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Core STEM Competencies in Paper Manufacturing Occupations

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As part of the nation's concerns about the digital divide, productivity, and core competencies in math and science, there has been increasing research focus on the extent to which various occupations require competences in science, technology, engineering, and mathematics (STEM). Illustrative of these concerns is a 2014 report by the Georgetown University Center on Education and the Workforce.² In an effort to identify occupational competencies associated with STEM the Georgetown researchers reviewed occupational competencies for 167 STEM occupations within the following broad categories: (1) Computer, (2) Mathematical Science, (3) Architects, Surveyors, and Technicians, (4) Engineers and Engineering Technicians, and (5) Life and Physical Science.² The detailed profile for each occupation included such worker attributes and job characteristics as knowledge, abilities, skills, tasks, tools and technology, job zone, education, work interests, work values, work context, and work styles,³ each of which is ranked by its relative occupational importance on a scale from 0 to 100.⁴ The analysis resulted in 39 STEM core cognitive and non-cognitive competencies.

To explore the extent to which these 39 core STEM competencies are prevalent in Paper Manufacturing and if STEM competencies can be used to address some of the concerns about the changing workforce within the industry, we looked at occupational profiles for three labor categories - biochemists, chemical engineers, and paper goods machine operators.⁵ Table 1 lists all 39 core STEM competencies ranked by their importance from 0 to 100 for the three occupations and the scores for the biochemists, chemical engineers and paper machine operators are included in columns I, II, and III, respectively. Table 2 reflects the level of education reported by the respondents for each of the three categories. As expected, biochemists and chemical engineers earned advanced degrees at the doctorate and master's levels – 41% of biochemists earned doctorate degrees and 16% of chemical engineers earned masters' degrees. On the other hand, 75% of the paper machine operators received high-school diploma.

From Table 1, machine operators, while having the lower educational attainment level, ranked the following STEM competencies higher than did biochemists and chemical engineers: production and processing knowledge, mechanical knowledge, control precision ability, equipment selection skill, operation monitoring skill, operation and control skill, equipment maintenance skill, repairing skill, and realistic work interest.

¹ This discussion is the result of the author's collaboration with Roy Craft, Director, Program Development, Georgia Tech Professional Education.

² To download the full report, see: <http://cew.georgetown.edu/stem>.

³ A more detailed discussion on the types of occupations as well as occupational competencies can be found at O*NET: <http://www.onetonline.org/>.

⁴ The ranking is based on the O*NET questionnaires filled out by a random sample of workers within randomly selected industries. For more information on the O*NET

data collection methods, see:

<http://www.onetcenter.org/dataCollection.html>.

⁵ The following video clip (especially starting at minute 3 presents a general discussion of the issues of workforce in the industry in Maine and in the US, in general: https://www.youtube.com/watch?v=dZyyfTe1x0M&feature=player_embedded. The video is a part of the video clip collection on the CPBIS Website discussing different concerns and attitudes of the papermakers in the U.S. and EU: <http://www.cpbis.gatech.edu/connect/video>.

Some production-related STEM knowledge and skills were ranked lower for both biochemists and chemical engineers. Biochemists ranked the following STEM competencies as least important: production and processing knowledge, building and construction knowledge, mechanical knowledge, and troubleshooting skill. The least important core STEM competencies for chemical engineers were: control precision ability, equipment selection skill, quality control analysis skill, operation and control skill, equipment maintenance and repairing skills. When looking at the difference in the average scores across STEM categories for chemical engineers vs. machine operators (Table 1), the highest difference of 53 points is for STEM values, followed by 35, 28, 15, and 13 points for STEM knowledge, STEM work interests, STEM abilities and STEM skills, respectively.

On the other hand, biochemists and chemical engineers ranked investigative work interest at 100 and 95 points, respectively, while machine operators assigned 33 points to this work interest. Finally, machine operators reported the lowest scores for STEM work values: achievement, independent and recognition with 17, 28, 17 points, respectively. Last, but not least, among non-STEM competencies, the English language was ranked as the highest for all three occupations – 79, 70, and 71, for biochemists, chemical engineers and machine operators, respectively. The highest scoring non-STEM skill for the three occupations was split between (i) monitoring and (ii) judgement and decision making. Finally, for the most important non-STEM ability biochemists chose written comprehension, chemical engineers – information ordering, and machine operators – arm-hand steadiness.

