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STEM Education and Sustainable Growth in Regions: Lessons Learned from the U.S. WIRED Program Evaluation

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Abstract : It is recent that STEM (Science, Technology, Engineering and Mathematics) education emerged as a great concern of the U.S. policy makers in terms of securing national and regional competitiveness. However, few attempts to embrace STEM education as a source for sustainable regional growth have been made mainly due to methodological challenges. This paper investigates the role of STEM education in achieving sustainable economic growth. For the purpose of the paper, a U.S. federal workforce development program named Workforce Innovation in Regional Economic Development (WIRED) in Southeastern Virginia that was implemented between 2007 and 2010 is selected and evaluated qualitatively. By identifying three themes as a result of three-stage coding methods, the evaluation results call for particular attention of local policy makers and key stakeholders to STEM education as a source of sustainable long-term economic growth in regions.

Keywords : STEM education, Talent Development, WIRED, Sustainable Growth, Qualitative Evaluation, NVivo

I. INTRODUCTION

The focus on the role of education in the fields of Science, Technology, Engineering, and Mathematics (STEM) is a recent interest of educators and policy makers. The years between 2005 and 2007 are noteworthy as several reports released by well-known organizations in those years noted the status of American STEM education to be failing to keep up with other countries around the world (Business Roundtable 2005; Education Commission of the States 2005; National Summit on Competitiveness 2005; National Academies 2007). Some of the recommendations in those reports, including the National Academies' famous report Rising Above the Gathering Storm, were seminal for the American Competitiveness Initiative, as they contributed to increasing the public's and policy makers' understanding of the link between STEM education and national prosperity from a long-term perspective.

While a growing concern for STEM education in regard to national competitiveness is found, less attention has been given to the role of STEM education in achieving sustainable local economic growth especially from the evaluation point of view. This paper therefore conducts an evaluation of a local workforce development program that was funded by the U.S. Department of Labor between 2006 and 2010. Particular attention is given to its STEM education component during the qualitative evaluation process while addressing the possible methodological challenges of evaluating STEM education efforts. The paper starts with reviewing prior studies on STEM education and its contribution to economic prosperity both at the national and the local level. It then proceeds to the description of the case selected for qualitative evaluation. Methodology on collecting data for analysis is followed. The paper summarizes evaluation results and provides policy implications drawn from the results.

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2. LITERATURE REVIEW

Scholars agree with the importance of (technological) knowledge accumulated and embedded in human as a key source for sustainable economic growth by increasing productivity. The relationship between knowledge and growth is confirmed many times by well-known economists including Solow (1957) and Romer (1990a,b). In the early 2000s, however, that the educators, policy makers, business people and the general public in the US started recognizing the low performance of their students and the shortage of workforce in STEM fields. Growing public concerns on STEM-related issues led policy makers keen to promoting STEM education through national and local legislation. Academic studies also started discussing the importance of STEM education for promoting national and regional competitiveness by creating high quality jobs. The National Academies' comprehensive 2007 report Rising above the Gathering Storm, for example, is notable in investigating the role of STEM education not only for students' performance but also for economic prosperity. Business Roundtable's 2005 report, Tapping America's Potential, is similar to the National Academies (2007), although the report emphasizes its five recommendations rather than exploring academic evidence for the role of STEM education. Education Commission of the States' (2005) conclusion emphasizing STEM education to maintain the U.S. leadership in the world's economy is not so different from the National Academies (2007) or the Business Roundtable (2005).

By accepting the recommendations from the earlier reports such as Business Roundtable (2005), Education Commission of the States (2005), and the National Academies (2007), a numerous STEM education programs have been launched and implemented since the mid-2000s (Kuenzi 2008; U.S. GAO 2005, 2014). Representative examples of the latest programs for STEM education are: The National Institute of Health's Science Education Partnership Award (SEPA), the National Science Foundation's (NSF) Research in Engineering Education and Discovery Research K-12 (DR-K12), NASA's Aerospace Research and Career Development (ARCD) Program, and the Department of Education's (ED) Mathematics and Science Partnerships. <Table 1> summarizes major U.S. programs promoting STEM education at the national level.

It is difficult, however, to find studies measuring the impacts of STEM education initiatives on economic growth. A report by the U.S. Government Accountability Office (GAO 2005) explains why there is such a shortage of evaluation studies regarding STEM education initiatives. The GAO report categorizes a variety of federal STEM-education programs by program goals, types of assistance, and target groups. All of the 207 federal programs funded by 13 federal agencies during the fiscal year 2004 pursued the following goals:

- attract and prepare students at any education level to pursue coursework in STEM fields;
- attract students to pursue degrees (2-year through Ph.D);
- provide growth and research opportunities for college and graduate students in STEM fields;
- attract graduates to pursue careers in STEM fields;
- improve teacher education in STEM areas;
- and improve the capacity of institutions to promote or foster STEM fields (GAO 2005: 14).

