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NEWPATH: An Innovative Program to Nurture IT Entrepreneurs

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ABSTRACT

The number of freshmen interested in entrepreneurship has grown dramatically in the last few years. In response, many universities have created entrepreneurship programs, including ones focused on engineering entrepreneurship. In this paper, we report on *NEWPATH*, an innovative NSF-supported program at Ohio State, designed to nurture students to become IT entrepreneurs. While the program builds on the experiences of other schools, it includes a number of novel components that are integrated together in an unusual manner to interlock and complement each other. The result is an ecosystem that is exceptionally effective in achieving its key goal of helping students succeed as IT entrepreneurs. Indeed, between the 25 or so students who are active in NEWPATH, three or four enterprises have been launched and have acquired or are close to acquiring VC/angel funding; a couple of others were launched with seed-funding before the involved students decided their business model was not as viable as they thought and suspended work. The students involved range from sophomores through seniors/recent graduates.

Key Words: IT entrepreneurship, Collaborative learning, Community of Inquiry

INTRODUCTION

It is a long held truism that entrepreneurship is the engine that drives the American economy. This is even more relevant today, given the current and recent economic developments and the need

for even large corporations to adopt an entrepreneurial mindset in order to be able to react nimbly to market developments. *Engineering* entrepreneurship, based on effective use of the numerous recent developments in science and technology, is especially important to ensuring a vibrant national economy. Equally, it can prove extremely rewarding to the individual entrepreneur who has the knowledge to see the potential applications of such developments and the entrepreneurial skills to realize the potential in an actual product at the right time and in the right market. Thus while many previously very successful companies have, in the last several years, gone bankrupt and, indeed, whole economies have suffered considerable damage, a number of individual entrepreneurs and teams of entrepreneurs have launched remarkably successful new businesses that have not only rewarded them very richly in financial terms but also enabled these individuals to leave their mark on society and culture.

Not surprisingly, the number of engineering freshmen interested in entrepreneurship has grown dramatically in the last several years (see, e.g., [10, 11]). In response, many universities have created entrepreneurship programs, including ones focused on engineering entrepreneurship (see, e.g., [1, 2, 6, 18, 19, 21, 30] and others). *Information technology* (IT) has been key, indeed, it has either been the primary technology underlying or the *enabling* factor in many of the most successful enterprises of the last decade or two. In this paper, we report on *NEWPATH*, an innovative program supported by the National Science Foundation (NSF), at Ohio State, designed to nurture students to become IT entrepreneurs. While some components of NEWPATH are based on the experiences of other programs, our focus is on IT; not just on the potential products and services that effectively exploit IT but also on the particular entrepreneurial considerations, such as market research, that IT enables us to address in new and extremely effective ways. In addition, NEWPATH includes a unique integrative component that enables students to help each other grow as budding entrepreneurs. The result is an ecosystem that is exceptionally effective in achieving its key goal of helping nurture future IT entrepreneurs.

Over the last several years, researchers have developed various models of learning that attempt to identify particular factors that play key roles in helping students learn in different disciplines, including especially STEM disciplines. These have ranged from *constructionism* (e.g., [22, 15) which is based on the idea that effective learning is most likely when an integral part of the learning activity is having the learner construct a meaningful product; to *collaborative* learning [7, 13, 14] and the *community of inquiry* model [12, 29] which argues that constructivism must be complemented by collaborative learning in order to be truly effective; to the broader *how people learn* framework [3]. *Internships* and other experiential activities that are common to many of the engineering entrepreneurship programs and are also a key part of NEWPATH, may be considered to be the constructivist components of these programs. But, as hinted above and as we will see in detail later in the paper, NEWPATH is unique in including an *integrative* component that not only enables but actively

promotes collaborative learning. (We should note that "NEWPATH", although written in all-caps, is the name of the program, not an acronym.)

Standish-Kuon and Rice [28] compare programs related to engineering entrepreneurship at a number of universities. They classify the programs into three different models based mainly on where the program is located, the possibilities being in the engineering school of the university or in its business school or split between them. As we will see, in terms of this characterization, NEWPATH fits in the last category; in particular, the *entrepreneurship-minor* that students complete is in the business school, several of the other main activities that students engage in are in the Computer Science & Engineering (CSE) Department in the engineering school, and the culminating entrepreneurship-practicum is mainly in the business school but with active coordination with the CSE Department. Standish-Kuon and Rice also consider a number of key factors that influenced the direction and organization of engineering entrepreneurship programs at those universities. As we will see later in the paper, most of the factors they consider had little or no impact on the development and growth of the NEWPATH program. Instead, the main factors that guided the evolution of our program were the reactions of the students in the program to various aspects of the program and, especially, their impact on students' growth as IT entrepreneurs; assessment results, detailed later, also guided this evolution. In addition, our focus, as noted above, on IT-based entrepreneurship played a major role in developing various components of the program.

In the next section, we summarize some recent work related to models of learning. In Section 3, we detail various aspects of the NEWPATH program and summarize the importance role that the NEWPATH *community* plays in the success of the program. In Section 4, we summarize the results of assessments of the program; we also highlight some of the specific successes, in the form of IT enterprises that NEWPATH students have launched. In Section 5 we briefly summarize related work, looking at the details of some other programs in engineering entrepreneurship. Section 6 concludes the paper with a summary of lessons learned and our future plans.

MODELS OF ENTREPRENEURIAL LEARNING

A number of researchers (e.g., [4, 17, 20]) have investigated the key problems that new enterprises often encounter and the tasks that entrepreneurs must be effective at in order to address those problems. The tasks that entrepreneurs must be effective at, as identified by these and others, include the ability to conduct market analysis, see the potential of new products and services, make decisions under uncertainty and risk, etc. Many schools have established curricula for *minor* programs in entrepreneurship designed to develop their students' abilities with respect to these tasks. In the next section, we will briefly detail the curriculum that NEWPATH students are required to go through

as part of their entrepreneurship minor. As we will see, these courses, which are in some respects similar to courses in the entrepreneurship minor programs at other schools and innovative in other respects, are designed to develop important skills for the future entrepreneur. We will also detail how the students' major programs are structured so that the completion of the entrepreneurship minor does not require the student to remain in school for a substantially longer period of time than he or she would otherwise have to. As noted in [28], this is one of the major issues that other schools that have focused on engineering entrepreneurship have had to contend with.

The courses in these entrepreneurship minor programs, including most of the ones in our program, are structured in a fairly standard fashion with the main component being lectures by the instructor. Indeed, since these courses tend to be taken not just by engineering students but by students from across the campus interested in entrepreneurship, they tend to be large-size classes with relatively little student interaction or direct participation. Over the last several years, a number of models have been developed corresponding to student learning in a variety of disciplines including science and engineering. These models stress the great importance of students applying their knowledge in appropriate activities and, perhaps even more importantly, of interacting with each other and helping each other learn. Below we summarize some key findings from these developments and in the next section we will see how these findings have influenced NEWPATH.