There are a few interesting takeaways from this cursory look at the occupational STEM competencies. First, it would be interesting to isolate the surveys by and examine these occupations within the narrower paper industry sectors. Second, non-STEM competencies, such as the English language, are prerequisites for subsequent proficiency in STEM-related fields, regardless of the level of education. Additionally, the big gap in the work interest and value scores between biochemists and chemical engineers, on the one hand, and machine operators, on the other hand, identifies an opportunity to improve the “brand” or professional image for the machine operating occupations. This is especially true given that machine operators identified some of the STEM

competencies as more important than biochemists and chemical engineers did and the relatively small differences in average scores for STEM abilities and STEM skills between machine operators and chemical engineers. Further, the higher scores on STEM competencies for biochemists and chemical engineers still have some room to grow – the average scores for STEM skills, knowledge and abilities for chemical engineers are 49, 67, and 60, respectively. Finally, some of the related industry occupations are identified as green – biochemical engineers, biomass plant technicians, and chemical engineers – making them more appealing to the general public and younger, more environmentally-conscious, workforce.⁶ Emphasizing these jobs as technologically advanced, green, and with ample room for further professional advancement and personal fulfillment may help in the effort of attracting just the right kind of talent to the industry.

Table 1. Core STEM Competencies

Cognitive									
STEM Skills	I	II	III	STEM Knowledge	I	II	III		
Mathematics	69	69	28	Production and Processing	14	71	77		
Science	91	81	6	Computers and Electronics	63	60	26		
Critical Thinking	78	75	50	Engineering and Technology	53	97	35		
Active Learning	75	66	38	Design	36	67	31		
Complex Problem Solving	72	75	47	Building and Construction	6	29	9		
Operations Analysis	56	63	19	Mechanical	32	53	60		
Technology Design	31	44	13	Mathematics	79	84	49		
Equipment Selection	31	28	35	Physics	83	75	17		
Programming	31	28	10	Chemistry	84	88	14		
Quality Control Analysis	50	47	50	Biology	83	44	0		
Operation Monitoring	47	50	66	Average	53	67	32		
Operation and Control	35	16	56						
Equipment Maintenance	22	0	41	STEM Abilities			I	II	III
Troubleshooting	25	53	41	Problem Sensitivity	69	75	60		
Repairing	22	0	35	Deductive Reasoning	78	72	50		
Systems Analysis	63	72	35	Inductive Reasoning	78	72	47		
Systems Evaluation	56	66	35	Mathematical Reasoning	72	75	25		
Average	50	49	36	Number Facility	56	66	28		
				Perceptual Speed	53	53	47		
				Control Precision	35	6	56		
				Average	63	60	45		
Non-Cognitive									
STEM Work Interests	I	II	III	STEM Work Values	I	II	III		
Realistic	61	89	95	Achievement	78	72	17		
Investigative	100	95	33	Independence	67	72	28		
Average	81	92	64	Recognition	83	78	17		
				Average	76	74	21		

Table 2. Educational Attainment

⁶ For the list of all green occupations, see: <http://www.onetcenter.org/green.html/>.

Occupation	% of Respondents	Education Level Required
Biochemists	41	Doctoral degree
	32	Post-doctoral training
	18	Bachelor's degree
Chemical Engineers	72	Bachelor's degree
	16	Master's degree
	8	Post-baccalaureate certificate
Paper Goods Machine Operators	75	High school diploma or equivalent
	24	Less than high school diploma
	1	Post-secondary certificate

Trend Indicators from Industry Intelligence Inc.

[Industry Intelligence Inc.](http://www.industryintel.com) has provided market intelligence to more than 600 companies worldwide since it began as Forestweb in 1999. Industry Intelligence delivers a daily report featuring news of the paper and forest products industries. For your subscription visit: <http://www.industryintel.com>

Below is a sampling of recent Industry Intelligence headlines, chosen to mirror significant trends and other interesting developments in and around the paper and forest products industries.

Average fossil carbon footprint of European cartonboard and carton industries currently at 915 kg CO₂eq./tonne of cartonboard produced and converted, according to Pro Carton; figures among best of all packaging materials for environmental performance

Additionally, a study of biogenic carbon in cartons shows a significant amount is “locked up” in the carton’s raw material – wood fibre.

