STEM workforce preparation program aligned with New Jersey's 21st Century Life and Career Skills standard

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Abstract

The Education Sector is the primary provider of prepared talent for the Talent Marketplace, where the Workplace Sector is the primary customer. Constant and rapid change in the workplace leads to changing needs for knowledge and skills. It is imperative that today's educators become informed of these evolving needs, so that they can better prepare tomorrow's workforce, sitting in their classrooms today, for employment and successful career development. R_xeSEARCH: An Educational Journey, which has both an Applied Science Classroom Track and a Workplace Track, is described as a model program for education-workplace collaboration. The Workplace Track aims at developing student skills and behaviors that have broad application also outside the science, technology and engineering workplace sector.

By incorporating scientific habits of mind in daily living, we are able to identify, analyze and solve problems. Having learned to distinguish facts from fiction, and being able to understand and interpret evidence, we are better equipped to make critical decisions that can impact our future.

All these skills are also important in every workplace where the ability to think critically, to device creative solutions to problems and to make decisions based on facts and projected outcomes, is highly valued (Adult Literacy, 2008; Lievens et al, 2001; Price and Turnbull, 2007; Shaffer et al, 2007).

The Talent Marketplace

As citizens we move in and out of our roles as consumers. Most of us contribute to a production supply line in our daily work and we help maintain a marketplace with millions of products and services delivered and received daily. If we consider talent to be such a product, it will allow us to define the talent marketplace. We can then define the supply chain that leads to the talent marketplace, and we can delve into the talent consumer characteristics. There are producers/developers and users/ consumers of marketable talent. Who are they and how do the interact?

The Developers of Talent

Obviously, talent comes as raw material to the first station of refinement. The loving care of parents and family has already laid the groundwork for a finished product. Whether it begins in day-care, pre-Kindergarten or Kindergarten, the development process continues for at least another twelve years. The

increasingly refined product – student learners – move from teacher to teacher, grade to grade. Finally, one day, Talent Preparation Stage 1 is over on high school graduation day.

The education system responsible for this product development has changed little over the past decades. Educational standards are now being compared between nations, and increasingly, best practices are shared, stimulating discussion about needs for improvement.

However, educators everywhere struggle with a key dilemma. There are only so many years in the life of a young person that can be dedicated to primary and secondary education, but there is a growing body of knowledge from which to choose what is necessary to know at the end of secondary school. New blueprints for learning and teaching, such as the US Next Generation Science Standards (Achieve, 2012) do not provide advice on how to find resources to get the ever more demanding teaching job done.

The Users of Talent

We are all consumers of science products and services provided by talent that contribute to research, development and commercialization, spanning a wide range of professions. The workplace views this skills base of its employees as one of its main assets (Grindley, 1991), closely linked to its core competencies (Garavan et al, 2001).

How does this talent find its way into workplaces where products and services of science are prepared?

Some of the talent is hired directly from high schools and community colleges into service and support functions and manufacturing. Entry-level jobs might be populated by competitive Bachelor degree college graduates whereas highly specialized, advanced degree holders (M.S. and Ph.D.) are sought for key manager and executive positions. Employees with special, highly valued competencies, “knowledge workers,” (Jackson et al, 2003) are sought after and targeted for career development, often involving international assignments (Bartlett and Ghoshal, 2003; Caligiuri and Di Santo, 2001; Stahl et al., 2007). However, the workplace sector is in a state of constant change. This change is driven by a need to adapt to economic and political circumstances, both at regional, national and international levels.

Increasingly, the workplace sector operates globally. Multinational enterprises work in strategic alliances across organizational boundaries and national borders. Their missions, operational principles, standards of quality, ethics and conduct are constantly influenced by other network members. As norms change in these networks, all members become aware and adjust accordingly. This means that change happens quickly, and at some level change is continuously ongoing (Albrecht and Sack, 2000).

