Going and Passing Through Community Colleges: Examining the Effectiveness of *Project Lead The Way* in STEM Pathways

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Abstract

Project Lead The Way (PLTW), which aims to create a seamless pathway from secondary education to college and career success in STEM fields, was first implemented in the State of Iowa in 2005. As a part of a statewide, longitudinal research in PLTW, this study intends to explore the effectiveness of PLTW in college persistence by analyzing multiple data sources, including state's K-12, community college MIS, and National Student Clearinghouse to examine multiple educational pathways of PLTW and non-PLTW students into higher education, more specifically looking at patterns of students' educational mobility within two years after high school graduation.

Keywords: STEM education, community college, educational pathway, longitudinal study

Going and Passing Through Community Colleges: Examining the Effectiveness of *Project Lead The Way* in Student Educational Pathways in STEM

Among the nation's post-secondary education institutions, community colleges serve an important role in increasing the numbers of STEM degree recipients and leading to a more skilled workforce. From 1985 to 2009, recipients of associate's degrees in science and engineering from two-year institutions increased from 26,500 to 54,284 (National Science Foundation, 2011). Among these degree recipients, the number of associate's degree recipients in engineering in 2007 was 2,272, the highest number since 1995 (National Science Board, 2010). At baccalaureate level, the number of female students awarded in science and engineering shown an increase from 1985 to 2005.

However, when we look at the number of bachelor's degrees in engineering, computer science, and mathematics, the proportion of female students has declined from 1993 to 2007 (NSB, 2010). It is also disheartening that the proportion of underrepresented minorities (URMs) with a STEM bachelor's degree has not been kept up with their population growth (NSB, 2010). To broaden participation among URMs, including females in STEM education, researchers, educators, and policymakers began to recognize the role of community colleges in students' educational pathways, specifically providing educational access for all students (Hoffman, Starobin, Laanan, & Rivera, 2010; Starobin, Laanan, & Burger, 2010). Community colleges' open access, relatively low tuition and fees, and convenient locations continue to attract a large number of students, particularly URMs seeking to obtain a degree (Mooney & Foley, 2011; Tsapogas, 2004). For this reason, this study pays an attention at community colleges as they offer an opportunity to begin their postsecondary education and transfer to a four-year institution. This study also focuses on an educational program that is designed and implemented at secondary education level to expand the proportion of students who persist in STEM-related

fields at post-secondary level. We specifically look at Project Lead The Way (PLTW), which aims to provide a seamless path to college and career success in STEM-related fields for middle school and high school students (Blais, 2003).

Project Lead The Way and Postsecondary Institutions

PLTW has been implemented in every U.S. state since the late 1990s, was first introduced to the state of Iowa in 2005. Since then Iowa PLTW experienced a fast, steady growth from only about 200 students in 2005 to more than 2,000 in 2009 (Schenk, Rethwisch, Laanan, Chapman, Starobin & Zhang, 2010). It has been a great interest of the State of Iowa legislature, governmental agencies, business, and all educational sectors to increase a number of STEM graduates at the postsecondary level. Over the years, Iowa PLTW has played a critical role in meeting the need of the state by motivating students to pursue STEM disciplines through hands-on and project-based learning curriculum in secondary schools and sending students to colleges and universities.

There has not been any empirical evidence to show the effectiveness of PLTW in students' persistence to postsecondary education until 2008, when a team of researchers began to examine the program effectiveness in PLTW students' academic achievements, high school graduation, as well as immediate entry to postsecondary education. Results from the study revealed that the participation of PLTW increased the odds of attending community colleges, compared to no college attendance, by 50 percent (Schenk, Laanan, Starobin, Rethwisch, Moeller, & Chapman, 2012). What remain unknown is how these students persisted one year after the immediate entry to higher education; thus the persistence in postsecondary education and whether they are major in STEM fields. Thus, purpose of this study is to take a look at patterns of students' educational mobility among postsecondary institutions within two years after high school graduation. Additionally, we are interested in examining whether PLTW

students are more likely to enroll in a STEM major than non-PLTW students in a postsecondary institution. There are two research questions guided this study: 1) How do PLTW and non-PLTW students persist to postsecondary institutions within two years after high school graduation?, and 2) To what extent do PLTW and non-PLTW students enroll in a STEM major within two years after high school graduation?

