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Undergraduate Involvement in Intellectual Property Protection at Universities: Views from Technology Transfer Professionals*

NATHALIE DUVAL-COUETIL
College of Technology and Burton Morgan Center for Entrepreneurship, Purdue University, 1201 State Street, West Lafayette, IN 47907, USA. E-mail: natduval@purdue.edu

JESSAMINE PILCHER and ELIZABETH HART-WELLS
Office of Technology Commercialization, Purdue University, Kurz Purdue Technology Center, 1281 Win Hentschel Boulevard, West Lafayette, IN 47906, USA. E-mail: eahart-wells@purdue.edu, jgpilcher@prf.org

PHIL WEILERSTEIN
National Collegiate Inventors and Innovators Alliance, 100 Venture Way, Hadley, MA 01035, USA. E-mail: pweilerstein@nciia.org

CHAD GOTCH
College of Education, Washington State University, Cleveland Hall, Pullman WA 99164, USA. E-mail: cgotch@wsu.edu

Undergraduate students are increasingly engaged in developing products and technologies that are commercially viable outside of the university through their involvement in courses and experiential programs focused on product design and entrepreneurship. The involvement of undergraduates in intellectual property protection leads to interesting questions related to how best to align student interests with institutional policies and practices since most are not employed by their universities in the way that faculty and many graduate students are. This paper summarizes the results of a survey designed to examine trends in the level and nature of undergraduate involvement in creating intellectual property. It was administered to intellectual property professionals in technology transfer offices at 30 U.S. universities with strong emphases in engineering, science, and technology. Findings indicate that involvement in intellectual property protection among undergraduates is growing at over half of the institutions surveyed; there is a lack of consensus among institutions of how to manage IP generated by undergraduates; and that the resources technology transfer offices have to devote to communicating policy is critical to the manner in which policy is applied.

Keywords: Intellectual property; technology commercialization; undergraduate; entrepreneurship; engineering education; product design; innovation

1. Introduction

In recent years, there has been a significant increase in the number and diversity of students participating in courses and activities focused on innovation and entrepreneurship and the development of products, technologies, and services that are commercially viable. This trend has been driven by a number of factors, including: (1) accreditation requirements in fields like engineering that drive the integration of more ''real world'' experiences into educational programs [1]; (2) economic trends where smaller companies are increasingly seen a source of jobs [2]; (3) a movement to equip students in a wide range of disciplines with entrepreneurship education [3, 4]; and (4) a general movement towards creating more entrepreneurial universities able to generate revenues by engaging with the private sector [5, 6]. To better prepare students for the contemporary workplace and economy, institutions are developing courses and experiential learning programs focused on teaching students how to create value from their knowledge. They are also establishing entrepreneurship centers, stepping up technology commercialization efforts, and expanding business incubation activities.

The increased emphasis on ''real-world'' product innovation and entrepreneurship education suggests that technology transfer offices are likely to see increased activity and interest in intellectual property protection by undergraduates. Further, heightened awareness of successful student-driven ventures such as Facebook have led to increased interest among institutions in clarifying policies and creating services to support student inventors and entrepreneurs. The fact that most undergraduates pay to attend a university, unlike faculty and graduate students who are paid to conduct research, generates an interesting set of questions for institutions, including: Who owns the IP developed by a student as part of a course project or experiential program? How is the contribution of a student versus that of the university defined? Who should students turn to for assistance with IP protection

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issues? And, who bears the responsibility for educating student and faculty participants to a level of IP literacy such that they understand students' rights and obligations? The purpose of this paper is to explore the extent to which undergraduate students are involved in intellectual property protection at universities and the manner in which technology transfer offices are addressing their activity.

2. Background

2.1 Management of intellectual property at universities

To understand the management of technology commercialization activities at universities, it is helpful to be familiar with basic intellectual property definitions and principles as well as the role of technology transfer offices (TTOs). The United States Patent and Trademark Office define intellectual property as "creations of the mind—creative works or ideas embodied in a form that can be shared or can enable others to recreate, emulate, or manufacture them" [7]. There are four primary ways to protect IP—patents, trademarks, copyrights, or trade secrets. For an idea to be patentable it must be reduced to practice, meaning that it has been conceptualized and effort has gone into creating a physical representation. Legally, the inventor(s) of any device or design is the person(s) who conceived the idea. An individual who assists in reducing the idea into practice is not necessarily an inventor, and claiming them as such could result in a patent being invalid. An individual who works on a project that results in IP, but did not help to conceive the idea, although not an inventor can be considered a contributor and can be granted royalties if agreed upon by the inventor/owner and stated in a legal contract.