The *How People Learn* (HPL) framework [3, 8, 24, 25] captures some general *learning principles*. According to HPL, the learning environment and learning activities should be designed to be *learner-centered*, accounting for the knowledge, skills, preconceptions, and common misconceptions of the learners; *knowledge-centered*, to help students learn by thinking qualitatively and organizing their knowledge around key concepts; and be *assessment-centered*, by monitoring student progress and provide formative, timely feedback to help students be aware of gaps in their understanding. Most importantly, HPL stresses the importance of organizing the learning environment to be *community-centered* in order to encourage students to learn from one another.

The main idea underlying *constructivism* is that learners are not "empty vessels" to be filled with knowledge by the instructor [9]. Rather, learners understand a new topic by constructing mental models of the item. *Constructionism* extends the idea by arguing that this can happen most effectively when students make tangible models, possibly in software, of the item in question [16, 22, 23]. Scardamalia *et al*. [26, 27] in developing CSILE (Computer Supported Intentional Learning Environments), argue that students learn most effectively when they engage in *knowledge-building*, as against *knowledge-reproduction*. The approach of the *Cognition and Technology Group at Vanderbilt* (CTGV) group [5] has some similarities to that of CSILE.

Figure 1 depicts the *Community of Inquiry* (CoI) model [29], another framework that stresses the importance of interaction among students to help them develop a thorough understanding of the

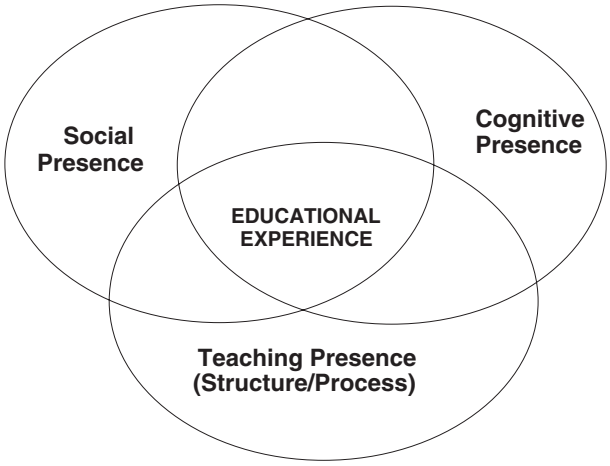


Figure 1. Community of Inquiry (CoI) Model.

topic under study. Although CoI was originally designed primarily for analyzing on-line educational systems, it is also appropriate for learning environments that are (mostly or entirely) face-to-face.

The three principal elements of the CoI model are social presence, cognitive presence and teaching presence. Social presence may be defined as the degree to which participants in the learning environment feel affectively connected one to another; cognitive presence represents the extent to which learners are able to, via interactions with each other, construct and refine their understanding of important ideas through *reflection* and *discussion*; and teaching presence is the design of various instructional activities such as lectures *as well as* activities intended to facilitate interactions among students to help their learning.

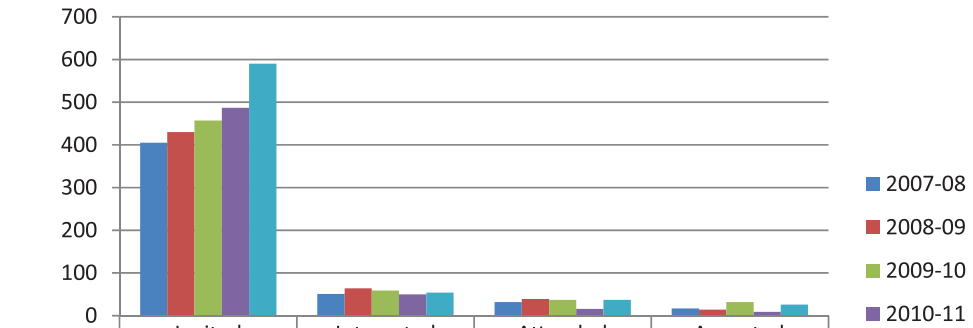
To summarize, the learning environment should provide three mutually supporting components, these being a suitable set of instructional activities including appropriate courses in relevant topics; activities, in the constructivist/constructionist sense, in which students apply the concepts and ideas learned in the courses to solve realistic problems or, in the case of entrepreneurship, to create businesses or parts thereof; and have the students engage in discussions and other activities as a *community of inquiry* to learn from each other's experiences and understanding of key ideas. As Garrison *et al*. [12] who proposed the CoI model put it, "... education is a collaborative reconstruction of experience". This idea of students forming a community-of-inquiry is especially relevant for engineering entrepreneurship programs where students need to see how the ideas they might read about or learn about in the classroom work in actual startups and to analyze the results by thoroughly discussing them with their peers. As we will see, a central component of the NEWPATH program is designed to do just that.

NEWPATH PROGRAM DETAILS

As described below, each year selected students in IT-related areas are admitted to the NEWPATH program. These students are expected, in addition to completing the requirements of their degree program, to take courses in entrepreneurship, complete internships in IT startups, etc. We will present complete details of the NEWPATH curriculum below. One important point worth stressing even at this stage is that NEWPATH is *not* a major or a minor program at the successful completion of which, the student receives a certificate or diploma of some kind. Instead, it is an *opportunity program* intended to nurture students interested in IT entrepreneurship. That is, it provides opportunities for students to deepen their understanding of important entrepreneurial ideas such as market research, venture capital, etc.; to sharpen their networking skills (and creating a useful, if small, network of successful IT entrepreneurs and others who can help them in their future entrepreneurial ventures); to develop their abilities to make presentations *related to potential IT startups* to different audiences such as IT developers and VCs; and, finally, engage in a *community-of-inquiry* of students, all with a strong interest in IT-entrepreneurship, but with a wide range of levels of relevant knowledge and skills (see Section on NEWPATH Community).

Admission to the program

NEWPATH has taken a multi-pronged approach to attracting a suitable mix of students, including word-of-mouth publicity, a program website, and informational meetings for potential new recruits. In the first step of the process each year, we obtain a list of names and e-mail addresses of all Ohio State students who met three specific criteria, and invited them to an informational meeting about NEWPATH. The criteria were: a. major or pre-major in an OSU undergraduate computing degree program, i.e., computer science and engineering, computer and information science, electrical and computer engineering, or information systems in business; b. at least a 3.0 GPA at OSU; or, no GPA at all, i.e., a first-semester student; and c. at most a certain number of credit-hours completed toward graduation. The first criterion is self-evident given the main purpose of NEWPATH: these are the computing majors offered at OSU. The second criterion is based on the expectation that students in NEWPATH should be able to complete their degree program in four years, even with the addition of an entrepreneurship minor (see below) that adds slightly to their overall requirements: students with high GPAs are more likely to have some AP credit to help offset the additional credit hours in the minor, for example, and are more likely not to delay graduation by having to repeat courses, etc. The third criterion recognizes that students need enough remaining time at OSU to complete the entrepreneurship minor, at least one internship, and the senior-year e-practicum; and effectively contribute to and benefit from the NEWPATH community. The third criterion also gives



	Invited	Interested	Attended	Accepted
2007-08	405	51	32	17
2008-09	430	64	39	14
2009-10	457	59	37	32
2010-11	487	50	16	9
2011-12	590	54	37	26

Figure 2. Admission to NEWPATH.

us some control over the number of invitees. This was important since, in order for the students in the program to function effectively as as *community of inquiry*, it has to be of a suitable size.