Conceptual Framework of the Study

College student persistence has been a topic of interest to researchers, educators, administrators, parents, and students in the past decades. A body of existing literature suggests that educational experiences, motivations, and academic performance at multiple educational levels can predict student persistence (Tinto, 1975; 1993, Bean, 1980, Astin, 1993). Furthermore, students' demographic characteristics, such as age, race, and gender influence their persistence (Astin, 1972; Leppel, 2001; Spady, 1970). Other scholars indicated that students' experiences in K-12 classrooms directly impact on persistence in STEM education at the post-secondary level. For instance, Berryman (1993) argues that students' inadequate academic preparation significantly limited their science achievement. Astin and Astin (1992) also confirmed that students' adequate mathematical and academic preparations play a critical role in persistence in science, engineering, and mathematics. In addition to student performance in math courses in secondary education, science courses were also identified as a significant predictor of students' retention in STEM majors (Bonous-Hammarth, 2000; Sells, 1980). Such evidence from educational research studies came to a conclusion that this nation must make efforts to ensure the readiness of the U.S. workforce for the projected growth in science and engineering workforce by improving K-12 math and science preparation (NSF, 2006b).

This study adopts Pascarella's model of student learning and cognitive development (1985) and Hagedorn's conceptualization of student retention (Hagedorn & Cepeda, 2004;

Hagedorn, Moon, Cypers, Maxwell & Lester, 2006; Hagedorn, Cypers & Lester, 2008). Pascarella's model suggests that students' development is a function of the direct and indirect effects of five major variables, including 1) student background and precollege characteristics, 2) structural and organization characteristics of the institution, 3) institutional environment, 4) interactions with socializing agents, and 5) quality of student effort. Based on transcript analysis of transfer student retention, Hagedorn and colleagues (Hagedorn & Cepeda, 2004; Hagedorn, Moon, Cypers, Maxwell & Lester, 2006; Hagedorn, Cypers & Lester, 2008) affirmed that students' academic success lead to a likelihood of transfer to a 4-year institution and have positive influence on student retention in postsecondary education. Conceptually, students' transfer from a community college to a four-year institution was conceived as student persistence in postsecondary education. This concept is also known as system retention.

In addition to the student persistent frameworks, particularly the application of the system retention framework, we adopted the counterfactual framework (Haalvelmo 1943; Holland, 1986; Rubin, 1986) in examining to what extent PLTW participation impacts on student's major in STEM fields at a postsecondary institution. Based on a recent study of Iowa PLTW, it was evident that the PLTW participation was affected by school and district-level selection bias (Schenk, Laanan, Starobin, Rethwisch, Moeller, & Chapman, 2012). For instance, school districts that implement PLTW are larger, more urban, and have a smaller proportion of low SES students compared to districts that do not.

There is also student-level selection bias due to students' choice of PLTW courses. We can determine if there is any selection bias by estimating the likelihood of entering PLTW while conditioning on data prior to enrollment. By examining the students' socio-demographic and testing data, we then calculate the conditional probability of receiving the treatment given the observed. Thus, a propensity score matching technique was employed to generate treatment

(PLTW students) and control (non-PLTW students) groups with a comprehensive longitudinal data set that includes secondary and postsecondary educational and demographic information (note 1). In addition, this study applied different matching algorithms, such as commonly used "nearest neighbor" to match students to the nearest similar students. This study also used genetic algorithms to optimize matches and minimize differences between participants and nonparticipants.

Methodology

This study is a part of a large-scale, multi-year research project regarding Iowa PLTW with a special focus on students who graduated from high school in the spring of 2009. Students who were enrolled in at least one PLTW course during high school were identified and denoted as a PLTW participant. A control cohort was chosen from students who were enrolled a school which offered PLTW, but were not actually enrolled in any PLTW courses. Approximately 1,000 PLTW students and 15,000 non-PLTW students who graduated from Iowa high schools in 2009 are included in the study. Three data sources were merged to form the comprehensive PLTW dataset. Figure 1 shows the capability of the researchers to follow students from 8th grade through college. Project EASIER contains data on K-12 students and includes information on which students enrolled in PLTW courses, their academic performance, standardized test scores (Iowa Test of Basic Skills, ITBS and Iowa Test of Educational Development, ITED), and other demographic information. The State of Iowa also maintains a comprehensive database of students enrolled in Iowa's 15 community colleges. The database contains demographic information, the courses in which the student is enrolled, their course program, and other educational and demographic data. Finally, the National Student Clearinghouse (NSC) contains enrollment records for over 3,000 education institutions. NSC denotes the dates when students