The passage of the Bayh-Dole Act is the principal factor in explaining the increase in patenting and licensing activities by academic institutions in the United States [8]. This legislation gave U.S. universities, small businesses and non-profit organizations control of the inventions and intellectual property that resulted from federally-funded research with the expectation that these organizations would take steps to secure and exploit it for the benefit of the university and society. Prior to the Bay-Dole Act, there were limited incentives for universities to commercialize higher-risk; early stage technologies and less than five percent of U.S. government patents were commercially licensed [9]. Although some faculty have voiced concerns over the years about moving the university from an academic to a more commercial mission [10], the opportunity for revenue generation provides considerable incentive for universities to pursue commercialization. This is particularly true in light of decreasing federal and state funding for education and the increasing emphasis on the role universities play in economic development [11, 12].

In order to manage the opportunities and challenges introduced by increased IP protection and commercialization, many universities created administrative units commonly referred to as technology transfer offices (TTOs). The main function of a TTO is to act as an institution's intermediary between the IP creators (i.e., inventors) and partners who aid in the commercialization process (e.g., entrepreneurs, industry partners, attorneys). As such they are responsible for putting in place policies, processes and practices which: (1) support IP creation, (2) provide clear ownership determination of IP, (3) encourage IP commercialization opportunities and (4) develop long-term IP management strategies. Because TTOs were established primarily to fulfill the requirements of the Bayh Dole Act, the majority of IP policy and practice has focused mainly on researchers, faculty, staff and graduate students, who are typically employees of the university and governed by an employment agreement. Given the diversity the various stakeholders involved in the IP management process at universities—inventors, administrators, attorneys, entrepreneurs, and industry partners—a desired outcome is balancing the interests of all parties. Although policies and incentives are typically intended to be beneficial to all stakeholders, there are often trade-offs between participants in the process.

Active management of IP appears to be paying off for some universities. A summary of patent and licensing revenue data from the Association of University Technology Managers (AUTM) revealed that research-related income of $2.4 billion in 2010 was generated by 155 universities and 27 hospitals and research institutes surveyed [13]. It also found that more than 657 new products and more than 650 new companies were created as a result of academic R&D. Another recent report found that university licenses were credited with generating 279,000 U.S. jobs and contributed up to $187 billion to the U.S. GDP activity between 1996 and 2007 [14]. As a result, institutions continue to grow and invest in technology transfer activities. Examples of initiatives being pursued include: increases in funding for early stage research to bring it to the "proof of concept" stage; technology accelerators offering enhanced business incubation; portals where companies and entrepreneurs can find academic innovations available for licensing; simplified licensing contracts; and endowments designated for investments in university-based startups [9].

2.2 Undergraduate students and intellectual property

Until fairly recently, little attention has been paid to the topic of university IP policy specifically as it relates to undergraduates. The lack of literature on the topic suggests that the level of involvement by undergraduates in IP protection has not warranted much attention and/or that many entrepreneurship or product development courses have been created with limited consideration of institutional IP policy. Data collected from informal surveys and discussions at recent entrepreneurship and engineering education conference sessions suggest that interest in how to manage IP issues is growing among faculty and program administrators. These data indicate that there are four main contexts, each posing unique IP related issues, in which undergraduates can potentially confront issues related to the ownership of intellectual property, including: (1) entrepreneurship education programs and experiential learning activities, (2) industry-sponsored engineering or product design courses, (3) non-industry sponsored product design courses; and (4) undergraduate research (Fig. 1). Another common theme that emerges from discussions is that faculty members do not feel prepared to counsel students in IP matters. Their primary concerns include: a lack of knowledge about what kinds of legal agreements are necessary; difficulty students have in understanding policies; how to balance the interests of students, industry sponsors and the institution; and how challenging it is to change institutional policy. They also described ever-changing rules, "don't ask, don't tell" policies, and concerns about the extra time it takes to manage related paperwork.

The literature suggests that having clear policies and communicating them is key to the management of intellectual property. An IP Policy Primer prepared by the National Collegiate Inventors and Innovators Association, an organization that supports student inventors through educational programs and grants to further intellectual property development, states that a good IP policy removes gray areas, and spells out each player's stake, rights, and responsibilities [15]. Similarly, in an article describing IP issues faced by universities seeking to commercialize student innovation at all levels, Evans [11] indicated the need to create understandable IP policy and provide educational materials suited to each constituent. However, an accurate understanding of IP ownership rights and policy appears to be the exception more than the rule at many institutions. In a survey intended to inform their own policy changes, North Carolina State University found the factors that universities considered in asserting IP rights for undergraduates were ill-defined [16]. Even within institutions, stakeholders have different views; A study conducted by the University of North Dakota found that the perception of IP ownership related to work involving students was viewed quite differently by the