MeadWestvaco, RockTenn each announce special meetings of their respective shareholders to approve previously announced combination of two companies; merger expected to close July 1, at which point MWV and RockTenn will become subsidiaries of WestRock

WestRock will trade on the New York Stock Exchange under the ticker symbol WRK.

Catalyst Paper announces investment of nearly C\$16M in recently acquired pulp and paper mill in Rumford, Maine, including C\$11.4M to upgrade recovery boiler during current planned maintenance shut, expected to be completed May 30

The project is expected to result in reduced energy costs and to mitigate seasonal energy cost exposure.

Zilkha Biomass Energy holds ribbon cutting for 275,000 tons/year black pellet plant in Selma, Alabama; a renewable fuel similar to coal, black

pellets have more energy in them than conventional pellets and are denser, lowering transport costs

The area’s wood basket was a key factor in Zilkha’s choice of Selma for the facility. “There were a lot of trees within 60 miles, which is about the distance you want,” said Zilkha.

World dissolving pulp capacity continues to grow, with several projects slated for 2015, while dissolving pulp prices drop to about US\$800/tonne at end of 2014; China's dissolving pulp industry suffers huge loss in 2014, resulting in grade changes: report

Dissolving pulp projects under construction include an expansion by Lenzing, a 200-kt/a capacity Aditya Birla project in Laos, and Domtar’s 516-kt/a project in Canada.

World's first biorefinery to produce cellulosic ethanol from sawdust, St1 Biofuels, to be built on sawmill site in Kajaani, Finland, will have capacity of 10 million liters/year, cost €40M to build and will use Novozymes' customized enzymes

The plant will initially produce 10 million liters (2.7 million gallons) of cellulosic ethanol per year, but can be scaled up to annual output of 50 to 100 million liters.

CMPC to start up new 1.3 million tonnes/year eucalyptus pulp mill line in Guaíba, Brazil, on May 3, bringing company's capacity to 4.1 million tonnes/year of hardwood and softwood pulp

With the startup of the new Guaíba line, CMPC will have a hardwood and softwood pulp capacity of 4.1 million tonnes/year.

CMPC's new 1.3 million tonnes/year pulp line in Guaíba, Brazil, starts up May 3, as previously scheduled, adding to mill's existing 500,000 tonnes/year capacity; new line can be expanded to 1.5 million tonnes/year, with minor investments

This is an addition to the existing capacity of the mill of 500,000 tons per year.

Fibria, Klabin sign agreement for selling hardwood pulp to be produced at Klabin's 1.5 million tonnes/year mill in Paraná, Brazil, due to start up in 2016; Fibria will sell at least 900,000 tonnes/year of the output, all of it outside South America

Klabin will sell the additional volume produced by the new plant directly as follows: hardwood pulp in Brazil and South America, and softwood pulp and fluff in the global market.

Eldorado Brasil beginning construction of new 2-million tonnes/year eucalyptus pulp line in Três Lagoas, Brazil, to start up in H1 2018

The project will result in South America's largest single-line production of bleached kraft pulp, bringing the Três Lagoas mill's capacity to 4 million tonnes/year.

Global forest and paper industry shows improvement on range of sustainability indicators, according to ICFPA's 2015 Sustainability Progress Report; over 2005-2013, GHG emissions intensity fell 17% and SO2 emissions declined 40%, among other achievements

Among the other achievements noted by The International Council of Forest and Paper Associations: Between 2005 and 2013, greenhouse gas emissions intensity was reduced by 17%; the share of bio-energy in the industry's fuel mix increased by 8 percentage points, to 61%; sulfur dioxide emissions decreased by 40%; the global paper recycling rate increased to 58%.

China exports 17,081 tonnes of kraft paper in February, bringing year-to-date total to 45,165 tonnes, up 83.1% from a year earlier; total value of kraft paper exports for January-February increases 95.4% year-over-year to US\$51.387M

This according to a report by China Customs

APP's Paper Excellence brings former Tembec BCTMP mill in Chetwynd, British Columbia, back online, after C\$50M in upgrades; mill is the most recent of four mills in British Columbia that the company has bought and restarted in recent years

Tembec had shut down the 240,000-tonnes/year hardwood bleached chemithermomechanical pulp mill in September 2012.