were enrolled, the institution, and institutional type (e.g., 4-year or 2-year college). Some colleges have also begun to report the student's major and degree completion.

Since appearing in the National Student Clearinghouse data as early as August 1, 2009, many students have attended two or more higher education institutions. However, at the current stage of the research, the researchers focused on: 1) the first attended institution, where students persisted at least 30 days and did not withdraw at any time in the fall semester and 2) the second attended institution, where students persisted at least 30 days and did not withdraw at any time in the subsequent fall semester. As indicated in the Figure 2, we examined ten possible educational pathways after the first attendance. These educational pathways are: from a community college to: 1) community college, 2) 4-year institution, 3) completion, 4) no-enrollment; from a 4-year institution to: 5) community college, 6) 4-year institution, 7) no-enrollment; as well as from no-enrollment to: 8) community college, 9) 4-year institution, and 10) no-enrollment.

To examine students' college major, the researchers followed the 2009 cohort into postsecondary institutions and looked at their reported major from the National Student Clearinghouse data through December 2011. Not all postsecondary institutions reported the student's major to the NSC; thus this analysis is limited to the institutions that reported a major. The detailed methodology to examine the impact of PLTW on the immediate entry to the postsecondary education and the formation of the treatment (PLTW students) and control (non-PLTW students) groups, see the previous study of Schenk and colleagues (Schenk, Laanan, Rethwisch, Starobin, Moeller, Zhang, & Chapman, 2010). Going beyond the previous study, this paper tracked the same 2009 cohort and focused on the students' educational pathways to the second attended institution or no attendance as well as their college major.

Results

Pathways from Community College: Approximately 32% of PLTW students and 28% of non-PLTW students transitioned into community college in the fall of 2009 (see Figure 3). From community college, almost a half of students (both PLTW students and non-PLTW students) persisted to community college in a subsequent year. Those who transferred to a 4-year institution, PLTW students attended a 4-year institution at higher proportion (16%) than non-PLTW students (9%). Also, it is notable that PLTW students were proportionally lower (35%) than non-PLTW students (43%) with regard to "stopping out" from higher education from community college. We observed no college completion in the record.

Pathways from 4-year Institution: Among 263 observed PLTW students who enter a 4-year institution upon high school graduation, 87% of these students continue to enroll in a 4-year institution (Figure 4). For both PLTW students and non-PLTW students, less than 5% transferred from a 4-year institution to a community college. From a 4-year institution, students (both PLTW and non-PLTW participants) were less likely to "stopping out" from higher education than those who attended community college as their first entry to higher education.

Pathways from No-Enrollment: Of those students who did not attend any postsecondary institution immediately after high school graduation (30% PLTW students and 49% non-PLTW students) more than 12% of them enrolled in a community college during the second year (Figure 5). Additionally, 5% of both PLTW and non-PLTW students enrolled in a 4-year institution. This finding is critical as students are looking to "come back" to educational pathway, particularly at the postsecondary level.

Student College Major: Between 2010 and December 2012, 5,439 students from the Class of 2009 were enrolled in higher education with a reported major. The proportion of PLTW participants enrolled in a STEM major was higher than non-participants. Of the 323 PLTW participants, a quarter was enrolled in a STEM major as defined by the National Science

Foundation (Figure 6). Only ten percent of non-participants enrolled in a STEM major during the same time period. However, there are significant differences between participants and non-participants that are not attributable to the PLTW program. We derived a comparable group of PLTW participants and non-PLTW participants. Within the comparable group, 27% of participants with a reported major were studying STEM, compared to 16% of non-participants. The p-value from the t-test was 0.007, which showed a statistically significant difference.