The chart (Figure 2) shows, for each of the last five years, the number of students invited to the informational session, of those invited the number who expressed an interest in attending, the number who actually attended, and the number who were admitted to the program following the session. The GPA distribution across all courses at Ohio State and the 3.0 cut off meant that approximately the top 40% of the students who met the other criteria were invited; thus for 2011-12, about 600 students out of about 1500 possible candidates were invited. Of the invited students each year, roughly a tenth indicated interest in attending the informational meeting, and were informed of the place and time of the meeting. In other words, apparently not that many high-achieving computing majors (at least, as freshmen or sophomores) wish to become entrepreneurs. About half of the interested students actually attended the meeting. Of these students, averaging over the five years, about half formally applied to NEWPATH by submitting a simple application that involved completing a one-paragraph essay question asking why they thought IT-startups tend to fail. The net result of this process was that each year something like 3–4% of all the invited students ended up in the NEWPATH program. About 6–8% of the students admitted to the program were women or members of other groups underrepresented in IT majors. This roughly matches their percentages among IT majors as a whole across the country and at Ohio State.

In addition to those admitted in the normal recruiting cycle described above, we admitted a handful of other students who did not receive our original e-mail invitation (or were not admitted

because of some other reason) but who had a strong interest in entrepreneurship and approached us after hearing about the program, and made a case for why they should be admitted. This has resulted in the admission of some students who are well suited to NEWPATH but who we would have otherwise missed; e.g., an economics major with a moderate understanding of IT and a strong interest in IT-entrepreneurship would fall in this category.

Our experience in admitting students to the program may be summarized as follows:

a. There is enough interest in entrepreneurship among OSU computing students to yield a steady stream of about twelve to fifteen highly qualified incoming NEWPATH participants each year, resulting in a manageable steady-state group size of about 30 students overall; and
b. Similar institutions are likely to find a similar fraction of computing students who are serious about entrepreneurship education and careers as entrepreneurs.

NEWPATH Curriculum

Each student in NEWPATH, as explained above, is pursuing a computing-related major (or pre-major). These include *Computer Science & Engineering* (CSE), *Computer & Information Science* (CIS), *Electrical &Computer Engineering* (ECE), and *Management Information Systems* (MIS). The requirements of the student's specific major program dictate the main set of courses that the student is required to complete; this is depicted in the block on the left side of Figure 3. For example, the courses in the CSE major consists of required and elective courses in a range of topics from software design principles and practices to algorithms, from computer systems and architectures to computer networking, from AI to computer graphics and video game design; and a culminating capstone project course which may, for example, consist of designing and implementing a set of web services to meet the requirements of a real client.

NEWPATH students also complete, as depicted in the block on the right, the *entrepreneurship minor*, offered in the business college. This minor has existed for many years but NEWPATH students take a specialized version of the program that consists of five courses as follows. A course on *innovation and entrepreneurship in modern business* which examines the theoretical foundations of innovation and entrepreneurship; followed by a course on *new venture creation* which explores the process for creating new ventures, including ideation, evaluation of business opportunities, business planning, and assembling business resources. The remaining three courses which may be taken in any order are: *entrepreneurial marketing*, focusing on marketing concepts and methods of entrepreneurs leading growth-oriented companies; *entrepreneurial financing*, which presents a two-part process in which companies invest in both real and human capital assets and then find the financial capital necessary to pay for those investments; and

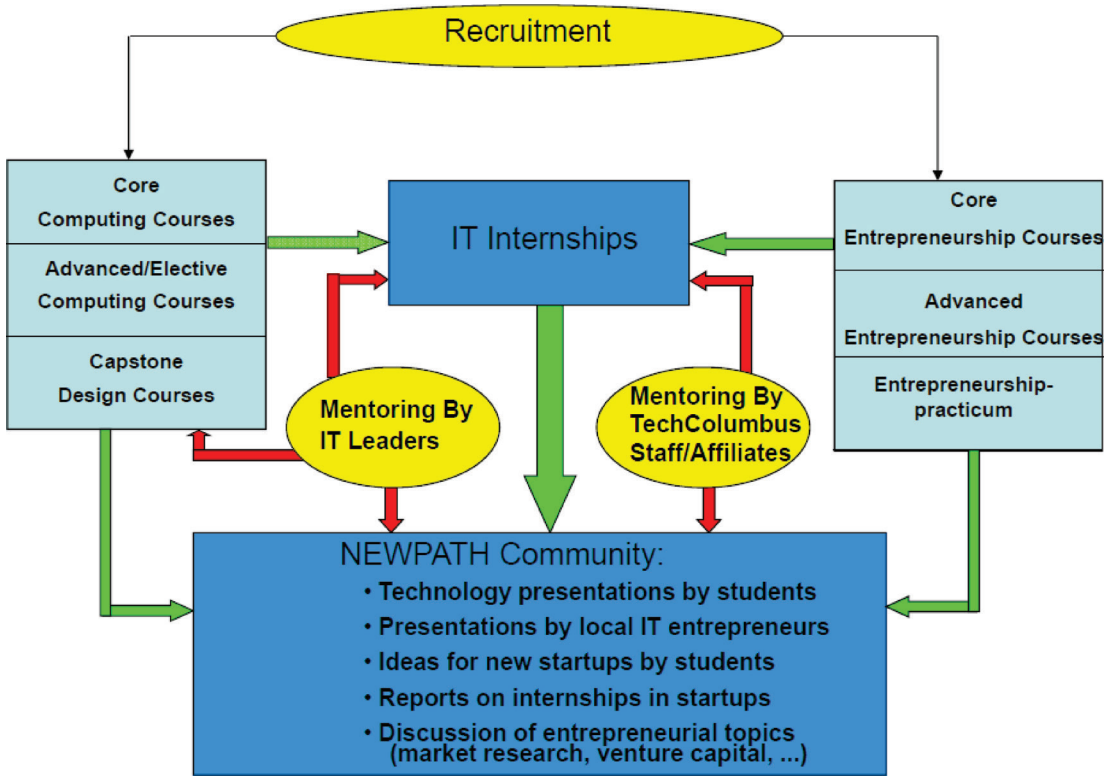


Figure 3. Components of NEWPATH Students' Program.

high-performance ventures, which explores the key managerial practices and skills necessary to lead a successful growing business[1].