US paperback books sales climb 10.3% year-over-year in January, hardback books climb 3.6%, e-books drop 10.2%; children, young adult e-book sales fall sharply, down 37.4%, while educational materials see double-digit declines: Assn. of American Publishers

Figures represent publishers' net revenue for the U.S. (i.e. what publishers sell to bookstores, direct to consumer, online venues, etc.), and are not retailer/consumer sales figures.

IP expects to restart its printing-writing papers mill in Ticonderoga, New York, in late May, after month long shutdown to install equipment needed to switch mill from being powered by fuel oil to natural gas, which will replace about 60% of fuel oil

The mill will use trucks to transport natural gas to help power the plant after the failure of its plan for a pipeline under Lake Champlain from Vermont.

Evergreen Packaging expects to see long-term benefits from converting two boilers at its mill in Canton, North Carolina, to natural gas, as it will cut fuel and maintenance costs, says mill official; construction to start end of 2016, be completed by 2019

Two coal-fired boilers will be switched to natural gas. The upgrade is required under new U.S. EPA rules; it is reported that without it the mill would have to close down.

AF&PA Statistics

Since our last reporting of American Forest and Paper Association statistics releases, the Association has issued its April printing and writing and paperboard reports. In addition, it has released its annual capacity survey.

Printing and Writing

Total shipments decreased 6 percent in April compared to April 2014, with inventory levels increasing 1 percent from March. Uncoated free sheet (UFS) paper shipments in April decreased 3 percent compared to April 2014. Imports of UFS increased 3 percent year-over-year in March. April coated free sheet (CFS) paper shipments decreased 9 percent compared to April 2014. Imports of CFS papers increased 13 percent in March, the tenth year-over-year increase in the last 12 months. Uncoated mechanical (UM) paper shipments decreased 9 percent when compared with April 2014. Imports of UM papers were down 11 percent in March, the ninth consecutive monthly decline. Coated mechanical (CM) shipments in April decreased 11 percent relative to April 2014. Imports of CM were down 8 percent in March and exports increased by 29 percent, the third consecutive increase.

Paperboard

Total boxboard production increased 0.3 percent when compared to April 2014 but decreased 0.9 percent from March. Unbleached kraft boxboard production increased over the same month last year and increased compared to March. Total solid bleached boxboard & liner production increased when compared to April 2014 and increased compared to March. The production of recycled boxboard decreased compared to April 2014 and decreased when compared to March.

Purchase the full reports by contacting Caroline Nealon, Statistics_Publications@afandpa.org or 202-463-2448.

Annual Capacity Survey

U.S. paper and paperboard capacity declined 1.7 percent in 2014; it is expected to hold nearly stable in 2015.

Containerboard and tissue remain growth sectors for the paper industry. Tissue capacity reached an all-time high in 2014 and the upward trend is expected to continue next year. Capacity to produce newsprint and printing-writing papers continued to decline.

The survey reports U.S. industry capacity data for 2014 and 2015 for all major grades of paper, paperboard and pulp, as well as fiber consumption, based on a comprehensive survey of all U.S. pulp and paper mills. Survey respondents represent more than 88 percent of the U.S. industry capacity.

Purchase the annual capacity survey by contacting Kory Bockman at kory_bockman@afandpa.org or 202-463-4716.

Paper Quotes

“The first quarter of 2015 began with a number of challenges including the significant weakening of the euro, the market situation in Russia and the operational cost penalties in specialty papers.” – *Dante C. Parrini, Glatfelter chairman and chief executive officer, announcing a Q1 2015 earnings decrease.*

“This plant will take up to 80,000 tonnes of wastepaper out of Australia’s landfill each year, which is enough to fill a tennis court to more than twice the