A variety of target groups, such as K-12 students, undergraduate and graduate students, postdoctoral scholars, teachers, and professors, were provided with different types of assistance including financial, institutional, and physical infrastructure supports for achieving those program goals. Finding the majority of federal STEM education programs had not been evaluated by the time GAO prepared their report; the GAO report indicates the pursuit of multiple program goals while targeting multiple groups is a major challenge to measure program effectiveness (GAO 2005).

Another recently released GAO report points out multiple target groups within federal STEM education programs as an obstacle for evaluation (GAO 2012). The GAO report also urges the Office of Science and Technology Policy to better coordinate STEM-education efforts across federal agencies by finding overlap and redundancy in services provided, fields of focus, and program goals pursued by federal agencies implementing STEM education programs. After criticizing the efforts of federal agencies in collecting reliable performance data on their STEM education programs, the GAO also finds that two-thirds of the federal STEM education programs in FY 2005 have not completed their evaluations until the GAO report released. Even among the 29 percent of the federal programs completing the evaluations, issues—such as evaluation design, limited data availability, and lack of robust criteria for outcome measurement—are found (GAO 2012).

The GAO is not the only organization examining the shortage of evaluation efforts by the federal agencies in charge of STEM education programs. The Education Department's Report of the Academic Competitiveness Council released in

Table 1. Major U.S. Federal Programs for STEM Education (FY 2012)

US Federal Agency	Program	FY2012 Program obligations (> $10,000,000 only)
NASA	Aerospace Research and Career Development (ARCD) Program	$58,000,000
	Science Directorate – STEM Education activities	$41,000,000
	STEM Education and Accountability Projects – Higher Education	$21,000,000
	STEM Education and Accountability Projects – Formal & Informal Education	
NSF	Advanced Technological Education (ATE)	$64,070,000
	Advancing Informal STEM Learning	$62,430,000
	Discovery Research K-12 (DR-K12)	$99,570,000
	Research in Engineering Education	$11,810,000
	Graduate Research Fellowship (GRF) Program	$197,930,000
	Math and Science Partnership Program (MSP)	$57,070,000
	Transforming Undergrad Education in STEM (TUES)	$39,060,000
	Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP)	$25,300,000
	Integrative Graduate Education and Research Traineeship (IGERT) Program	$65,430,000
Dept. of Education	Mathematics and Science Partnerships	$148,353,872
	Upward Bound Math-Science	$44,141,410
NIH	Cancer Education Grants Program (R25)	$12,473,029
	Graduate Program Partnerships	$11,121,000
	Initiative for Maximizing Student Development	$23,300,000
	MARC U-STAR NRSA Program	$21,300,000
	National Cancer Institute Cancer Education and Career Development Program (R25)	$18,285,877
	Post-baccalaureate Intramural Research Training Award Program	$24,400,000
	RISE (Research Initiative for Scientific Enhancement)	$28,600,000
	Ruth L. Kirschstein National Research Service Award Institutional Research Training Grants (T32, T35)	$348,287,734
	Ruth L. Kirschstein NRSA for Individual Predoctoral Fellows, including Fellowships to Promote Diversity in Health-related Research	$58,784,787
EPA	Science to Achieve Results Graduate Fellowship Program	$15,600,000

(Source: U.S. GAO 2014)

2007 agrees with GAO by finding the lack of evaluation efforts regarding STEM education programs both at the K-12 and higher education levels. According to the report, only three out of the 115 programs investigated finished evaluations that were scientifically rigorous (ED 2007). Similar to GAO's conclusions (2005, 2012), stronger interagency coordination among federal agencies, as well as with states and local systems, is suggested as one way to improve STEM education programs. More attention to program goals in designing and operating the programs is also urged in addition to the emphasis given to the introduction of rigorous, independent evaluation efforts for those programs (ED 2007).

Although the dearth of STEM education evaluation efforts is a critical issue for improving the quality of STEM education, a more serious issue is the divide between program goals and outcome measures for STEM education at the K-12 level and in higher education. Especially for K-12 students, the majority of programs are limited to pursuing education-related values rather than improving student learning, teacher quality, and the engagement and perception of students in STEM from a

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comprehensive perspective. Program metrics for K-12 education are also problematic as they focus on measuring the achievements of program participants. Standardized test scores of students, numbers of participants in after-school STEM projects, and the percentage of teachers capable to teach subjects related to STEM are examples used to measure the performance of STEM education programs for K-12 (ED 2007). Since the long-term goal of STEM education is economic growth through increasing the number of high skills jobs mostly in STEM fields, the evaluation of STEM education in K-12 level should measure the impacts of the education in nurturing the STEM workforce.