Conclusions

This study can provide insightful knowledge to researchers who are interested in STEM education by applying a quasi-experimental longitudinal research design. In particular, this study examined the relationship between PLTW participation and college persistence and effectiveness of PLTW in major in STEM fields at the postsecondary level. Furthermore, the utility of the multiple merged statewide datasets as well as the application of the propensity score matching technique were described.

Our study results revealed that more PLTW participants enroll in higher education the year after graduating high school than students from the same school district, and the PLTW participation has a positive impact on students to immediately enroll in higher education the year after graduating from high school. Additional finding from this study provided the evidence that PLTW participants were more likely to transfer from a community college to a 4-year institution within two years after high school graduation. Once in college, PLTW participants are more likely to enroll in a STEM major than similar students. Twenty-eight percent of PLTW participants from the class of 2009 enrolled in a STEM major. While this proportion may change until a student graduates, the proportion was ten percent higher than similar students for the same time period.

The results of this study, however, raise further questions. Due to time constraints, the authors did not have the ability to fully record college completion. It is our hope to follow up with these students to measure the six-year graduation rate for immediate enrollees in four-year colleges as well as their persistent in major in STEM fields.

Note 1: The data set includes the Project EASIER (Iowa secondary school data set), the Community College MIS (transition to Iowa community college), Regent transcripts (transition to Iowa public 4-year universities), and the National Student Clearinghouse data (transition to 4-year institutions nationwide).

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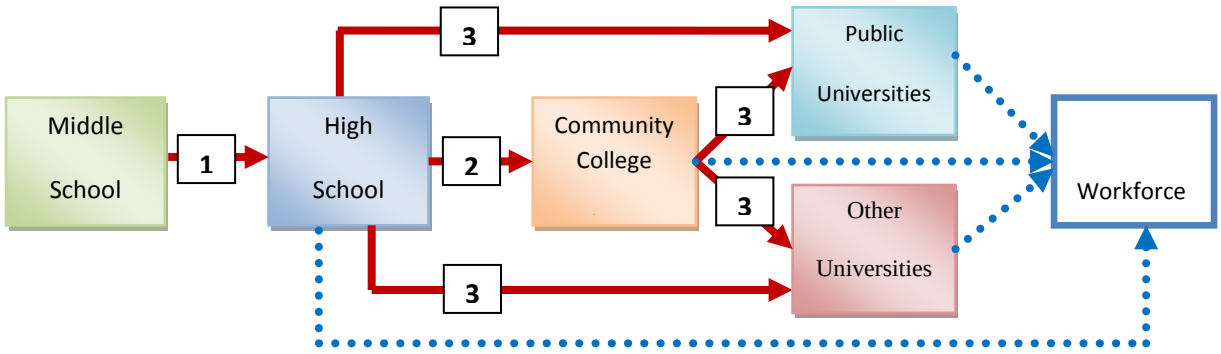
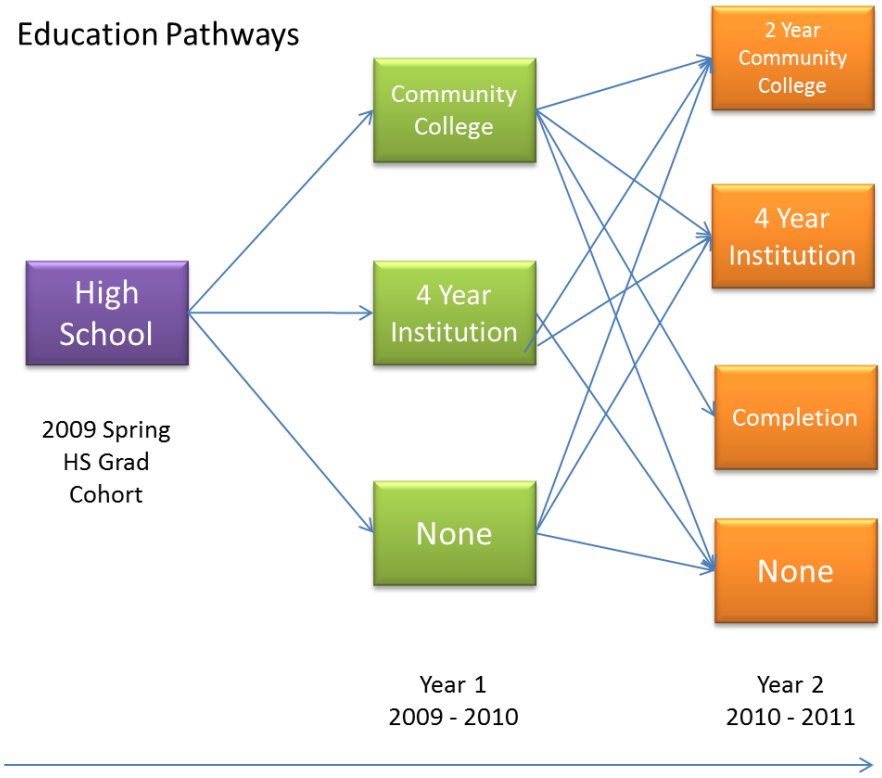
Figure 1. Iowa Statewide Longitudinal Dataset: Tracking Project Lead The Way Students