Many NEWPATH students also complete the *entrepreneurship practicum* (e-practicum). The course is not part of the standard entrepreneurship minor program. Instead, it is piggy-backed onto the business college's MBA Program on Entrepreneurship. A student team in the course will typically consist of one student from NEWPATH and three or four MBA students, with a suitable range of interests and skills. The e-practicum is intended to give the teams a unique opportunity to engage in a serious, several-month long activity in which they are required to apply their knowledge and skills - in IT and its applications, as well as in entrepreneurship - to go through the planning,

[1]The standard entrepreneurship-minor program requires students to take only the first two courses (respectively on innovation and entrepreneurship in modern business; and new venture creation). The rest may be chosen from a variety of courses, including from outside the business school, e.g., in departments such as social science. The NEWPATH team felt that it would make more sense for students in the program to take the three specific courses (all taught in the business school) that address problems that IT startups tend to face, these being the ones listed above.

creation and, possibly, deployment of a small IT venture of their own. Each team is advised by one or two executive mentors. The mentors are experienced entrepreneurs, accomplished business executives, commercialization experts, and angel/venture capitalists drawn from *TechColumbus*[2] personnel and staff of its affiliate companies. The final task for the team is a full-scale "pitch" to potential investors, consisting of representatives from the TechColumbus-managed *First 50 Fund*, as well as others. Should a pitch be accepted for funding, or if the team should decide to pursue the business plan on its own, it is given the license to do so. Students learn through the e-practicum experience that failure of IT enterprises from startups to large companies is often not from their product development capabilities but from poor vision and understanding of technology advancement directions and from lack of a winning market strategy. Thus, at the end of the e-practicum, NEWPATH students reconsider the key question, why do so many IT-startups tend to fail, that they tried answering in their original application to the program, except now they are well on their way to becoming successful entrepreneurs.

The middle portion of Figure 3 depicts key parts, which we will consider in detail later, of the NEWPATH program that, while not being associated with particular courses, play a central role in helping students in the program to grow as IT entrepreneurs. In particular, the spirited discussions in the *integrative seminar* of the NEWPATH *community*, with active participation of not just the students in the program and its faculty advisors but also members of TechColumbus and local IT entrepreneurs, enables students to integrate the knowledge they acquire in their courses with their own experiences as interns in IT startups and the experiences of IT entrepreneurs to develop a keen understanding of entrepreneurial concepts and practices; and to sharpen their intuitions about taking advantage of entrepreneurial opportunities while avoiding any pitfalls. We believe that this active community is a key contributor to the success of NEWPATH students who participate in the e-practicum described above. Returning to the e-practicum, when we initially conceived of the idea, we had serious misgivings about how well such an arrangement would work, since the MBA students, many with years of experience as business professionals, may not welcome NEWPATH students as part of their teams. As it turned out, however, the unique combination of IT skills, the enthusiasm for IT entrepreneurship, and the sharp entrepreneurial intuitions that NEWPATH students brought to the table were the perfect match for the more mature MBA students. Indeed, many of the most successful teams in the MBA program, including ones that competed effectively in the 10-X competition (see below) were those that included NEWPATH students.

[2]TechColumbus (https://www.rev1ventures.com) is a central-Ohio public-private partnership whose mission is to accelerate the advancement of the region's innovation economy.

We conclude this section with a brief comment concerning an issue that engineering entrepreneurship programs have reported (e.g., see [28]): the substantial additional time to graduation that students face in having to take the extra courses, beyond the ones required for their engineering major, required in such programs. We were able to partially address this problem by allowing the student who completes the entrepreneurship minor to "double-count" some of the credit hours of the minor toward meeting the technical electives requirements of their major program.

Internships in IT-Startups

A key component of the NEWPATH program is *student internships* in IT startups. *TechColumbus* which has been involved with NEWPATH since its inception, indeed was part of the original proposal to NSF that resulted in the creation of the program, and continues to play an active role in the program, is key to this aspect of NEWPATH. The main goal of this component of the program is to supplement the student's academic development in computing and entrepreneurship with quality experiential learning at entrepreneurial firms led by successful IT entrepreneurs. Our value-proposition to these entrepreneurs is that NEWPATH students will provide great enthusiasm and (possibly surprising) technical strength. As an added incentive, especially given that many of these startups tend to be on shoestring budgets, the program subsidizes the first three months of a student's internship by paying up to 50% of the student's wages from NEWPATH funds.

Briefly, the approach we have developed and fine-tuned over the last several years works as follows. During the summers following their sophomore year and their senior year, NEWPATH students are expected to take up an internship in an IT startup. We decided that these would be the ideal times in the program for these internships because by the end of their sophomore year, students would have completed the first two courses of the entrepreneurship minor and would have completed some of the computer science courses. They would also have, via the *integrative seminar* (see section on NEWPATH Community) interacted with and learned from senior NEWPATH students about various interesting and challenging aspects of IT entrepreneurship. Thus they would be ready for a first-hand experience of life inside an IT startup. By contrast, most freshmen students would most likely have just started on their entrepreneurship minor courses as well as on their CS courses; at the other end, senior students would most likely be busy with their post-graduation-job search, or, hopefully, planning the launch of their own IT startup, possibly as a continuation of their work in the e-practicum.

In January/February of each year, we ask NEWPATH students interested in internships during the upcoming summer to prepare, by a specified deadline, a short resume and a brief paragraph describing their main interests and IT-related technical qualifications. We provide them models based on students' resumes/paragraphs from previous years. At the same time, we work with TechColumbus to get in touch with CEOs or other senior people in local IT startups, to interest them in considering

hiring NEWPATH students as interns. On the first Thursday of each month, TechColumbus arranges, on its campus, an informal *mixer* at which CEOs and other senior people from local high-tech startups, VCs (and potential VCs), and others interested in enterprises based on innovative technology can gather to discuss their common interests and identify potential opportunities for working together. Once NEWPATH students' resumes are ready, TechColumbus arranges, immediately prior to one of these mixers, a session at which interested people from IT startups can meet with the NEWPATH students, discuss the students' interests and backgrounds, and possible matches with their own needs.