Considering STEM education for K-12 students in the context of nurturing the future workforce for high-skilled jobs, this paper presents a successful example of a federal workforce development program. Designed and implemented originally as a workforce development program targeted to strengthen a clear linkage to regional economic development efforts, the program contains various approaches to workforce development including STEM education. More details of the program are described in the next section, followed by discussion of the procedure for qualitatively evaluating this workforce development program.

3. PROGRAM DESCRIPTION: WIRED IN SOUTHEASTERN VIRGINIA (SEVA-PORT)

Workforce Innovation in Regional Economic Development (WIRED) is one of the three nationwide pilot projects implemented by the Employment and Training Administration (ETA) of the Department of Labor (DOL) under the Workforce Investment Act. WIRED was announced in November 2005 and formally launched in February 2006 with the announcement of its first 13 awarded regions where the local economies are heavily dependent on so-called "high-growth/high-demand" industries as defined by DOL. The overarching goal of the WIRED program during its implementation period was "to expand employment and advancement of the opportunities for workers and to catalyze the creation of high-skill and high-wage opportunities in regional economies (ETA webpage, retrieved on 01/29/13)." The most notable aspect of the WIRED program is that it attempts to maximize benefits from the program-related support by linking personnel, resources, and strategies for workforce development with those for economic development. Forty-one grants were given to 39 different regions for three different time periods (generations): February 2006, January 2007, and June 2007.

Southeastern Virginia was one of the third generation regions for the WIRED program announced in June 2007. The Southeastern part of the Commonwealth of Virginia receiving the WIRED grant is composed of eleven counties and thirteen independent cities. <Fig. 1> below presents the geographic location of Southeastern Virginia:

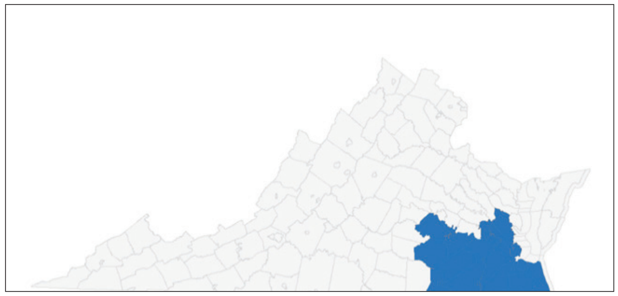

Fig. 1. Southeastern Virginia
(Source: U.S. Census Bureau)

The formal name of the WIRED program in Southeast Virginia is "Southeastern Virginia Partnership for Regional Transformation (SEVA-PORT)". With a $5 million budget for three years, a variety of projects and activities were implemented between 2007 and 2010 to link workforce and economic development in two local high growth industries: modeling and simulation (M&S) and transportation, warehousing and distribution (TWD). The three goals that were identified as the major challenges for Southeast Virginia were: 1) supporting the current and future workforce needs of the TWD and M&S industries through network/relationship building, industry-driven training, and research and development and entrepreneurship; 2) mitigating the negative impacts of the Defense Base Realignment and Closure in that area by preparing future economic opportunities; and 3) enhancing the collaboration between workforce development (WD) and economic development (ED) in the local area and expanding the range of collaborative activities across the entire Southeastern Virginia (Commonwealth of Virginia 2008).

Various partners from the fields of education including WD, ED, business and industry, and research development joined forces to implement SEVA-PORT in their regions. Activities such as internships, career awareness programs at local secondary schools in M&S and TWD fields, and curriculum development efforts for local community colleges were held for the purpose of achieving the first SEVA-PORT goal cited above. An analysis of training needs for M&S and TWD industries, tuition support for the training classes relevant to the two targeted industries, and some outreach efforts for strengthening the network among the counties and independent cities funded by SEVA-PORT were implemented with respect to the second program goal. Last to address the third goal, quarterly meetings were held for the SEVA-PORT participants and local stakeholders to share information on the ongoing projects and their results. Also forums were established that met on a regular basis to seek future opportunities through networking and sharing best practices (Commonwealth of Virginia 2008; SEVA-PORT et al. 2010).