Studies of the impact of company size on productivity and growth gave rise to descriptors borrowed from the animal kingdom. Birch and Medoff (1994) labeled small (less than 20 employees) and large companies (more than 500 employees) as Mice and Elephants, respectively. Neither of these two ”species” generate significant new employment. Enterprises who grow quickly by acquiring their competitors may approach a plateau of productivity (Dickerson et al, 1997) and find themselves in competition with Gazelles (Birch and Medoff, 1994). These are neither small nor large, but often young, nimble and fast moving companies, quick to adapt to change (Acs and Mueller, 2008).

Internal organizational changes have led to new demands on the individual employees. The very large departments growing inside the elephant corporations, characterized by many layers of management, have been found to foster risk aversion, inertia and slow decision making. “Flattening” of organizational units have led to increased personal accountability, faster communication and quicker decision making deep down in the organization (Hammer and Champy, 2003; Industry Week, 1998; Malone, 2004). Many businesses encourage employees to become “intrapreneurs” who engage their skill portfolio where it is best needed, and who are sought out by task teams in need of a specialist (Carrier, 2009; Filion, 2002; Wunderer, 2001). These new business behaviors reward employees who are innovative, creative and good team contributors, leading to opportunities for personal and professional development, self-reliance and accountability (Bassi and McMurrer, 2008, Industry Week 1998). Through these experiences, the workplace sector has learned the importance and value of having skilled employees at the right place at the right time (Guthridge 2008; Rawlinson et al, 2008; Siegel, 2008).
Armed with knowledge about these trends of rapid change educators would be able to help prepare students for the realities of the workplace while they are still in the classroom, helping them secure employment and develop strong careers. How might this be achieved?

1. *Establish a Dialog between the Education and Workplace Sectors*

A productive discussion must be initiated about the ever-changing needs and continuous adjustments in the science workplace. The workplace sector must share their insights and projections for future talent needs and the education sector must find ways to take this information to the classroom.

2. *Agree to stay connected*

The initial dialog must be escalated to a sustainable relationship between the two sectors. Workplace dynamics will lead to ever-changing needs for new talent (Schuler et al, 2011; Tarique and Schuler, 2010). Consequently, the exchange between the education and workplace sectors can never stop. We

are constantly aiming at a moving target. There will always be a "Tomorrow's Workforce" sitting in a classroom and those students must be given the benefit of understanding new trends in the workplace.

3. Establish a "Win-Win" centerpiece program

While planning and exchange is important, sustained effects can only result from a deeply anchored program that yields benefits from both parties.

What follows is a description of a curriculum-based program which specifically addresses the need to communicate science workplace operations and behaviors as well as future talent needs directly to classroom teachers.

R_xeSEARCH: An Educational Journey

This is a novel and innovative program designed to help high school students develop skills and behaviors necessary for successful careers in the workplace. The program was created by Bristol-Myers Squibb as a key element in the company's strategic education philanthropy portfolio. It operated under a partnership of healthcare-based organizations and corporations, dedicated to help improve science education and science workforce preparation. The program brings relevance and real-world application to the learning of science, technology, engineering and mathematics (STEM), engaging students in hands-on exploration and meta-cognitive activities. The program consists of two tracks.

The Applied Science Classroom Track

This component borrows applied STEM from research and development in the pharmaceutical industry. The backbone for the short course is the sequence of activities from an unmet medical need, through discovery research, pre-clinical and clinical R&D up to readiness for commercialization of a new drug.

Starting with the emergence of a new fictitious infectious disease - High School Syndrome - students delve into introductory aspects of general health: ***What is a disease? How are diseases classified, and what is a cure?*** Searching for ways to attack the disease, guided by drug discovery researchers they are engaged in fact finding, critical analysis and logical reasoning along with lab exercises:

"How can we identify and test chemical leads found in nature? What can we learn from the biochemistry of microbial toxins? How have natives of the rain forest developed resistance against a similar disease through ritual use of plant extracts?"

Engaging in laboratory experimentation, students address other key questions:

"What is the actual biochemical target? How can a model system be developed for screen for new chemical leads to be developed? How can we test for activity against the disease in the lab?"