Context	Description	IP Questions
Entrepreneurship courses or related experiential learning programs (e.g. business and product development competitions)	Courses that involve the development of products, concepts and/or business plans as part of class assignments or competitions.	- Does the university assert any ownership over products developed as part of a class assignment? - How does an institution distinguish what a student develops as part of his or her academic program as opposed to what is developed in his/her dorm room?
Non-industry sponsored engineering, science, or technology-related capstone product development courses	Design courses that involve the development of products or technologies that are generated from individual students or teams of students, with and without input from faculty.	- Does the university assert any ownership over products developed as part of a class assignment? - How to measure the contributions of team members and/or those of faculty? - What agreements are needed?
Industry-sponsored engineering, science, or technology-related capstone product development courses.	Design courses that involve the development of products or solutions for industry partners. These typically involve funding and involvement provided by a company and their employees, and IP generated is owned by the sponsor.	- What agreements are needed? - Do students need to be offered equivalent curricular alternatives so that they don't have to work on creating IP for a third party? - How to balance the interests of all parties?
Undergraduate research	Student involvement in research typically conducted in conjunction with faculty, post-docs, and/or graduate students.	- Do students need to sign special agreements? - Is IP ownership affected by whether a student does research for money or for credit?

Fig. 1. Contexts in which undergraduates confront intellectual property and related issues.

students and faculty, with students consistently assigning more ownership to students than to faculty [17].

Researchers have pointed out the distinction between undergraduates who typically pay to attend a university and benefit from its resources, in contrast to faculty and many graduate students who are paid by an institution to teach or conduct research. Nordheden and Hoeflich [18] addressed this issue within the context of the increasing involvement in research by undergraduates. They pointed out that because students typically do research for credit and not money, they do not have an employment contract with the university and are not covered under what is referred to as the "workplace doctrine," which could put them in a position to challenge a university for a share of the rights. They suggested the need for students to sign over their rights before conducting research, but point out that this could conflict with university policies toward students. Silvernagel [17] described two competing schools of thought in the area—one is that student policy should reflect that of faculty because if differences exist one party might be less likely to participate in research, versus a second where imposing a policy on students who are not being supported by research funding could stifle their creativity.

Interviews and pilot survey data collected from university technology transfer professionals prior to conducting this study suggested that there were few institutions with explicit policies directed at undergraduates [19]. Instead, most applied the general IP policies of the institution where undergraduates operated in a gray area and where, as one interviewee stated, technology transfer offices "turn a blind eye." Another gray area identified in pilot survey data was the definition of "significant use of university resources" in relation to the development of intellectual property. This referred to the use of libraries, computers, software, space, hardware, and materials owned or provided by a university and the degree to which was considered in the assignment of IP. Some institutions made distinctions such as "expensive, core, specialized equipment," or "facilities not available to the public." They varied as to whether they included IP developed as part of classes or class assignments. Other issues that emerged from pilot data included the degree to which faculty should be involved in enforcing IP policy and whether technology transfer offices have the resources to devote to student IP.

The experience of the authors has been that when faculty are unable to clearly articulate IP policy to students and/or when it is not well understood or perceived by students to be in favor of the institution, it can inhibit innovation and prevent students from obtaining the feedback and assistance that could help advance their projects or ventures. Furthermore, naïve or incorrect assumptions about rights and obligations can lead to suspicion or mistrust that inhibits creativity and collaboration. When this occurs, students may resort to working on projects that simply meet the minimal requirements of the course, while keeping their "real" projects to themselves for fear that the university will claim ownership. While these fears are unfounded in many cases, they highlight the need to educate and communicate IP policy to students in a way that encourages them to innovate and ultimately create goodwill. This was the goal of North Carolina State University, which found that "requiring disclosure and possibly asserting university ownership of inventions created by undergraduate students as a result of their coursework was antithetical to the fundamental nature and purpose of the university, and would have a negative impact on student perceptions and alumni philanthropy." As a result, the university revised their patent policy to clarify the students' rights, allowing them to own the IP generated through their normal coursework [16].

3. Purpose and research questions

The purpose of this exploratory study was to examine trends in the level and nature of undergraduate involvement in creating intellectual property and institutional policies and practices in relation to them. The research questions were:

- What is the extent and nature of undergraduate involvement with technology transfer offices?
- To what extent do universities have specific policies related to undergraduate IP?
- To what extent are IP policies understood by students and faculty?
- What are general (unofficial) attitudes and practices related to IP involving undergraduate students?

4. Methods

A new survey instrument was developed to capture data necessary to answer the research questions. It was comprised of both objective and subjective questions in order to understand trends and attitudes related to the management of IP generated by undergraduates. Items were created based on a literature review as well as pilot data collected via interviews with technology transfer professionals prior to conducting the study. The survey instrument was reviewed by faculty, technology transfer professionals, IP attorneys, and educational assessment experts.

Purposive sampling was used to identify 50 universities with a strong emphasis in the STEM disciplines and/or entrepreneurship and that were considered most likely to have active involvement in technology transfer activities that may involve undergraduates. Directors of TTOs at these institutions were asked via email to complete the online survey. Over the course of several weeks, follow-up email reminder messages were sent and telephone calls were made to encourage participation. This paper reports on survey data collected from a sample of 31 universities from across the U.S. which completed the survey in its entirety. Of these, 14 were private and 17 public. Approximately half enrolled under 30,000 undergraduate and graduate students and half over.