Note: The transition shown in [1] is tracked by Iowa's secondary data system (Project EASIER); the transition into community colleges [2] is from Iowa's community college data system (MIS), we obtain the transition into public universities; and the transition into other higher education institutions [3] is from the National Student Clearinghouse.

Figure 2. Educational Pathways within Two Years after High School Graduation



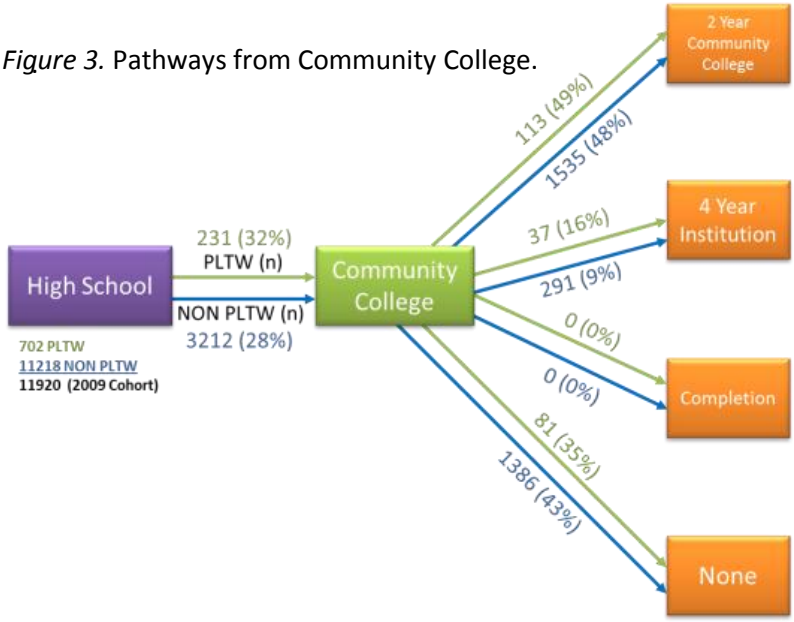


Figure 3. Pathways from Community College.

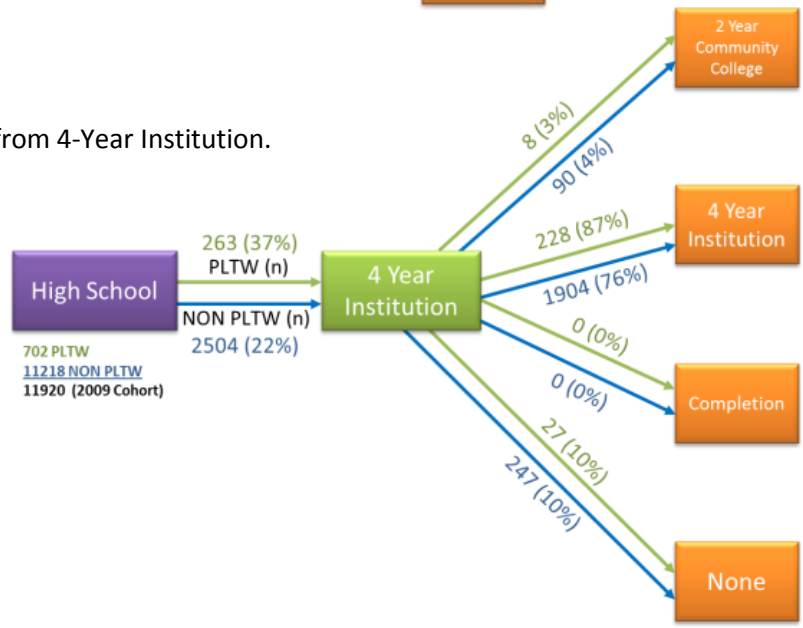


Figure 4. Pathways from 4-Year Institution.