4. METHODOLOGY AND DATA COLLECTION

The evaluation of the SEVA-PORT initiative focusing on the STEM education component is based on thirty three semi-structured interviews with local program participants involved in the SEVA-PORT implementation process. The protocol for the semi-structured interviews was developed from a summative evaluation perspective. The method of summative evaluation research is to determine the overall effectiveness and potential opportunity for generalization of a certain program or policy by examining effective types of programs or activities as interventions. The summative evaluation method is commonly accepted by policy evaluators to decide whether a pilot program can be expanded to new sites or switched to a permanent program (Patton 2002).

The semi-structured interview protocol was composed of questions asking about specific activities and projects under the SEVA-PORT initiative and whether those activities and projects contributed to achieving at least one of the three program goals. Relevant prior studies, such as the implementation monitoring reports for all of the WIRED regions and other empirical studies examining linking efforts between WD and ED, were referenced in developing the interview protocol (BPA 2008, 2009; PPA 2009; Harper-Anderson 2008). Some characteristics of the Southeastern Virginia region that could affect the performance and implementation process of SEVA-PORT were also identified. <Table 2> presents the interview protocol for the evaluation.

As for the sampling method, the snowball sampling was applied. Also known as chain sampling, snowball sampling starts the interview process with one or a small sample of people and then expands the pool by asking the initial interviewee(s)

Table 2. Interview Protocol for the Qualitative Evaluation of SEVA-PORT

Purpose	Interview Question (Pre-determined)
Perception on the SEVA-PORT program effectiveness	– How effective do you think SEVA-PORT has been in your region? – Based on your understanding, do you think SEVA-PORT is different from other WD/ED programs you have involved? If so, what was the biggest difference between SEVA-PORT and the other WD/ED programs?
Role in SEVA-PORT	– What aspects of your region/regional economy were especially helpful or obstructive in implementing the SEVA-PORT initiative?
Regional Characteristics	– What aspects of your region/regional economy were especially helpful or obstructive in implementing the SEVA-PORT initiative?
Relationship Change among Participants	– Could you tell me what organizations have played a lead role in your region during the SEVA-PORT implementation and some details about the organizations? – Did you notice changes in your organization's relationship (partnership) with other organizations, such as other WD or ED organizations and federal/state/local governments during and after the SEVA-PORT implementation? – Do you think any of these changes (if any) are continuing now even after SEVA-PORT?
Network Structure	– How would you describe the way decisions related to SEVA-PORT were made in your region? – Could you point out three to five people (within different organizations) with whom you were in contact the most frequently regarding SEVA-PORT? – What prompted your frequent contact with the selected organizations during and after SEVA-PORT?
Position Change	– Are you currently in the same position as you were during SEVA-PORT?

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for names of additional interviewees (Colman 1958; Patton 2002; Hesse-Biber and Leavy 2006). The snowball sampling in the summative evaluation context is particularly useful by locating key participants in the program of interest (Patton 2002).

Considering the SEVA-PORT initiative was led by three staff organizations, the Local Workforce Investment Boards responsible for Southeast Virginia, two initial contacts at those staff organizations were identified and contacted for the interview. To avoid the caveat of the snowball sampling distorting the sample of interviewees, the list of interviewees was compared with the key participating organizations listed in the SEVA-PORT final report (SEVA-PORT et al. 2010). Interviewees were also asked whether any key participants involved in the SEVA-PORT implementation process were missing from the list of people already interviewed or scheduled for interviews. Only one of the key participants was not interviewed as the individual had relocated to another area for a new job.

All of the thirty three interviews were conducted between April and August in 2011. The average time spent for every interview was forty five minutes, and all of the interviews were tape-recorded. The demographic information of all interviewees with one exception was also collected at the end of their interviews. All of the interviews recorded were then transcribed and imported into NVivo 9.0, a computer software program for qualitative analysis. To maintain the confidentiality of the interviewees, every interviewee was coded with a random number between 0 and 33.

5. EVALUATION RESULTS

The qualitative evaluation of SEVA-PORT follows the general procedure for grounded theory research (Strauss and Corbin 1998; Creswell 2007). The method of open coding was applied as the first cycle coding method for the identification of key concepts and categories in the transcribed interviews (Strauss and Corbin 1998; Charmaz 2006; Saldana 2009). The open coding results of the initial analysis of SEVA-PORT illustrate that STEM education was one of four key program components under the SEVA-PORT initiative. Fifteen out of thirty three interviewees responded that they were involved in implementing a project that was STEM-related education.

Axial coding then was used for the second coding of the transcribed interviews (Charmaz 2006). Applied as a common second coding method particularly for grounded theory research, axial coding extends the initial analysis results by reassembling the data. The categories that emerge from the open coding process function as the "axis" in reassembling the data during axial coding. Particularly for the STEM education component in the SEVA-PORT evaluation, axial coding is helpful for evaluating similarities among the benefits from the activities under SEVA-PORT. <Fig. 2> on the next page presents the results of axial coding regarding the STEM education component of SEVA-PORT.