A whole range of new challenges are encountered in pre-clinical development:

"How can we find out if our drug has toxic effects on the body? How do we prevent the body's chemical defenses from destroying our compound? Can a test tube synthesis be scaled up to produce kilogram quantities? How much drug can we package in a pill so that we get the needed effect?"

Students face different issues faced with testing the lead candidate in clinical trials:

"Is the dose-effect relationship the same as for animal models? Can we get away with one daily dose, or will more be needed to fight the infection? What happens if you take the drug together with other medications? How do you choose clinical trial subjects to give an ineffective placebo treatment?"

Ethical dilemmas are faced when a choice has to be made between drug candidates based on effect profiles: ***"Do we go with drug A that is very effective but has bad side effects, drug B with intermediate effect and relatively low side effects, or drug C with a low effect potential and no side effects?"***

Difficult decision challenges follow when the commercialization potential is analyzed: "***How do you balance the high costs of R&D against future revenues which depend on global disease epidemiology, economy of affected populations and health care policies?"*** Students must argue for their decision to select the final drug candidate based on different characteristics and varying revenue potential. Throughout the course students engage in inter-disciplinary use science, math, technology to move the project along through team-based activities. They derive facts and insights from scientists, engineers and other professionals, and teachers add current issues from media and historical records.

Figure 1 describes the translation of industry-specific R&D elements and course objectives:

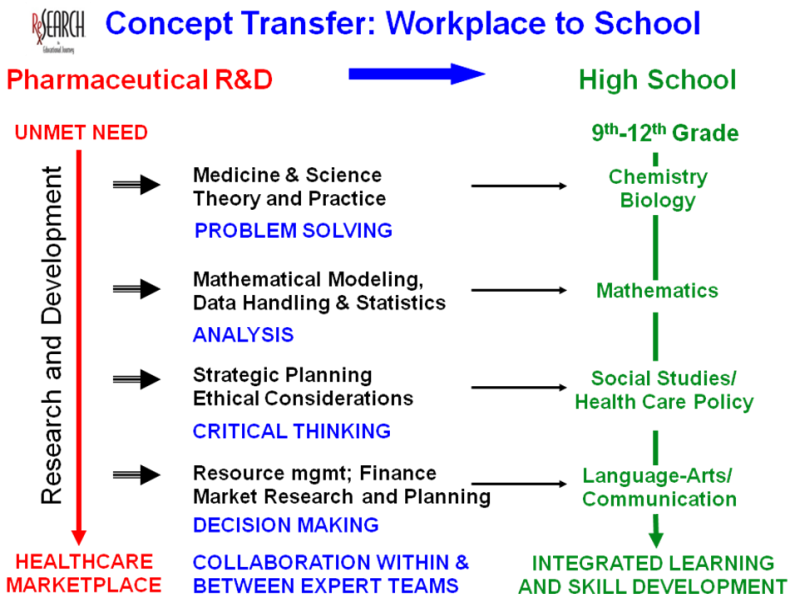

Table 1 shows an overview of the eleven lessons of the Applied Science Classroom Track.

Table 1. ***Course Overview***

Lesson 1	Introduction	Diseases and Their Impact
Lesson 2	Discovery Research	Targets and Magic Bullets
Lesson 3	Discovery Research	Screening for Solutions
Lesson 4	Discovery Research	The Power of Molecules
Lesson 5	Preclinical Development	Chromatography Separation
Lesson 6	Preclinical Development	Selecting the Best Molecule
Lesson 7	Clinical R&D	Investigational New Drug Application (IND) and Phase I Clinical Research
Lesson 8	Clinical R&D	Phase II Clinical Trials
Lesson 9	Clinical R&D	Phase III Clinical Trials and New Drug Application (NDA)
Lesson 10	Commercialization	Exploring the Business of Science and Medicine
Lesson 11	Marketing	Where Business and Science Overlap

This program element provides a scaffold for the paired element, The Workplace Track.

The Workplace Track

This element builds on the Applied Science Classroom Track by helping students understand and learn the behaviors and skills they need in their repertoire in order to effectively meld into the workplace.