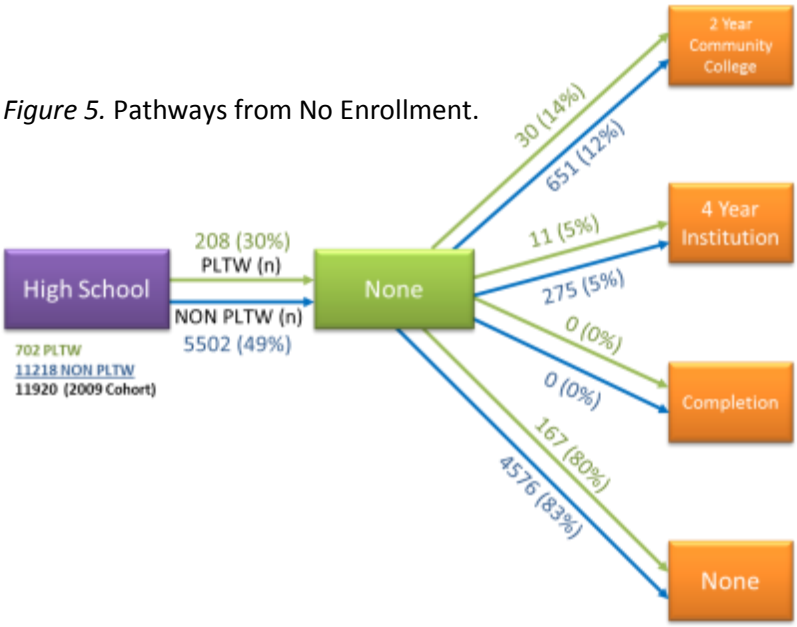
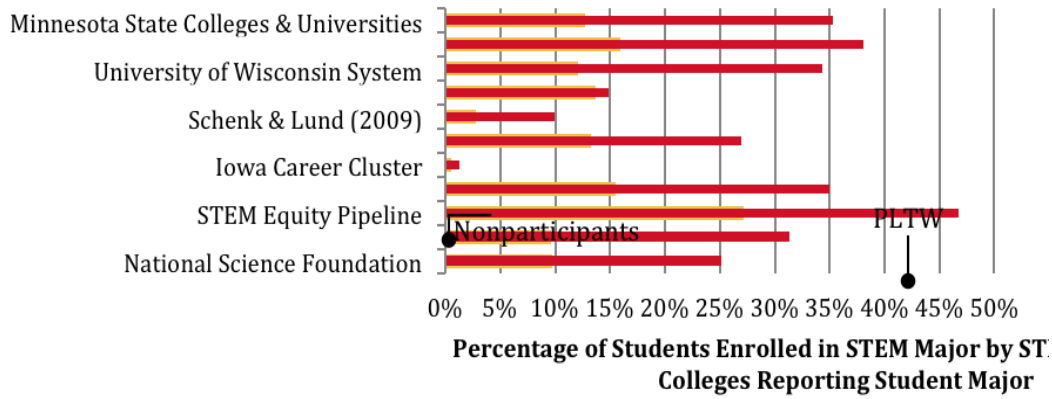


Figure 5. Pathways from No Enrollment.

Figure 6


Minnesota State Colleges & Universities
University of Wisconsin System
Schenk & Lund (2009)
Iowa Career Cluster
STEM Equity Pipeline
National Science Foundation
Nonparticipants
PLTW
0% 5% 10% 15% 20% 25% 30% 35% 40% 45% 50%
Percentage of Students Enrolled in STEM Major by ST
Colleges Reporting Student Major