The final stage of applying the grounded theory approach is selective coding where inter-relationships among the categories and their sub-categories in the model are identified and described from the axial coding results. Among the possible forms of displaying the results of selective coding, this paper

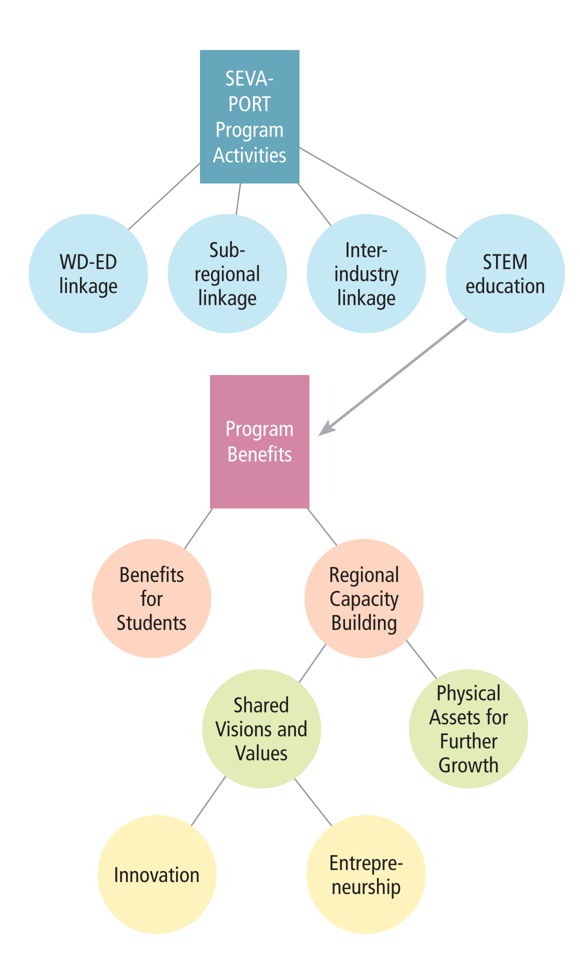

Fig. 2. Axial Coding Results for STEM Education in SEVA-PORT

applies a method of narrative statement. Each theme or theory found in the earlier coding processes is illustrated with quotes from the transcribed interviews that reveal and support the theme (Creswell and Brown 1992; Strauss and Corbin 1998; Creswell 2007). All of the quotes are verbatim from the transcribed interviews. The quotes are presented with the number of the data source that is randomly given to each interviewee for confidentiality. In order to maintain the anonymity of stakeholders or institutions within the region, XXXX is presented whenever the specific names need to be mentioned.

Figure 2 above presents STEM education in the context of three categories: program activities, benefits, and regional capacity building. Three themes (STEM education for talent pipeline development, STEM education activities as a critical source for regional growth, and shared understanding of STEM education as a source for innovation) based on the categories are identified. Each theme is discussed in detail below.

Theme 1: STEM education as a linking effort (Talent Pipeline Development)

The first theme identified as a result of open coding is concerned with four different contexts of linking efforts taking forms of specific projects implemented under SEVA-PORT. The first theme originates from the fact that the overarching theme of the WIRED initiative was to link local workforce development (WD) efforts with the economic development (ED) efforts. At the program implementation level, however, local participants recognized their roles within SEVA-PORT in one of the four different contexts: (1) the linking efforts between WD and ED which was the original goal of WIRED, (2) the linking efforts among the three different sub-regions in Southeastern Virginia – i.e., the Greater Peninsula area, Crater area, and the Hampton Roads area, (3) the linking efforts between the two targeted local industries – i.e., TWD and M&S, and (4) STEM education as the linking effort within WD so-called "talent pipeline development."

Regarding the STEM education portion of SEVA-PORT, fifteen interviewees stated that at least a part of their roles in SEVA-PORT was related to STEM education. The fact that almost half of the interviewees participated in STEM education projects reflected the emphasis of SEVA-PORT given to talent pipeline development. The quote below summarized which different types of activities for STEM education were implemented with the DOL funding for SEVA-PORT.

> Interviewee #1 So what we did for our talent pipeline thing was developing programs that impacted every stage along the [talent] pipeline. We developed for example M&S curriculum for high school courses. We developed M&S camps and career exploring programs for high school students. We developed projects with the career and technical education schools.

The statements below also present other examples of STEM-related education efforts including curriculum development for high school students and community colleges/universities, summer camps or after-school projects, internships, and high school counselor tours.

