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21st Century STEM Education

"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..."
— President Barack Obama, March 23, 2015

The United States has developed as a global leader, in large part, through the genius and hard work of its scientists, engineers, and innovators. In a world that’s becoming increasingly complex—where success is driven not only by what you know, but by what you can do with what you know—it’s more important than ever for our youth to be equipped with the knowledge and skills to solve tough problems, gather and evaluate evidence, and make sense of information. These are the types of skills that students learn by studying science, technology, engineering, and math—subjects collectively known as STEM.

This education trend is pushed by leaders around the globe, both in the western world and in developing countries. Educators understand the importance of science and math, and are focusing on engaging students in these subjects from very young age—starting in primary schools.

Ministries of Education are investing in one major task—increasing the number of students majoring in STEM subjects. These students will later choose STEM careers in fields such as engineering, computing, and medicine, which are the key building blocks for any modern economy. It is becoming evidently clear that if there is one educational focus today that can truly bring change to developing nations, it is STEM education.

Yet, few students pursue expertise in STEM fields today. Additionally, there is an inadequate pipeline of teachers skilled in those subjects. That’s why President Obama and many other leaders have set a priority of increasing the number of students and teachers who are proficient in these vital fields.
Our Future Economy

Globalization is posing a major challenge on countries around the world. For example, most consumer electronics were once made in Hong Kong or Singapore. This huge industry migrated to China 20 years ago, but as the cost of living in China increases, production is now moving to Vietnam and other countries. The conclusion here is crystal clear: labor-based economies are hard to keep. In the 21st century, a country’s independence is directly related to their economic strength. Focusing on knowledge-based industries is a much safer investment for building a healthy economy.

A good example of a STEM-focused nation is Singapore. At the turn of the century, Singapore’s government pledged to spend S$6 billion over five years to kickstart a Bio Medical Science initiative. This small island nation of five million inhabitants has made a huge leap from an industry focus on consumer electronics production to biotech research and development. Today, Singapore has emerged as the world’s third most biotech innovative country, preceded only by the USA and Denmark.

Knowledge-based industries require innovators, educators, researchers, and leaders who can solve the most pressing challenges facing their nation and the world, both today and tomorrow.

But, right now, not enough of our youth have access to quality STEM learning opportunities, and too few students see these disciplines as springboards for their careers.
Our Goal

President Obama has articulated a clear priority for STEM education: Within a decade, American students must “move from the middle to the top of the pack in science and math.” Countries around the world are all participating in this “technology race to the top,” and Ministries of Education are setting the same goals:

- Increasing the number of students majoring in STEM subjects.
- Engaging kids at very young age to learn science and math.
- Providing schools with modern technologies and content that will both attract the students and help them cope with the abstract concept of science and math.

As such, the focus on computer hardware specification is shifted to the focus on the digital curriculum quality bundled and offered by these computers.

The new Google Chromebook computer, offered to schools since 2012, is living proof to this change in focus. The Chromebook is a very “weak” computer in terms of hardware specification—it is merely a thin client with all its software and student data stored on the cloud. Yet, it enables ministries of education to easily update all student applications and deliver more and more digital content. As a result, schools are snapping up Chromebooks, and Google expects to provide American schools with more than 7.3 million units in 2015, a 27% increase compared to 2014 sales.

Empowering Science and Math

Numerous technology projects done in the United States and Europe, including school computing and 1:1 computing, all carry the same conclusion: The key elements which distinguished between a successful to a non-successful project are content and training.

A computer platform is indeed a very good start. Students relate to it and are more open to learn and explore with the use of a computer, compared to any other educational tool. However, if not used to deliver the local syllabus, the computer will soon become destructive and be used for gaming, messaging, and other non-related educational activities.

Computer-based digital laboratories offer a very important tool for science education, allowing students to use computers and tablets to perform science experiments. Students are using probes connected to their computers for measuring temperature, humidity, force, motion, and many other parameters. With a powerful, fast, and easy-to-use digital lab, students are able to explore many topics such as photosynthesis, acid-base titration, greenhouse effect, and Newton’s laws, to name just a few. This dramatically increases student understanding of the theoretical and abstract subjects in biology, chemistry, and physics, while developing student learning motivation for these subjects.