Several days prior to this session, we send out, to the startups, a flier describing the NEWPATH program and the students' interest in working as interns in their respective companies. The flyer provides a brief summary of NEWPATH's goals and approach, and describes the kinds of internships that would be appropriate for our students, these being ones that would help the student develop his or her entrepreneurial skills. The flyer also provides links to a (password protected) website where the interested startups can access the students' resumes and brief descriptions of their interests. (See Appendix for a copy of the flyer.) The session is held in a conference room with NEWPATH students, people from the startups, people from TechColumbus, and some NEWPATH faculty, seated around a large table. Typically, there are about ten NEWPATH students, people from about seven or eight startups, two or three members of TechColumbus, and two or three NEWPATH faculty. The main part of the session consists of brief overviews of NEWPATH and the internship program by a member of TechColumbus and by one of the NEWPATH faculty, followed by brief introduction by each student, and then a presentation by people from each of the startups outlining the main business of the particular startup and what they are looking for in their interns, followed by questions and answers. The meeting then breaks up, more or less slowly, into small groups with each group consisting of one or two students getting into serious conversations with a couple of people from the startups. At some point the groups, at their own pace, move out of the conference room to join the mixer where they continue their discussions, sometimes merging with other groups. NEWPATH faculty and TechColumbus members stay around to answer any questions but the discussions are mostly between the students and the startups and any VCs who might be at the mixer. Often people from startups who are not planning to hire NEWPATH interns during the coming summer but have done so in previous years join in to speak of their (almost uniformly very positive) experiences with NEWPATH interns. Similarly, senior NEWPATH students who are about to graduate might attend the mixer and talk about their experiences. The purpose of this session at TechColumbus is not for the startups to hire interns immediately although that does happen. More commonly, following the meeting session and mixer, senior people from particular startups get in touch with individual students that they felt were exceptionally well-matched to their needs, and arrange for more extensive interviews and discussions. Typically, every student interested in an internship finds a suitable one.

From the point of view of the startups, the main reasons for participating in the program are to:

- Gain access to talented candidates with a passion for entrepreneurship;
- Have flexibility in addressing their HR needs at a low cost, given the NEWPATH subsidy;
- Increase the organization's visibility, brand awareness and allure on the Ohio State campus;
- Cultivate stronger relationships with OSU, its students and faculty; and to
- Audition students as potential future employees or business partners.

The internship program has been extremely successful. The startups that have hired NEWPATH students as interns have been enthusiastic in their praise of the students' abilities, work ethic, and enthusiasm. Students learned first-hand lessons concerning such key issues as keeping the startup running even in the face of serious uncertainty about future prospects while pursuing funding opportunities, and these lessons are likely to be key to their future success. In some cases, the startups have persuaded students who have graduated from the program to join the company on a full-time, permanent basis; and these graduates have become key members of those companies. In other cases, entrepreneurs behind the startups became trusted, dependable long-term mentors to help the student's entrepreneurial career.

NEWPATH Community

One of the unique aspects of the NEWPATH program is the central role that *community* plays throughout the program. When the program was originally designed, we knew that we would be heavily dependent on TechColumbus and the startup community of central Ohio to find suitable internships for NEWPATH students. What we discovered within a short time of the program's start was that engaging the students in a number of overlapping communities was essential to achieving the program's primary goal of helping the students become successful IT entrepreneurs. To coin a phrase, it takes the NEWPATH community to nurture an IT entrepreneur! Below we briefly summarize some of the key activities and the related communities that NEWPATH students participate in and how they contribute to the students' growth as a future IT entrepreneur.

A central component of NEWPATH, one that helps organize these various activities, coordinate students' participation in them, and, most importantly, help students share, analyze, and learn from each other's experiences in these activities, is the weekly *integrative seminar*. All NEWPATH students, from freshmen to senior are expected to attend the seminar regularly. Initially, the reason we organized a single seminar for all students, from freshmen to seniors, was that each cohort was relatively small and organizing a separate session for each would not have made sense. Very soon, however, we recognized that a single joint weekly meeting of students at all levels was extremely helpful because it helped junior students learn from senior students' knowledge and experiences on the one hand; and, on the other, it allowed senior students, as they interacted with their junior

counterparts, to reflect on their own growth and the evolution in their thinking about various aspects of entrepreneurship. Indeed, we have often had past NEWPATH students who have graduated from the program come back to attend one of the weekly seminars and talk about their entrepreneurial activities both during the time they were in the program and since their graduation.

Below, we briefly summarize the various types of presentations that are made at the weekly seminar and how they help improve NEWPATH students' understanding of IT-entrepreneurship.

Research presentations: Although the courses in the entrepreneurship-minor program do provide students with an intellectual foundation for understanding important issues related to entrepreneurship, we felt that it would be useful to encourage individual students to research particular topics that are especially relevant for IT-enterprises; e.g., *crowdfunding* or using on-line tools for performing market research, the inside story behind successful (as well as failed) startups, etc., so that they can see how the concepts discussed in the courses apply in practice to IT-enterprises. Further, we wanted all students to learn from each students' research.

Hence, we adopted the following approach: at the start of each term, NEWPATH students may apply to participate in e-research during the term. The student has to identify a particular topic related to IT-entrepreneurship that would be suitable for such research. If approved, and most such proposals are approved, the student will be eligible to receive financial support of $10 per hour for work of up to five hours per week; this support for undergraduate research comes from the portion of the NSF funds that have been reserved for supporting students in the program. Near the end of the term or near the start of the following term, the student is required to make a presentation summarizing the main ideas that he or she has learned from the research. The presentations are summarized and made available on-line for students to review. Freshmen students do not, typically, apply to do e-research since they are not sure what topic to research or how to get started etc. However, after attending a handful of presentations by more senior students, they not only develop an understanding of the topics of the particular presentations but also understand how to do similar research.

Ideas for startups: Many of the students in the program have ideas for how a particular new/recent technology can be used as the basis of a new startup. Indeed, many students are first attracted to the NEWPATH program because they have such ideas, do not know what to do with them, and want to be able to discuss the idea with others who might have more experience with startups than they themselves have. The sessions at which these presentations are made tend to be the ones that draw the most active participation from all students. The degree of camaraderie and cooperation that students display in such meetings in helping each other hone their understanding and analysis of the technology as well as in critiquing business aspects of the enterprise is remarkable. Indeed, some of the IT-enterprises started by NEWPATH students listed in the Program Assessment and Results section below had their origins in such presentations.

Presentations by startups: Fortunately, in the last several years, a number of IT-entrepreneurs have made central Ohio their home, including many supported by TechColumbus, with seed funding or office space and facilities while they get started, etc. Frequently, however, especially given the rapid changes in IT technology, these entrepreneurs need help from young "geeks" who are not only immersed in such technology but also have a solid background in computing fundamentals as well as a strong interest in working with startups. This is clearly a perfect fit for NEWPATH students. Hence we frequently have presentations by these startups where the CEO (or another senior person in the startup) describes the basic idea of his or her business, describes the particular technical (and non-technical) problems they are currently encountering and possibly how those problems are impacting their future plans, and what opportunities might be available for NEWPATH students to work with them either on a short-term or a long-term basis.

This is somewhat similar to the presentations at the TechColumbus session described earlier but this discussion is focused on a single startup. Occasionally, we have a presentation by a *would-be-entrepreneur* with a well developed idea for a startup but does not have the technical background to get it going. In such cases, he or she is interested in getting the NEWPATH community's reactions as to whether the idea seems technically feasible and likely to be viable from a business point of view. And, if the answers are "yes", the would-be-entrepreneur is typically also interested in trying to recruit some NEWPATHers to join him/her in trying to launch the enterprise. Such presentations are especially useful since they drive home not just the rewards of entrepreneurship but also the potential risks: after investing time, effort, and resources, it may turn out that the enterprise was not in fact viable.