Survey respondents were asked if they were willing to participate in a follow-up interview and fourteen agreed. Interviews were conducted with eight universities to expand on and triangulate findings found via the survey research. Given the exploratory nature of the study and the sample size, descriptive statistics as well as qualitative survey and interview data were used to identify trends, summarize institutional practices, and describe attitudes towards undergraduate involvement in IP protection.

5. Results

Question 1: What is the extent and nature of undergraduate involvement with technology transfer offices in the past year?

Respondents were asked a number of questions related to trends in the frequency of their interactions with undergraduates within the previous year, the disciplines from which they came, and the factors driving growth in IP activity among undergraduates. There was great variation in the number of undergraduate with which TTOs reported to be interacting, however less than one quarter were seeing more than 20 per year. Of those surveyed, only one respondent reported that they had interacted with no undergraduate students within the previous year; of the remainder, 26% interacted with less than five; 31% 5–10; 16% 11–20; 16% 21–50; and 7% more than 50. When asked whether the number of undergraduates with which they interact was growing, 19% responded "yes, at a faster rate than for other inventor groups" (e.g. faculty and graduate students); 29% "yes, but at a rate similar to other inventor groups"; and 52% "no, staying about the same." Fifty-five percent of respondents agreed that undergraduate involvement in generating IP was concentrated in certain academic departments versus 29% who did not. Top departments cited were engineering, science, chemistry, and computer science.

Growth in the generation of IP by undergraduates was attributed to a number of factors. Respondents agreed most strongly that growth was driven by entrepreneurial competitions, a general increased emphasis on entrepreneurship on their campuses, and engineering design courses, and to a slightly lesser degree due to undergraduate participation in research or university success stories related to technology commercialization (Table 1). Open-ended survey and interview questions asked respondents about additional factors driving growth in IP generation. They cited: TTO presentations in engineering senior design classes, student business incubators, student concerns about a lack of jobs, access to funds and mentors, the buzz about entrepreneurship in the media, and involvement in developing apps for smart phones.

> "Our university has become very focused on entrepreneurship at all levels. At the level of faculty staff and graduate students in our research enterprise we've become very focused on it but also at the undergraduate level. There are multiple programs across the university in the different colleges that are emphasizing entrepreneurship."

> "I think there has been an increase in resources available over the last six to eight years, particularly focusing on some reworking of entrepreneurship curriculum. Certainly, the College of Engineering and the entrepreneurship center have taken a much more

Table 1. Factors driving growth in IP activity among undergraduates

Factors	Disagree or strongly disagree	Agree	Strongly agree
Entrepreneurship or product innovation-related competitions	10%	39%	51%
A general increased emphasis on entrepreneurship and technology commercialization on your campus	7%	48%	45%
Engineering design/product development courses	16%	39%	45%
Entrepreneurship courses offered on campus	16%	48%	36%
Entrepreneurship-related clubs or student organizations	16%	52%	32%
Seminars or workshops related to entrepreneurship and intellectual property (not semester-long)	23%	48%	29%
More students pursuing entrepreneurial careers	23%	48%	29%
Undergraduate participation in research	32%	39%	29%
University intellectual-property success stories	42%	42%	16%

active role in not just providing the curricula that allows students to experience and get hands-on access to developing business plans and building small businesses, but they've actively promoted new and innovative ways of engaging undergraduates with alumni on the coasts, particularly the West Coast, to encourage them and give them a mentorship and a network as they begin to develop their own ideas.''

Students were reported to be most frequently seeking advice related to understanding their personal rights related to IP, or guidance related to a specific invention (Table 2). Interviews indicated that many of the questions students bring to the TTO have to do with concerns about ownership and/or resources offered by the institution. Interviewees also described the mistrust students have about university ownership and involvement.

''They're either questions of a general nature about intellectual property, or they're questions that are directed at trying to find out whether they have some obligation to the university and the university's policies.''

''It really is usually ownership to make sure that they own it, or they would like us to file it. Often they will be asking about resources available to them, so that we'll direct them to the different resources around campus . . . they're pretty generic''

''There's a lot of sort of mistrust. Are you going to own my company? Are you going to take a third of my company? Are you going to charge me huge amounts of money? All that kind of stuff, and so, we assure them that, no, we're not going to, that we're reasonable people and give them a sense of what it's about.''

''The number one is do I own this? Is the university going to steal this from me? That's about the way it's presented.''

Question 2: To what extent do universities have specific policies related to undergraduate IP?

Respondents were asked a number of questions related to the extent to which they addressed undergraduates specifically in their IP policies, how these differed from those directed at faculty and graduate student inventors, and whether they anticipated any changes to their policies. Thirty-five percent of those surveyed reported having a specific policy for IP developed by undergraduates, while 65% did not. In response to whether institutions had instituted any programmatic changes to accommodate undergraduates, 23% said yes, 13% said they were in progress, and 65% said no. Most of the institutions surveyed leaned towards undergraduate student owning their IP, unless they were employees of the institution or if they voluntarily choose to assign their IP to the university.

