tools for measurable insights and monitoring of student progress



Promote diversity and inclusivity at every turn



Be affordable and simple to implement and scale



Allow for measurable insights against desired outcomes and KPIs



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