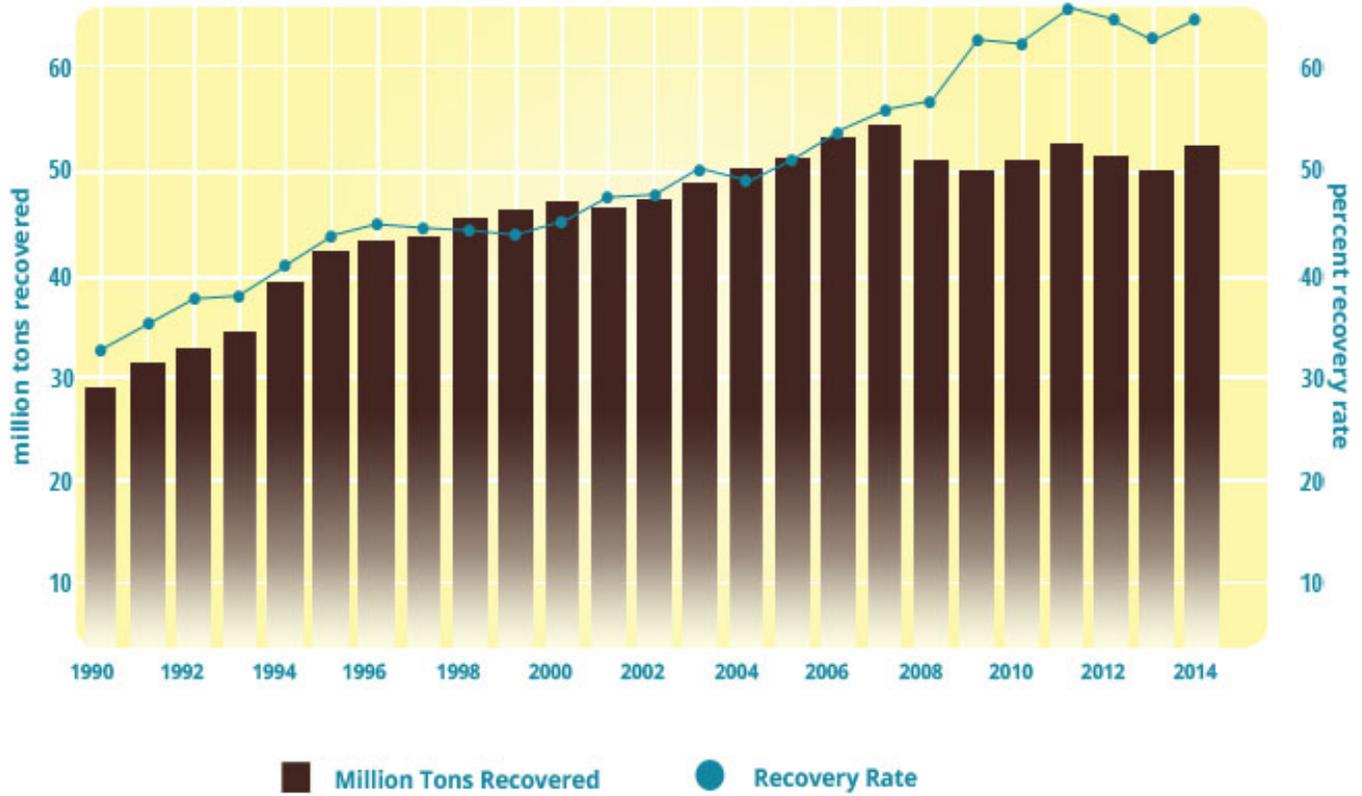
height of the Eureka Tower [975 ft.]. We are committed to meeting the growing demand for premium, local recycled paper,” – *Peter Williams, Chief Operating Officer, Australian Paper, announcing the startup of an AU\$90M deinked pulp mill in Maryvale, Australia.*

“The current Australian market demand for recycled content office papers is only one third of the new plant’s capacity, so we need everyone’s help to lift the demand for Australian-made recycled content paper and do the right thing for our local environment.” – *Mr. Williams, on the same occasion.*

“The lower demand for folding (cartons made from paperboard) is being attributed to lower sales of frozen food through retail channels as restaurant traffic appears to be increasing with the improving economy” – *Clearwater Paper Co. President and CEO Linda K. Massman, during a recent conference call for stock market analysts.*

Statistics Corner: Paper Recovery

As shown in the figure below, the U.S. paper recovery rate rose from 63.5 percent in 2013 to 65.4 percent in 2014. Total U.S. paper recovery rose by 1.9 percentage points in 2014, with domestic mill consumption advancing 1.9 percent to 30.5 million tons and net exports expanding 1.5 percent to 20.2 million tons. There are also some domestic uses of recovered paper outside the paper industry, including as base materials for insulation and molded pulp products. ■



Paper Recovery and Recovery Rate (Source: AF&PA)