''Our default situation is—if we don't take any action, then undergraduate students own any intellectual property that they create. So any of their homework assignments, special projects, anything that they create during the course of their learning experiences, they own that.''

''Student projects that relate to coursework (a particular class, not an ongoing research project) are student property. We only work with them if they ask us to and are willing to voluntarily assign to the university.''

''Our policies are directed at employees versus non-employees. It doesn't matter if the student is an undergraduate or a graduate student; the starting point is whether their invention was developed as a student or a university employee.''

Less than 10% reported that their institution asserted ownership of the IP created by undergraduates, which in some cases, could then be licensed to students.

''It used to be that the University did not claim ownership to undergraduate inventions. In 2007, the IP policy was changed to include undergraduates. There is a slim possibility it would change back.''

''We have an exclusive license agreement which is very attractive to an undergraduate start-up company. Essentially, we will file a provisional patent application. They can take that to any law firm they wish. We grant them an exclusive license to it. They owe us nothing—no reports or any royalties unless they have sales of over $1M in any one year, then they owe us a 1% royalty and reports thereafter.''

Seventy-seven percent of respondents did consider the ''use of significant university resources'' when assigning IP ownership to undergraduates. University resources that were taken into consideration most frequently were research labs, parts, components and supplies, and machine shop use (Table 3). Taken into consideration to a lesser degree were library resources, internet access, and advice or mentoring from the TTO. When asked in an open-ended question to provide examples of resources that were likely to be taken into consideration when assigning IP, the number one response was funding. Interviewees strongly agreed that if the student was paid a salary by the university or participated in

Table 2. Frequency with which students seek particular types of advice from TTOs

Reasons	Rarely	Occasionally	Frequently
An understanding of their personal rights in relation to university IP policies	19%	65%	16%
Guidance related to a specific invention or technology	13%	71%	16%
General entrepreneurship and business start-up questions	32%	48%	13%
General knowledge about patents and the IP protection process	35%	52%	13%
Financial benefits/obligations related to IP	45%	35%	6%

Table 3. Frequency with which university resources are considered in IP ownership decisions

Resources	Never	Sometimes	Always
Research labs	19%	39%	42%
Parts/components/supplies (e.g., electronic components, metal, chemicals, etc.)	26%	48%	26%
Advice or mentoring from professors—(direct input to solve problem or generate ideas)	45%	29%	26%
Machine/fabrication shop	32%	45%	23%
Class assignments	68%	19%	13%
Computer servers	52%	42%	6%
Software provided by the university	48%	48%	3%
Computer labs	55%	42%	3%
Office space	65%	32%	3%
Advice/mentoring from technology commercialization office	77%	19%	3%
Internet access/networks provided by the university	71%	29%	0%
Library resources/databases	77%	23%	0%

funded research that that the IP must be assigned to the university.

> "I would say the decision point comes when a student sort of crosses the line between using university facilities that are dedicated for educational purposes—a chemistry laboratory that's fully equipped with supplies and so on. If that lab is set up for educational purposes to teach Organic Chemistry 300 Lab or whatever it is, then regardless of the amount of resources that the student utilizes, we consider that to be an educational activity, and, therefore, the student owns any intellectual property that they create. If a student crosses the line and steps into a research lab where there's an active research program and funding from outside sources - that's the demarcation that I would make between when we should consider asking a student to sign an agreement and when it's not necessary for them to sign an agreement."

The use of special equipment and materials not typically afforded to other students was also an important criteria in assigning ownership. The extent to which other resources were considered varied widely across institutions and it appears that this is a gray area which provides some flexibility to the university. Interviewees were asked, whether their institutions had a clearly defined policy related to the specific type and amount of resources that will be considered and several responded that they did not.

> "Students own their IP if it was developed in the normal course of their program of study using only facilities normally available to students in their major and only if those rights are not superseded by other conditions (e.g. work for hire; work on a faculty grant/contract; being part of a special opportunity not available to most students)."

> "It's not straight-forward, not well-defined, but we do say, so long as you're not part of a research project or using a laboratory significantly, the chances are that significant use won't come into account for the undergraduates."

> "I think it's understood that if they're paid by the university and are working specifically on that problem or project, that would be covered. If they use university labs, that would be covered. It's not clear to me that if they use a computer lab that's open to anybody whether or not that that would be covered."

> "No I would say it's subjective. We don't—we do not try to delineate where that line is."

IP policy also appeared to be relatively straightforward when students were involved in industry-sponsored engineering or product design courses. However, this was described as leading to other complexities. A few institutions indicated that students had to be given the opportunity to opt out of industry-sponsored engineering courses if they did not want to sign over their IP rights. This meant that comparable curricular alternatives had to be available.