Moreover, students can create their own science projects, analyze their measurements, and conduct collaborative research with other student groups.

The use of such 21st century modern laboratories combined with computers and tablets appeals to students, attracts them to explore science, and motivates them to select science and math as their main focus in school—and future career.
Boxlight is working with key schools and ministries of education to provide the best solution for K–12 science education. Our Computer-Based Laboratory (CBL), the Labdisc, offers the most advanced all-in-one science laboratory, with up to 15 sensors built in a single wireless meter. Together with our multi-platform Globilab analysis software and our mobile science cart, we are delivering the most modern and comprehensive solution for science education today.

The Labdisc enables hands-on experimenting in science—a key requirement for students’ understanding of abstract science concepts.

The Labdisc replaces more than 20 traditional meters, cables, and individual sensors. What’s more, it saves teachers more than 90 minutes in preparation and equipment calibration before every lab session.

Our modern, mobile science cart stores and charges 16 Labdisc units and 16 tablet computers. It brings science to every class in the school and eliminates the need for investing in a special room for a school science laboratory. Finally, messy and expensive science labs with heavy equipment are a thing of the past.

Our science offering currently includes more than 1,300 pages of experiment guides in physics, biology, chemistry, and environmental science. These guides are translated and localized to the needs of the Ministry of Education. They are correlated to the topics of the local syllabus, and enhance the theoretical text books with real science activities.

Training is critical for any successful project. As such, we conduct a 3- to 5-day teacher course as part of the Labdisc implementation. This course is coupled with 6 months of activities including weekly tasks, school completion, and school projects.

The Labdisc is being used all around the globe, in developing countries as well as in the USA, UK, Russia, and China.

Since being launched in 2011, the Labdisc products are been used by over 500,000 students in more than 30 countries and 15 different languages, winning 3 gold medals in international competitions.
Configuration for Every Science

Boxlight modern school laboratories are designed for providing teachers with the highest comfort in preparing for the lab session, while enabling the coverage of many science topics with the minimum set of equipment.

The Labdisc K-12 line includes 3 unique models dedicated to the broadest range of school science, with 7 to 15 built-in sensor configurations.

**Labdisc for general science**

Built-in sensors include:
Air Pressure, Ambient Temperature, Current, Distance (Motion), External Temperature, GPS, Light, Microphone, pH, Relative Humidity, Sound, Universal Input, Voltage.

- Typical activities include: Traveling speed with GPS, Newton’s laws, sound waves, electrical currents, pH titration, endothermic and exothermic reactions, Boyle’s Law, specific heat, and microclimate.

**Labdisc for biochemistry, biology, and chemistry**

Built-in sensors include:
Air Pressure, Ambient Temperature, Barometric Pressure, Colorimeter, Conductivity, Dissolved Oxygen, External Temperature, GPS, Heart Rate, Light, pH, Relative Humidity, Thermocouple, Turbidity, Universal Input.

- Typical activities include: Skin temperature; pulse rates before and after activity; sweat production and photosynthesis; solid, liquid, and gas phase changes; and pH titration.

**Labdisc for physics**

Built-in sensors include:
Accelerometer, Air Pressure, Ambient Temperature, Current, Distance (Motion), External Temperature, Light, Microphone, Universal Input, Voltage.

- Typical activities include: Lenz’s and Boyle’s laws, resistor networks, light source efficiency, light vs. distance, sound beat and wave superposition, Newton’s Second Law, and free-fall acceleration.
Primary and Middle School Lab Set

Primary and middle schools are using the Labdisc Gensci model, which is able to measure 12 different parameters and cover general science topics such as: plants, human body, electricity, mechanics, weather, environment, greenhouse effect, acid rain, and many more.

The science cart, together with Labdisc Gensci units and tablets, can serve the entire school, shared by the different classrooms to provide every 2 students with a full modern measurement station.