Presentations about Startup Weekend, Ruby Conference, etc.: The importance of *networking* for entrepreneurs, including for IT-entrepreneurs, can be hardly overstated. It is never too early for would-be-entrepreneurs to work on creating their networks. For a budding IT-entrepreneur, the network should include technology gurus who can help with technical questions, successful entrepreneurs who may be willing to provide guidance on various questions about launching new enterprises, would-be VCs who might be willing to risk small amounts on an ambitious young entrpreneur, and others who might be able to help make contacts with these people. In order to help NEWPATH students develop their networks, the program strongly encourages them to attend various events where they can expect to meet and interact closely with such people. One example is professional IT meetings such as the *Ruby Conference* (rubyconf.org/). NEWPATH provides support with registration and other expenses for students who wish to attend such conferences and have the technical background to benefit from doing so. Occasionally, advanced NEWPATH students may even make presentations at such conferences. On returning from such an event, the student makes a presentation to the NEWPATH group, discussing both the major technical points discussed

at the conference and how they may be used to create interesting software, as well as insights into building relations with that community.

Another example is the *Startup Weekend* (columbus.startupweekend.org/). This event, often organized by TechColumbus, attracts a fair number of attendees about 50% of whom have primarily technical interests (i.e., interested in designing and developing software systems of various kinds), and about 50% is the business aspects of IT enterprises. NEWPATH pays students' registration for the event and since it is in Columbus and since it is over a weekend, many attend the weekend. It is a major learning experience as students attend a number of very brief (60-second) pitches by people who have ideas for IT-startups, help evaluate the pitches to determine which ideas seem most interesting and viable, and join a team that attempts, over the next day-and-half to create a prototype implementation of the main software system underlying one of the pitches that was evaluated by the group as potentially viable. There have also been cases where third-year NEWPATH students have pitched their own idea and it has been chosen by the group as worth pursuing. But even if a student's pitch is not chosen by the group or even if a student does not make a pitch, the contacts that the student makes over the weekend can become part of his or her lifelong network. And the intensity of the experience helps students develop first-hand appreciation of the startup life.

Participation in competitions: An even more intense activity that NEWPATH students are encouraged to participate in are competitions such as the *10X program* (www.10xelerator.com/) which is coordinated by the Ohio State Fisher College of Business and provides seed funding of $20,000 per team for up to ten teams of entrepreneurs. But it is not just seed funding. The teams will work for about three months under the guidance of seasoned entrepreneurs, industry experts, and investors to prepare technology concepts and business models to be presented to VCs at the culmination of the program. The competition to be one of the ten chosen teams is intense not just because of the seed funding but because, assuming that the teams work well during the three months and come up with convincing proposals, the VCs at the final presentation tend to invest in them. The competitors include seasoned (but young) entrepreneurs, including many in the MBA entrepreneurship program of the college of business. In a sense, NEWPATHers are mere novices compared to the other competitors; nevertheless, NEWPATH teams, including some described in the next section, have won the competition.

***Presentations about legal and other issues*:** Legal issues such as intellectual property, copyright etc. are often problems for IT-entrepreneurs. The courses in the entrepreneurship minor touch on some of these but do not go into details that are particularly relevant for IT-enterprises. In order to ensure that NEWPATH students are aware of them, we occasionally have an expert from the Technology Commercialization Office at Ohio State or from TechColumbus talk about such issues.

These presentations tend to be like a lecture in a course until one of the senior NEWPATH students brings up a recent high-profile case involving the issue under discussion; at that point, the entire group gets into the discussion!

To summarize, the primary reason for the success of NEWPATH is not a novel set of courses, etc. Rather, the key idea underpinning the program, as described above, is that a close-knit community that meets regularly and engages in deep discussions, whose members share a common interest in IT-entrepreneurship but, at the same time, have diverse backgrounds with respect to levels of entrepreneurial knowledge and experience, is very effective in helping each member grow. It is the opportunity to be part of such a community that attracts the most entrepreneurially-inclined students to the program and keeps them engaged. This is precisely what the work on the *CoI* model [12, 29] suggests; and is a key reason for the effectiveness of the NEWPATH program. But to be truly successful, a community also needs, as one of the anonymous reviewers pointed out, suitable physical space where it can meet on a regular basis. Fortunately, we have been able to arrange for a conference-type room with a large table with seating for around 30 students. The NEWPATH community meets in that room every week on a continuing basis to engage its members in thought provoking discussions about the most important ideas relevant to IT entrepreneurship.

PROGRAM ASSESSMENT AND RESULTS

NEWPATH is participating in both a process and an outcome evaluation. In order to minimize any bias in the evaluation, it is conducted by an outside evaluator, the *Strategic Research Group*(*www.strategicresearchgroup.com/*), an independent group that specializes in program assessment. The process evaluation includes interviews of graduated or soon-to-be-graduated students to examine their entrepreneurial activities and interviews of startups who have had NEWPATH participants as interns. The outcome evaluation consists of a quasi-experimental evaluation where NEWPATH participants are compared to a group of similar students who did not participate in the program. Comparisons include attitudes, behaviors, and knowledge regarding entrepreneurship. The goal is to attempt to answer questions such as:

- Do participating NEWPATH students develop (1) stronger positive attitudes toward entrepreneurship, (2) greater interest in pursuing IT business ventures, and (3) more entrepreneurial knowledge and skill than comparable students who do not participate in NEWPATH?
- Are NEWPATH students more likely to pursue IT startup career positions after graduation than comparable students?
- Which NEWPATH program components are most critical at producing outcome effects?

The intended outcomes of the program are to:

- Provide a thorough education in computing fundamentals and in the most promising IT ideas and technologies;
- Help students in the program develop a thorough understanding of essential issues, concepts, and ideas related to creating, launching and running successful IT ventures;
- Offer students the opportunity to work as interns in IT startups; and
- Provide students a semi-realistic experience in planning, acquiring funding, and get to the stage of launching an IT venture via an e-practicum during the final year of the program.

Quasi-experimental design

The outcome evaluation design consists of administering a pre- and post-test survey to each incoming cohort of NEWPATH students and to a comparison group of students who attended the initial recruitment meeting but did not become members of the NEWPATH program, then administering a post-test survey at the end of the following academic year to both groups. All students in both groups were contacted via their Ohio State e-mail address. The message sent to the students in each group explained the purpose of the survey, indicated that participation was voluntary, and that their responses will be anonymous. Two reminders were sent, about ten days apart, requesting students who had not yet completed the survey, to do so. No monetary or other compensation was offered for participation.

The pre-survey questionnaire includes 20 attitude items, 14 questions regarding the students' perceived readiness to become an entrepreneur, and 20 skills assessment items. The post- survey questionnaire consists of the 14 readiness questions, a short series of questions to rate the NEWPATH program, and the 20 skills assessment items. One important difficulty is that both the "treatment'' group and the comparison group are relatively small. Hence it is difficult to conduct statistical analysis that compares the skills assessment items across time.