> "Very occasionally, there will be a design class with a sponsor where there's some obligation for us to enable the sponsor to acquire rights in the invention. So, we have a very strict rule about those classes for undergraduates, and the very strict rule is they shouldn't be frequent. They cannot be a class that's a requirement for graduation. So, they have to be electives, and the students are told in advance of taking the class that this is what the rule will be, that you won't own your own invention, and they sign a piece of paper saying they recognize it so that they're not surprised. So, in other words, we want the undergraduates to own their own invention unless they make significant use of our research facilities or money."

Other challenges were cited by respondents included: how to define what role an undergraduate played in IP generation and who should make the determination; the degree to which policies can be enforced; difficulty in tracking undergraduate IP; and applying policy in a consistent manner.

> "What we ask of our faculty is that they make the decision whether or not the student needs to sign the university's intellectual property agreement. If the student is going to be embedded in the research laboratory, working side-by-side with a faculty member, a post-doctoral student, a graduate student and a research assistant, well then, they really do need to sign the agreement, because if they made an intellectual contribution, they would own that. So, in a situation like that, because this is above and beyond the educational experience, then we would ask them to sign the agreement. However, if the student is going to be maintaining equipment or mixing solutions or taking care of animals or doing something rather routine where they really aren't going to contribute

intellectually, then they really don't need to sign it. So, we really rely on our faculty members. . .. And as we said, we do really try to minimize the number of students who are asked to sign legal agreements."

"I think there are probably a number of other things that are happening that we don't know about. We know about a few of them. I suspect there are others that we simply don't know about. I'm fairly certain that we don't know all of what's being developed out there. So the level of activity may be even higher than we've seen. There has certainly been a ramp up in the last couple of years."

"Our policy ends up covering things like senior design capstone classes in our engineering departments and it could cover but usually doesn't seem to cover inventions that would be, for instance, invented by a class of undergraduates in the business school. So, it is not a very consistently applied policy across the university. We don't really have a good window into entrepreneurship activity or whether it's up or down or sideways."

Question 3: To what extent are IP policies understood by students and faculty?

Respondents were asked about the degree to which they felt their IP policies and practices were understood by faculty at their institutions. Of the TTOs surveyed over half felt that faculty had a good to excellent understanding of how IP policy related to their own activity or to that of graduate students. In contrast, faculty understanding of IP policy as it related to undergraduates was considered good by only 29% of respondents (Table 4). In interviews, respondents were asked why this was the case. Reasons cited were: a lack of communication and/or education; visits to classes by TTO staff not being publicized; fears, rumors, and misunderstanding; a lack of motivation; and the complexity associated with policy.

In response to whether faculty should be more involved in handling IP topics and issues related to undergraduates, 39% of respondents indicated yes, 32% said no, and 29% were unsure. Respondents were also asked about the frequency with which they were consulted when new courses that involved entrepreneurship and innovation were developed; 29% said frequently, 45% said occasionally, and 26% said never. In follow-up interviews, when asked to explain the manner in which faculty could become more involved, the answers aligned with three themes. The first was that faculty need to become better educated about institutional IP policies to better address student questions and to prepare classes and programs that align with policies and practices. The second was that faculty need to communicate the policies to students in a more effective manner. The third was that faculty should support and communicate the university policies instead of what they personally believe the policies should be.

"I always like to remind the faculty in the departmental meetings that we're happy to speak to student groups if they would like for us to do that. We do try to educate the faculty about the intellectual property policy, and we kind of leave it to them to decide whether it's appropriate to pass that along to the students or not."

"It's kind of on an as-needed basis. So, we post information on our website. Also they can contact us by email or call, and so, we are always available to answer those kinds of questions, and it seems like—from our experience, faculty want this information and pay most attention to it when they have a need as opposed to us trying to educate everybody on a certain topic when it's convenient or seems appropriate to us."

"Regardless of what the policy says, we routinely heard from students that the University was going to claim their IP regardless, and therefore, they should save their best ideas for the senior project and do something silly, meaningless for a senior project in order to protect their IP. And, some of this was coming from faculty, and even though the policy is on the Web site, they just don't read. They would continue to tell students what they think the policy is or what the policy used to be."

"Faculty at my institution actually advise students about how to avoid having to share IP with the University."

Question 4: What are general (unofficial) attitudes and practices related to IP involving undergraduate students?

A number of more subjective questions were developed to understand unofficial attitudes and approaches toward undergrad IP. The first asked respondents to characterize their degree of involvement with undergraduates. Over 50% stated that they got involved with undergraduate students primarily on a case-by case basis, with the remainder split between playing a very active role in activities that could generate undergraduate IP and those that looked the other way (Table 5). Interview data suggested that TTOs are interested in undergraduate IP if the institution owns it and if it has promise. If that is the case, it is vetted and treated like faculty IP.