> Interviewee #3 One of the things we did was some curriculum development [for community colleges of the region]. We also created some summer camps for high school students.

> Interviewee #9 The first piece was the curriculum development in modeling and simulation and the acquisition of new equipment in M&S to teach the students. And I worked with the dean of the college to put the new curriculum in place and bring a board, new faculty members who are experienced in M&S. The second thing that we did was we used the part of the money to create co-op and paid-work experiences for students in companies.

> Interviewee #27 The first part was to develop a curriculum for high school students on M&S so we worked with lots of partners—school districts, the community colleges, and then VMASC [Virginia Modeling, Analysis, and Simulation Center], and school teachers. The next part was that we actually did a group of teachers—it was kind of "train the trainer" model where we went through the curriculum [we developed] with them [high school teachers] and they actually developed more lesson plans that teachers could use.

The quote below talks about the internship opportunities that were given to senior high school students and community college students who were interested in pursuing their careers

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in M&S and TWD industries:

> Interviewee #8 The second part was the opportunity to place some students in existing [M&S and TWD] companies so that they could get exposed to what those companies were doing and pick up some skills related to that particular business that they could use for themselves.

A quote from the Interviewee #21 is noteworthy as it reveals a view on internship programs from a person who actually owns an M&S firm in Southeastern Virginia and hires interns funded by SEVA-PORT. While internships are helpful to students (from local high schools, workforce training centers, and community colleges) in terms of acquiring skills and specific knowledge related to STEM, those internships are also beneficial to private companies by providing opportunities to support the local communities and search for potential employees without causing any extra costs to the firms:

> Interviewee #21 One element of having those programs [SEVA-PORT] is to support the community and give people the chance to learn but another element is get some capability and have them do something for you that does not cost you. But it costs you in mentorship time you have to spend with them. The WIRED interns I see as middle piece that was nice--we could afford to pay them, they had to do real work, and then they could either go on and do something else or stay with the company if we had a job for them. That is one model when you think about interns.

Meanwhile, some interviewees described their involvement in STEM education through high school counselor tours. The quote below shows that SEVA-PORT utilized the guidance counselors of the public high schools in introducing the students to the career opportunities in the two targeted industries.

> Interviewee #12 We developed guidance counselor initiatives where we took the guidance counselors into the M&S and TWD industries so they could see that the careers in the M&S and TWD industries are great and those industries are growing in the region.

Another strategy applied to the SEVA-PORT implementation exposed high school students to the STEM careers including some field trips, as discussed in the quote below:

> Interviewee #30 We did some field trips—we took them [high school students] to the Port of Virginia and some of the [local] universities, as a lot of the kids have never been to those campuses. So we gave them an opportunity to look at different ways in the STEM fields. We tried to broaden their horizons on the many different types of opportunities that would be available for them.

All of the quotes can be summarized with some notable characteristics of STEM education efforts under SEVA-PORT. First, a variety of activities ranging from summer camps to high school guidance counselor tours, were conducted for STEM education. As a result, target groups for those efforts varied depending on the types of specific activities. Summer camps or field trips, for example, were targeted for high school students while curriculum development efforts were aimed for expanding the capability of teachers in STEM fields. The other group of interest under SEVA-PORT STEM education was high school guidance counselors, who provided career tips and guidance to high school students. Second, STEM education of SEVA-PORT appeared to target high school students—junior and seniors specifically, compared to other STEM education efforts presented earlier in the literature. The quotes above discussing various efforts primarily for high school students are the supporting evidence. In relation to that, the third and the last finding is that developing a talent pipeline starting as early as high school to careers in STEM fields seemed to be a critical component of SEVA-PORT linking WD and ED in Southeastern Virginia.

Theme 2: Benefits from STEM-education activities

While the first theme focuses on identifying the characteristics of STEM education in SEVA-PORT, the second theme is related to the benefits earned from STEM education activities. Those benefits are twofold: benefits earned by high school students at the individual level and the benefits for capacity building in the local area where SEVA-PORT was implemented.

The interviewees quoted below illustrate why exposing high school students to STEM fields and careers is so important and beneficial at the individual level. Interviewee #7, for example, talks about the success of his/her summer camps in attracting high school students' interests in STEM fields. The more important thing according to the interviewee is that the impacts of his/her camps are sustained by keeping the camp participants interested in STEM. Interviewee #13, also points out the importance of STEM education projects in raising the awareness of high school students in STEM, although the interviewee is more focused on creating a career pathway for the students to get better-paying jobs in a long-term perspective.