Quasi-experimental results

We summarize the results with respect to students' entrepreneurial attitudes, their level of entrepreneurial knowledge, and their perception of the program.

Entrepreneurial attitudes: First, we looked to see whether there were any differences in pre-survey respondent entrepreneurial attitudes between the "Admitted'' and "Not Admitted'' groups using an independent-samples t-test, confirmed with non-parametric group-difference test (Mann-Whitney test). The survey is designed to measure five factors: Ownership, Independence, Income, Tolerance of Risk, and Work Effort. The results from a recent year appear in Table 1.

Factor	Admitted (N = 20)	Not Admitted (N = 8)	Difference	Significance
Ownership	3.42	2.46	0.95	P < 0.01
Independence	2.40	2.17	0.23	NS
Income	2.63	2.56	0.07	NS
Tolerance of Risk	2.44	2.09	0.35	NS
Work Effort	3.52	3.25	0.25	NS

NS = not significant

Table 1. Entrepreneurial Attitudes at Pre-Test, 2011-2012 Cohort.

These results suggest that the students admitted into NEWPATH scored statistically significantly higher in the Ownership factor, indicating that those students were more interested in having ownership of their efforts. However, as the respondents in the pre-test survey comprise the entire population and the total number of completed surveys is small larger differences can indicate potential emerging patterns. In this case we see that Independence, Tolerance of Risk and Work Effort are also substantially higher for those admitted than those not admitted for this cohort although the difference is not statistically significant due to the small sample sizes and wide variation. Interestingly, the remaining factor, Income, shows minimal difference between the two groups contrary to what one might have intuitively expected, i.e., that the potential for large incomes as entrepreneurs would be a major motivation for students.

Entrepreneurial knowledge: In order to assess the impact of the program on students' entrepreneurial knowledge, we designed a number of multiple-choice questions related to key concepts. For example, one of the questions reads as follows:

In the earliest stages of a startup, which of the following is a common form of financing?

1. Venture capital;
2. Angel funding;
3. Personal debt and savings;
4. IPO (Initial public offering);
5. All of the above.

The correct answer is (3), personal debt and savings. Another question reads as follows:

You have just met with a key potential account. It could be a large-scale project and also bolster your company's credibility in the industry. However, the potential client is afraid to do business with a startup. The best way to win them over is to:

1. Ask your world-famous VC investor to call the customer;
2. Offer to do a pilot implementation at a deep discount;

3. Arrange for the CEO of your company to meet with the customer;
4. Tell the customer you will contact them once your company is "proven" in the marketplace;
5. Get a character reference from friends or family;
6. None of the above; there is no way to win in this case.

The right answer here is (2), offer to do a deeply discounted pilot implementation.

Other questions were similar. The number of students in individual years who completed the post-test was quite small. Table 2 provides results, summed over all the years.

	Pre-test						Post-test					
	Admitted			Not Admitted			Admitted			Not Admitted		
	N	Mean	Range	N	Mean	Range	N	Mean	Range	N	Mean	Range
Total	36	10.86	3–15	17	9.29	4–15	14	11.07	6–15	12	9.25	3–15

Table 2. Entrepreneurial Knowledge (Summed over all years).

Although there seems to be some evidence that the program has a positive impact on the entrepreneurial knowledge that students gain over the course of the program, the relatively wide range in the students' scores as well as the small number of students who took the post-test make the conclusions rather unreliable. This part of the assessment needs to be continued in order to help draw more reliable conclusions.

***Student opinions of NEWPATH*:** All students who completed the post-survey were asked whether they were currently in NEWPATH and, if so, to rate certain aspects of the program. Specifically, students were asked to rate, on a scale of 0 to 10, 0 being the lowest rating and 10 the highest, how well NEWPATH performed with respect to three specific items. The items and the mean ratings appear in Table 3.

NEWPATH Ventures: The ultimate goal of the program is to nurture students to become IT entrpreneurs and to start their own ventures. NEWPATH has indeed been quite successful in achieving

Item	Mean Score
Providing you with the opportunities you need to learn how to become an entrepreneur	8.0
Providing you with the knowledge (such as funding sources, business permits and licenses, and copyright/ patents) you need to become an entrepreneur	7.0
Providing you with the practical experience you need to become an entrepreneur	7.1

Table 3. Student opinions of NEWPATH

this. We list a few of the ventures that current or former NEWPATHers have launched or are in the process of doing so.

- *uTap* is a web-based company created by two NEWPATH students that combines elements of Facebook Places, Google Maps and Twitter. *uTaP* is a location-based application designed to facilitate communication between OSU students. The idea for uTap is based on the observation "that everyone is trying to meet the people around them," to quote one of the students who created this venture. "With uTaP, students will feel much more comfortable asking for help or communicating with classmates while controlling who their audience is. *uTap* was one of the companies that was selected for seed funding by the 10X program.
- *ApproveIO* is a universal payment gateway that is easy for both merchants and developers. The gateway is flexible and supports all major processing networks. Merchants can obtain a new account or connect an existing one. Changes in the merchant account can be made quickly without changing any of the code on the merchant's site. *ApproveIO* is compliant with all standards regulating the payment industry and offers features that other gateways don't support. The company was founded recently by a NEWPATH student.
- *LaunchGram* aggregates pre-release demand signals for products coming soon. Consumers can create a *LaunchGram* account and subscribe to news about imminently launching products of interest. Once users subscribe, they can receive *LaunchGrams* via email with curated updates about product release date, pre-order availability, photos and video. *LaunchGram* does the hard work by scouring the web for the most up to date information about listed products. The same information can also be viewed on product-specific pages at the main website. The team is currently focusing on video games, movies, gadgets, and cars. Expansions are being planned for books, music, and more. *LaunchGram* was mentioned very favorably by *TechCrunch* and was another of the companies selected for seed funding by the 10X program.
- *SeizeTheDay* is an *iPhone* app created by a NEWPATH student that was featured as App of the Week by Time.com's *Techland*, and also hit the CNET.com homepage. It was featured as "new and noteworthy" on the front page of Apple's App store and has seen over 150,000 downloads. No company was set up based on *SeizeTheDay* but it and similar other products have considerable entrepreneurial potential.

***Summary Results*:** In summary, the formal assessments show positive results although the number of students involved in the assessment, both in the pre-test and in the post-test were relatively low. Hence we plan to continue these assessments in the coming years to arrive at definitive results. But the results in terms of the number IT enterprises launched by NEWPATH students and their successes in competing with other entrepreneurs who have much longer experience as professionals has been quite remarkable and attests to the validity of the NEWPATH approach to nurturing IT entrepreneurs.