Secondary School Lab Set

Our secondary school configuration offers more comprehensive experimenting in biology, chemistry, and physics, and includes a cart full of 16 x Labdisc Biochem units, which are able to measure 15 different parameters in biology and chemistry.

For physics labs, we offer a cart with 16 Labdisc Physio units, each equipped with 12 different sensors for measuring parameters such as electricity, mechanics, sound, light, and more.

Students working with the Labdisc Biochem can experiment in: acid-base titration, spectrophotometry, human body, seeds metabolism, specific heat, diffusion, photosynthesis, phase change, gas laws, weather, and more. With the Labdisc Physio, they can cover Newton’s laws, Lenz’s law, Ohm’s law, electricity, mechanics, sound waves, superposition, and more.

In addition to the Labdisc carts, we also provide science kits with all equipment needed to cover all of our secondary experiments.
Localization
We localize our digital science laboratory to meet the needs of the local Ministry of Education. Localization includes:

- Translating our software to the local language (already available in 15 languages).
- Providing the software free of charge for all schools and students.
- Correlating our experiment guides with the local science syllabus.

Pedagogic Research Support
Computer-Based Laboratories (CBL) have been used over the past 30 years in the USA and Europe, with the evident benefits below:

Improved Test Scores
Use of probeware technology tools for hands-on science experimenting can provide a learning advantage to students, as evidenced in student test scores in science courses (National Center for Education Statistics, 2002, 2012; Schneider et al., 2002).

Deeper Understanding of Scientific Concepts
A variety of studies have shown that probeware can have a positive impact on the depth of students' science understanding when used in a context of scientific investigations that engage students in scientific practices (Linn & Hsi, 2000; National Research Council, 2006; Schneider et al., 2002; Thornton, 2008; Zucker et al., 2008).

Supporting a Framework for K-12 Science Education
Use of technology tools for data collection, analysis, and visualization in a context of student scientific investigations can provide experiences with core scientific practices for students, as called for in *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council, 2011).
**Boxlight Case Study**

As the English idiom says, “A picture is worth a thousand words.” The photomontage on the following page was made out of the thousands of photos sent to us by teachers participating in our science project in Baku. It was presented to the Ministry of Education in Azerbaijan at the concluding ceremony of this successful project. An internal survey done by the Ministry of Education scored Boxlight at 6.7 out of a maximum of 7 points in teacher satisfaction.

Boxlight is using a well-proven procedure for all its projects.

Our offering includes:

- Pilot stage in 50 high schools, modernizing their labs with our Labdisc technology.
- Equip each of these 50 schools with 2 science carts:
  - Cart with 16 Labdiscs for physics (Labdisc Physio model).
  - Cart with 16 Labdiscs for biology and chemistry (Labdisc Biochem model).
- Translate our software and experiment books to the local language.
- Correlate our experiment guides with the local science syllabus.
- Provide a 3-day local teacher training.
- Open user groups for teachers using platforms such as Edmodo or Facebook.
- Employ a project moderator who engages teachers on conducting different science experiments each week.
- Have teachers and students upload their weekly work—lab reports, graphs, photos, and video clips—to our Edmodo/Facebook group.
- Conduct competitions between schools for the best experiment of the week.
- Keep ministry involvement in encouraging school participation.

As a result, we see a massive increase in student motivation towards science. With weekly engagement of students in science experiments and projects, students see the beauty in science and math and excel in these important subjects.

This will revolutionize science education in the country, leading to additional implementation phases in more schools, where pilot phase teachers are being used as trainers to all new teachers joining the project.

Eventually, Ministries of Education currently engaged in migrating to digital curriculum will see the huge benefits of using CBL in science education. And as a result, they are making it mandatory as part of science teaching requirements, matching countries such as the UK, USA, and France, where it is already mandatory.

Want to learn more about the Labdisc solution?
Visit [mimio.boxlight.com/labdisc](http://mimio.boxlight.com/labdisc).