> Interviewee #7 The other piece was really to engage [high school] students in STEM, you know, science, technology, engineering, and mathematics—focusing what the use of gaining in simulation as that aspect. Do I think it affected us? Absolutely, because I still have the students who continuously talk to me and send me emails and things like that from [summer] camps that we have already done and they are still interested in. It is still an important aspect in their lives. They were exposed to things that maybe they were not typically exposed to in maybe high school environment.

> Interviewee #13 One of the things the WIRED really did was to create that pathway and also to create a number of non-degree but fun programs—summer camps things like that, that would raise awareness among high school students. This is a career they can get a good job and good employment and then make it more exciting and more interesting to the young people.

Meanwhile, some other quotes explain the benefits of STEM education in terms of their local economies' capacity building. The statement given by Interviewee #30, for example, is significant as it sheds light on the role of STEM education targeting high school students in nurturing future STEM workforce for the labor market, which occurs much faster than people usually assume:

> Interviewee #30 So what you do with the students when they are younger, you expose them to STEM-related professions and give some information so later on, after four or five years they actually get involved…with those. Actually the effect happens a lot faster than what you think because if I had sixteen and seventeen years old students right now—they were part of the project [I implemented], in five years those students would be the ones looking for their jobs, twenty three, twenty four years old. So it actually happens a lot faster. So I think it was effective that way it was managed. And there were a lot of good projects that came out of the WIRED.

Another statement given by the Interviewee #20 is similar to the Interviewee #30 by finding curriculum development efforts as a foundation work for local workforce development:

> Interviewee #20 A major portion of the SEVA-PORT grant was directed towards creating the necessary infrastructure--working with community college systems, working with [high] school divisions, and trying to put it in place in curriculum that would help to develop a flow of technician level employees. And, the intent was that information would be shared and could be replicated with other school divisions, with other community colleges, and with other universities.

Based on the statements quoted above, three major characteristics of the second theme regarding the benefits from STEM education are found. First, STEM education activities implemented as a component of SEVA-PORT produced benefits both for individual students and their regions regardless of the variance in program types, goals, and/or target recipients. Second, individual benefits earned by high school students under SEVA-PORT include increased (and sustained) interests in STEM fields and the greater awareness in STEM. Third, at least several of the interviewees implementing those activities for the high school level STEM education understood the importance of their activities in the context of long-term regional growth and competitiveness.

Theme 3: Shared vision and values of STEM education in creating regional economic growth

The last theme of the STEM education evaluation of SEVA-PORT is concerned about shared understanding of STEM education as a source for innovation and entrepreneurship sustaining economic growth. In fact, the second theme was about "who earned what" as program benefits mainly from the high school level STEM education activities. In comparison, the third theme focuses on summarizing what lessons were learned by SEVA-PORT participants and how they continue to apply the lessons learned to their ordinary responsibilities in the region.

The statements below indicate that the SEVA-PORT implementations key regional stakeholders started to see the hid-

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den link between STEM education and innovation as the key for sustainable growth. Interviewee #5, for example, sees the importance of STEM education in the context of the regional characteristics, which is heavily dependent on the government sector such as logistics, military research and development facilities in the M&S industry:

> Interviewee #5 And the reason I think XXX and I see the importance of those [STEM education] projects [of SEVA-PORT] is for us in the government-dependent region like here Hampton Roads, our kids need to be innovative to think about new technologies.

The same person (Interviewee #5) also mentioned how he/she, as a local branch director of a nationwide non-profit education institute, was influenced by the SEVA-PORT participation in terms of dealing with STEM education:

> Interviewee #5 So I think the project we did not only opened kids eyes up about STEM and STEM careers but open our own eyes to be aware of. We are now going back to our national office and saying that we need more STEM [education] stuffs.

The statement of the Interviewee #19 is similar to the previous interviewee, although he/she, as an ED person, took the reverse approach by saying that STEM education is important to promote innovations in the key industry of the region:

> Interviewee #19 In most cases, we figure out we need intellectual capital and workforce development. We said we know our needs here--we have the general need that we have to fill innovations here--we got to be able to support ports and the maritime industry.

Some other interviewees emphasize on continuing to practice the shared value of innovation coming from STEM education in their everyday life. The quote from the Interviewee #7 is a notable example:

> Interviewee #7 Since the WIRED grant has ended, we have actually taken quite a few of these concepts. Basically, the outreach has continued in various mechanisms to include continuing the camps. I visit high schools on a routine basis. That was one of things that spur me on to continue the outreach. So, I am constantly going to high school classrooms, technology classrooms, and governor schools and interacting with them.