"We explain to them up front that if they want to go through us, that they're going to have to assign the IP to

Table 4. Respondent opinions about the degree to which faculty understand university IP policies

	Poor	Fair	Good	Excellent
IP policy as it relates to faculty	6%	35%	52%	6%
IP policy as it relates to graduate students	10%	42%	45%	3%
IP policy as it relates to undergraduate students	42%	29%	29%	0%

us, and then they would be treated per policy just like everybody else."

"Well, what we first do is effectively make sure that we have an ownership in it. So, that would be the very first thing that we would determine, and then, if we don't have an ownership, we will pretty much stop there unless there's something really compelling about the idea that would make us think that we would actually want to pursue it if they were interested in working with us."

Another factor is whether an undergraduate is committed to developing a technology further, which appears to be more the exception than the rule.

"Undergraduate students are more likely to think of it as a short-term project with a defined beginning and an end and not something that would, for instance, have a life beyond the time that they graduate from that particular class. We do take that into account. So, if there's no additional development plans, if there's no real future for the technology if you will, if they're not intending to move anything forward, we are more likely to just close the case. But we do evaluate them all just the same—maybe in a slightly shortened way—but we do look at them all, and we do give them all an evaluation."

When asked their opinions of the degree to which they should be involved with undergraduates, many agreed that they should be more involved but a majority also agreed that undergraduate IP yields very little return on investment of time or money (Table 6). It is clear that managing the technology transfer activities of faculty is a higher priority than commercializing inventions created by undergraduates given the expected return on investment to the university and TTO constraints related to time and resources.

"Well, as you would expect, most undergraduate intellectual property is not sufficiently substantial to be patentable and commercially attractive."

"Realistically, there are only so many of us and only so much time. So, we do have to try and work to the greatest possible value for the University."

"The answer to that is an unequivocal no, and the reason is I've got two-and-a-half thousand faculty to serve, and we barely keep up with that. If I opened the doors to 35,000 students, then we would not be able to do our job, and our job first and foremost is to manage intellectual property owned by the University."

One interviewee pointed to the need to pay attention to undergraduates in the event valuable IP is developed.

"Company X woke us up. We may want to have students share a small piece of equity with us if they develop companies based on work done at the University."

Another addressed the potential negative consequences and bad will that could be created by asserting ownership.

"Yeah, I kind of have issues with trying to claim stuff from the undergraduates just personally, but I know the institution probably has a different view of that. I think that the potential of bad PR that could come to the University if it tried to claim something that an undergraduate created is more risky than it's worth trying to capture it at all."

Some interviews felt that they should serve an educational mission since they are part of a university. These activities including providing access to resources, posting IP policy and information on websites, doing presentations for various audiences, offering internship programs, creating law clinics, creating brief and easy-to-understand license agreements, and increasingly using social networking to communicate with students.

"So, if I had five of me, I guess I'd probably inject myself in the freshman year, maybe, or junior year and identify courses that would probably be most likely to produce new ideas and then go and do an introductory presentation on IP—very general—to introduce the concept and the policy on campus at those targeted points."

"Could we be? Certainly I think we probably could be. Should we be might be a different question, and I—frankly, I think I'd leave that to others to answer,

Table 5. Statements that best describe university TTO practices toward undergraduate IP

Statements	n	Percent
Somewhat involved—we get involved on a case-by-case basis	17	55%
Passive—we tend to ignore it or look the other way	7	23%
Actively involved—we play an active role in activities that can generate undergraduate IP	7	23%

Table 6. Attitudes toward undergraduate IP

Attitudes	Disagree or strongly disagree	Agree	Strongly agree
We should be more involved in working with undergraduates	42%	58%	0%
We don't have the resources to meet the needs of undergraduates	48%	32%	19%
Undergraduate IP yields very little return on investment of time or money	36%	58%	6%
Undergraduate students are primarily generating IP that is not within the scope of the university IP policy	26%	55%	19%

perhaps the Deans and those who are in charge of the academic programs.''

''Tech transfer personnel, as I'm sure you're aware, primarily focus on doing what they need to do—managing IP, patenting, licensing agreements and all of that—and our primary mission is not education, but it's sort of a secondary mission of the office. So we try to take advantage of all those opportunities but, at the same time, really focus on our primary objectives.''

''Well I would say that certainly making presentations in a classroom setting, that's a good way to reach a large number of students, and, as I said, we always take advantage of those opportunities.''

''I think social media's probably the way to go for the students these days. So, we now have a Facebook page, a Twitter account, and all that sort of stuff.''

Finally, TTOs were asked if their policies were likely to change in the future. Approximately a third of the TTOs surveyed indicated they did and cited reasons such as increasing student success stories, expanding programs, corporate partners interested in protecting student IP, and to expand services to undergrads so that they receive the benefits afforded to other inventors.