RELATED WORK

As noted earlier, over the last two decades or so, a number of programs on engineering entrepreneurship have been created at various schools. Here we briefly summarize some of them and consider how NEWPATH relates to them.

The *engineering entrepreneurs program* at North Carolina State[3] requires students to complete three courses (titled, respectively, Introduction to Entrepreneurship and New Product Development, Engineering Entrepreneurship and New Product Development I, and Engineering Entrepreneurship and New Product Development II). In the first course (a 1-credit hour course), students work in teams led by *senior* students completing their capstone design project. Thus students get exposed to different areas of design and development. In the second course (3 credit hours), students are exposed to business aspects of entrepreneurship and come up with a design for an engineering product. In the third course (also 3 credit hours), students form entrepreneurship teams to prototype their designs ideas. The students run their eTeams as "virtual" startup companies with different students taking on different roles.

The goal of the Entrepreneurship Program at the University of Pennsylvania's School of Engineering and Applied Science[4] is "to train the founders and leaders of tomorrow's high-tech ventures". Students in the program are required to complete two courses. The first provides an introduction to the early phases of a high-tech venture. The second course investigates the necessary steps for planning a high-tech venture. It provides students, working in small teams of 3 or 4, an opportunity to develop and present a high-tech business plan. The emphasis in both courses is on the sequential risks and determinants of success in high-tech entrepreneurial ventures.

The College of Engineering in the University of Tennessee at Knoxville offers a minor program in Engineering Entrepreneurship[5] that "provides students with exposure to the broad range of skills required to succeed in a technologically-based entrepreneurial endeavor". Students are required to complete nineteen hours of course work ranging over such topics as engineering economics and technology commercialization. Also included in the nineteen hours are the students' engineering capstone design course.

The goal of the entrepreneurship program of the College of Engineering at Washington State[6] is "to identify junior-level engineering and business students who are interested in technological

[3] https://eep.ncsu.edu/

[4] www.seas.upenn.edu/entrepreneurship/overview.php

[5] www.engr.utk.edu/eep/minor.html

[6] www.cea.wsu.edu/entrepreneurship

entrepreneurship and to give them the tools and experiences to pursue their ideas". The program includes the following components. A 3-week program that consists of an initial week on campus where students learn a variety of key skills including communication, basics of finance, etc. This is followed by a 2-week to trip to Silicon Valley where the students are provided with opportunities to interact with entrepreneurs as well with venture capitalists. They may also attend sessions on marketing, visit large and small engineering enterprises, etc. The second component is a 12-week internship at a small company or large corporation; at the end of the internship, the students have to prepare a report that critiques the summer experience and outlines ideas they might have developed for new companies. The third component is a number of courses both on entrepreneurship as well as engineering design; students also have the opportunity to participate in a business plan competition.

In summary, most of these programs provide the students opportunities, mainly via standard courses, to develop some basic understanding of issues related to entrepreneurship. Although some of these programs have components that have some similarities to parts of NEWPATH, the combination of activities that make up NEWPATH, especially the central role of the NEWPATH community, seems unique. The other unique aspect of NEWPATH is the extensive set networking opportunities that it provides students, not just in the form of internships in startups but also participation in such activities as the Startup Weekend; these are also essential to helping students grow as IT entrepreneurs.

CONCLUSIONS, LESSONS LEARNED, AND FUTURE PLANS

Entrepreneurship, especially IT entrepreneurship, has been key to the growth of the American economy for a number of years. The primary goal of the NEWPATH program was to help nurture the next generation of IT entrepreneurs. Judging by the results, in terms of the number of startups and other entrepreneurial activities that NEWPATH students have engaged in, the program has been a complete success. When it was initially designed, we had expected the main components of the program to be the entrepreneurship minor, the internships in the startups, and the e-practicum. A key lesson that we learned early on was the importance of creating a close-knit community of students at *all* levels that enables them to learn from each others' experiences. This is especially important for entrepreneurship which is not just an academic topic that can be fully mastered by taking some courses. Students need to discuss and reflect on each others' experiences and ideas related to enterprises. Doing so helps them to relate their and other students' experiences to ideas and concepts that may have been abstractly discussed in the entrepreneurship courses and make those ideas solid and relevant. And having a community that includes students at all levels helps both the novice students as well as the more experienced ones.

The other important lesson we learned was the importance of helping students to get an early start in creating their network of contacts with successful entrepreneurs, technology gurus, potential partners in future enterprises, and potential venture capitalists. In order to achieve this, students have to be provided adequate opportunities to interact, via various activities such as the *Startup Weekend*. This does require some minimal financial resources and we were fortunate in having NSF funds that we could use for this purpose. These two important ideas were critical for NEWPATH's success in achieving its main goal.

We conclude with a brief summary of future plans for NEWPATH. First, as noted earlier, we will continue our formal assessments. Since several additional students have graduated recently from the program, we should be able to gather more assessment data by working with these students. Second, our NSF support is coming to an end shortly. Hence we are working with TechColumbus and other agencies to obtain funds to continue the program. Especially important, as noted above, are funds to support students to engage in networking activities. The "research support" described in the section on the NEWPATH community is also very useful since it provides motivation for beginning students to start exploring entrepreneurial issues seriously. TechColumbus has expressed interest in providing the necessary funding to continue these activities although many details remain to be worked out. We also hope to work with other schools to help them implement similar programs. We believe that the success of NEWPATH can be replicated as long as the main lessons summarized above are kept in mind.

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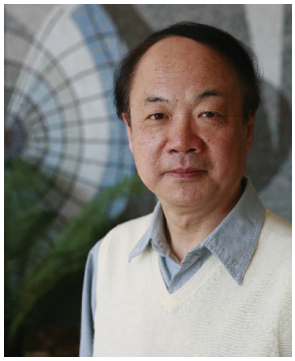

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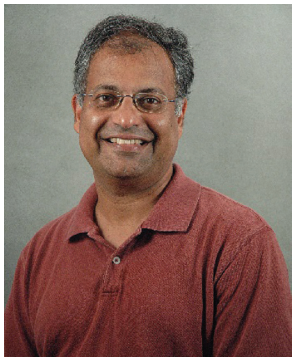

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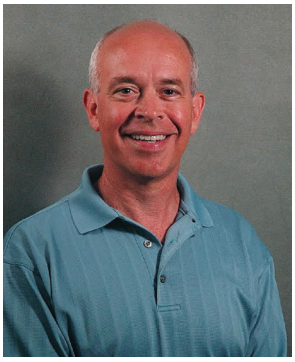

Bruce W. Weide is Professor Emeritus of CSE at the Ohio State University, where he continues to direct the Resolve/Reusable Software Research Group. His research interests include all aspects of software component engineering, including in teaching its principles to beginning CS students. He and colleague Tim Long were awarded the IEEE Computer Society's Computer Science and Engineering Undergraduate Teaching Award in 2000 for their work in the latter area. Weide holds a PhD in Computer Science from Carnegie Mellon University and a BSEE from the University of Toledo.