Another group of interviewees point out entrepreneurship as their lessons learned from the STEM education components of SEVA-PORT. Interviewee #1, for example, described how he/she and other regional participants grasped an idea of STEM education as their sustained challenge to make their region innovative and entrepreneurial, even after the completion of SEVA-PORT:

> Interviewee #1 Those communities that are most proficient in these STEM disciplines are those communities that will be the most successful in entrepreneurship and innovation. STEM drives entrepreneurialism and innovation. And if you develop a talent pipeline where you got kids coming up with sophisticated science skills, technology skills, engineering skills, and mathematical skills, you will have to develop the community that is entrepreneurial, innovative, and growing into the future. End of the story. That's what we earned from WIRED and that is what we are doing now--we are working on ways to continue promote STEM because we believe that STEM is the forerunner for the economic drivers of the future. That is the legacy of the WIRED I think that is pretty significant.

The statements under the category of the third theme are concerned with lessons learned and still sustained within the region even after the completion of SEVA-PORT in 2010. The first lesson is the increased understanding of local key stakeholders of the role of STEM education in creating innovations as a key driver for growth. The other type of shared vision and value is encouraging local entrepreneurship to be regarded as another key source for sustainable growth along with innovation as Interviewee #1 noted.

6. CONCLUSIONS AND POLICY IMPLICATIONS

This paper explores the importance of STEM education in securing sustainable regional growth. An evaluation of a federal initiative targeted for STEM education and economic development is selected as a way of analyzing it in the paper. The review on prior studies finds that scholars have agreed with the role of human capital as a key source for sustainable economic growth, although STEM education was not appreciated as a way of increasing human capital until the mid-2000s. The release of the National Academies' report Rising above the Gathering Storm and of other policy reports similar to that, however, allow policy makers to find the linkage of STEM education with long-term economic growth in local areas. A growing number of STEM education programs since mid-2000s at the federal level is the evidence of such linkage, despite the lack of the evaluation literature due to the insufficiency of indicators measuring the contribution of STEM education to economic growth and future workforce development. Noting the challenges and difficulties of evaluating STEM education efforts identified by the relevant literature, this paper conducts the qualitative assessment of a local workforce development including STEM education as its critical program component.

The WIRED program in Southeastern Virginia (or SEVA-PORT) is then introduced and analyzed with emphasis given to its STEM-education component. As a pilot project of DOL for linking WD and ED in local communities, the SEVA-PORT initiative was implemented between 2007 and 2010. For the qualitative evaluation, thirty-three local key stakeholders involved in the implementation of SEVA-PORT provided direct insight into the thinking of the people involved in the implementation of the program.

The results of the qualitative analysis based on three-stage coding methods (open coding, axial coding, and selective coding) identified three different themes regarding the STEM education in the context of achieving sustainable growth. First, the STEM education activities were implemented as one of the four major linking efforts under SEVA-PORT. STEM education was especially important in linking a major component within WD—the so-called, "talent pipeline"—starting with high school students and including professional workers in STEM fields. The first theme also finds that STEM education particularly at the high school level was emphasized in SEVA-PORT. The second theme focuses on the types of program benefits that were created by STEM education components under the program. The analysis results confirm the existence of two different types of benefits, which are the immediate program benefits going into local high school students as a target group of the program and the broader (and indirect) benefits directed for regional capacity building. In specific, benefits such as nurturing the future workforce and achieving long-term growth are mentioned in terms of regional capacity building. The third theme identified from the analysis indicates that the increased number of local key stakeholders share and continue to implement their efforts for innovation and entrepreneurship as the vision and values learned from their SEVA-PORT experiences.

The evaluation results of SEVA-PORT in this paper, especially the first theme, call for local policy makers' particular attention to STEM education as a key to sustainable long-term economic growth in regions. In fact, policy makers in the U.S. became more interested in applying workforce development and STEM education to achieving sustainable regional economic growth. U.S. federal STEM education programs listed in Table 1 are only a few examples. More STEM education efforts by DOL are expected as well, especially under the latest legal framework for workforce development called the Workforce Innovation and Opportunity Act.

The analysis results regarding the second theme provide a valuable implication to policy makers and local economic and workforce development practitioners by confirming that the role of STEM education is substantial to regional capacity in addition to the immediate and direct benefits affected to the program participants. This implication, however, requires additional evidence accumulated by further investigations of policy analysts and evaluation professionals both quantitatively and qualitatively.

Related to the second theme, the third theme of the evaluation results is even more important as it presents that the effects of educating policy actors and key stakeholders in regions could survive much longer and could function more effectively to achieve sustainable regional growth. The practices of innovation and entrepreneurship in the SEVA-PORT region continuing today are strong evidence in support of such learning effects.

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