A key objective of this program is to provide teachers and students with tools for learning in direct alignment with prevailing standards. Hence, the design of the Workplace Track was guided by the new Core Curriculum Content Standards #9 for the state of New Jersey (NJ CCCS, 2011). This standards document entitled 21st Century Life and Career Skills outlines six skill areas:

- Critical thinking and problem solving
- Creativity and innovation
- Collaboration, team work and leadership
- Cross-cultural understanding and interpersonal communication
- Communication and media fluency
- Accountability, productivity and ethics

While several of these skills and behaviors are not unique to science, significant value is added by emphasizing the importance of these as essential in the practice of science in the workplace.

This is accomplished both by providing teachers with a tool kit "Practicing Workplace Skills – A Teacher's Guide" and access to R&D professionals, including scientists, engineers, veterinarians, physicians, technicians, project managers and marketing specialists. It describes how these skills and behaviors are applied in the workplace, and provides exercises adapted for learners at the high school level.

Professionals who volunteer for teacher professional development and classroom activities receive specific training for these tasks. They understand their role as assistants to the teacher and learn basic aspects of classroom management and age-appropriate pedagogy.

However, the primary emphasis of training is on their role as *Practitioners of Science* in an integrated workplace where the individual performer is valued for his/her contributions and ability to adapt to and help lead productive change. These individuals describe their roles in drug discovery, development and commercialization and provide concrete examples of how each of the six skills and behaviors (Table 2) are practiced in a wide range of situations. They share how they constantly learn new skills that help them navigate the workplace, and become entrepreneurs on behalf of their employer and themselves.

They give examples of how the behaviors in NJCCCS9 are practiced in a wide range of situations:

- ***"How do you collaborate with someone who does not want to share what he knows?"***
- ***"How can our project team meet our deadline when we don't have the resources we need?"***
- ***"Half the team wants alternative A and the other half alternative B – How do we decide?"***
- ***"The new metabolism data do not look good for our lead – What do we tell management?"***
- ***"I don't like my boss and I think she does not like me – Who do I talk to?"***
- ***"We don't understand the culture of our Asian partners – How can we build trust?"***
- ***"I think I'll skip the call to our Chinese colleagues tonight – It's after my bedtime!"***
- ***"I saw my lab partner mess up an important assay – Who do I tell, and what do I say?"***
- ***"My colleague is emailing her friend at another company our new results – Is that OK?"***

They describe case examples from their professional careers that illustrate both successful and non-productive behaviors and the consequences. They also describe how mentors have helped them find their way, and how they now assist other workplace newcomers.

Through integration of the two program tracks students have the opportunity to practice all the critical workplace skills in the context of drug development.

R_xeSEARCH: An Educational Journey *as a program model - Telling your own workplace story*

This program was developed by a corporate member of the workplace sector. The integrated matrix of specialists, internal service providers and customers, supply lines and external alliance partners which are sometimes spread over several continents described has validity for both the private and public sectors. Hence, *R_xeSEARCH: An Educational Journey* is a model for productive interaction between the education and workplace sectors that is largely universal.

The workplace sector can assist educators simply by telling its own story.
So, whether the curriculum describes how sea wave and wind energy can fuel a power grid or how a larger, more fuel-efficient airframe is designed, or how disease is fought through innovative medicines, the model is equally powerful. Some of the factors that drive this success include:

- Workplace professionals tell the story they are passionate about - How they do their work.
- Teachers and students learn how science knowledge is applied to generate products and services.
- Employers gain access to education policy makers and share their needs for knowledge and skills.
- Educators feel "the pulse" of the workplace and can open a career window for students.
- Job candidates are attracted to the area based on access to quality schools.
- School boards gain leadership from a strong community that helps them attract quality teachers.
- Communities can grow based on strong tax revenue from both corporate and individual prosperity.

Taken together, the model makes has the potential to add value at local, as well as regional and national levels. It offers opportunities for joint exploration of current and future needs for knowledge, competencies and skills and engages students in active learning and practice for successful careers.

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