6. Discussion

The purpose of this study was to explore the extent of undergraduate involvement with technology transfer offices at universities with strong engineering and/or entrepreneurship and programs to understand the range of approaches institutions take towards students involved in developing new technologies or launching business ventures. Findings indicate that undergraduate involvement in the generation of IP is still very small relative to other inventor groups, but is growing at approximately half of the institutions surveyed and remaining constant at the remainder. The study confirmed that this growth can be attributed to both the growing emphasis on entrepreneurship education as well as a growing emphasis on ''real world'' oriented product design courses in disciplines such as engineering and the sciences. To serve this population of inventors and innovators, over two-thirds of respondents indicated that they had developed or were in the process of developing specific policies and/or practices directed at undergraduates.

The data show that across the institutions surveyed there is a lack of consensus on how to treat undergraduate inventors. Some institutions reported that they pursued a proactive approach focused on actively reaching out to undergraduate inventors while others adopted a more passive approach whereby TTOs serve undergraduates on an as-needed basis. In this sample, these differing approaches could not be attributed to specific university characteristics (small/large, private/public). While it is clear that many state-funded institutions may be bound historically by more rigid policies, within this sample, this did not appear to play a significant role in attitudes towards or the perceived ability to change policy to accommodate undergraduates. Instead policies and practices appeared to be driven by a number of factors including the entrepreneurial culture of the institution, different philosophies institutions have in relation to the role they play in the generation of undergraduate student inventions, the beliefs of specific individuals (TTO leadership or faculty champions), and the human and financial resources TTOs have to devote to educating and serving undergraduates.

Where policies directed at undergraduates existed, they remain subject to application and interpretation. TTOs highlighted the significant challenges associated with tracking undergraduate involvement in IP generation, particularly at large institutions and in areas such as software development, leading to questions about how to apply policies fairly. The definition and consideration of ''significant university resources'' also varied widely across institutions. Many defined this as using resources above and beyond what a typical student would have access to, such as research labs, machine shops, and supplies. However, a few institutions considered taking a course as use of a university resource. These findings suggest that there is considerable gray area when assigning ownership based on the use of these resources, which a few interviewees indicated could be of benefit to the institution in negotiations. Additional research is necessary to understand the degree to which this is prevalent and the manner in which TTOs navigate through these issues.

The finding that 65% of respondents felt that undergraduate IP yields very little return on investment suggests that institutions serving undergraduates do so for other reasons. Only one interview in the sample stated that involving undergraduates in startups was core to the university's mission. Others felt that they should be involved in monitoring undergraduate IP so that they would be aware of activity that might result in a venture with high potential. The prevailing belief was that involvement in the generation of intellectual property by undergraduates was more typically part of an educational experience. TTOs felt it was their responsibility to be aligned with the educational mission of the university by being responsive to this population. However, the extent to which they were able to do seemed to be based on the level of staff and other resources they had available. Therefore, there appears to be a tension between serving an educational mission and generating financial returns to the institution. This suggests that if universities

attach strategic importance to serving the undergraduate student population, this will require that the institutional leadership provide TTOs with the resources necessary to do so effectively.

The study confirms that ambiguity and a lack of communication about policies can create mistrust among students. Overall, TTOs believed that IP policies are not well understood across campus. It appears that faculty attitudes can play a key role in how undergraduates view the TTO office may fuel myths that prevent undergraduates from taking advantage of university resources. Because undergraduates commonly ask faculty for advice about projects and ideas, they are key in communicating institutional policies to students. One interviewee highlighted the possibility that faculty might even undermine the policy of the university by telling students how to avoid it. More research is necessary to understand faculty attitudes toward university IP policy and the degree it may influence student interactions or lack thereof with TTOs. The findings of the study highlight the importance of communicating institutional IP policies to faculty and students in a way that they are easily accessible, understood, and in a manner where involvement of the institution is viewed positively.

Finally, institutions must weigh the possible financial returns from undergraduate IP versus the negative perceptions that practices and policies that aren't perceived to be in favor of students can cause. For example, could undergraduate IP policies impact longer term goodwill that might manifest itself in support or donations to the institution by successful alums? Also, if trends that encourage student involvement in invention and entrepreneurship continue, could institutional IP policies become a factor in the decision-making process of what college to attend? These questions suggest that more research is necessary to understand the tangible and intangible returns of undergraduate IP policy to a university.

7. Conclusion

The purpose of this paper was to identify trends and factors that faculty and administrators should take into consideration when developing courses related to entrepreneurship and/or product development that may involve the creation of IP. It is clear that institutions have varying approaches to dealing with undergraduate generated IP and that at many policies are evolving. The findings of this study highlight the importance of finding more effective ways to communicate the underlying principles of IP and institutional policies to both students and faculty. Clarifying their rights and responsibilities is likely to reduce ambiguity and provide a better return on investment for the TTOs and the institution at large in terms of time, money, and goodwill. This work serves as the foundation and catalyst for additional research being undertaken by the authors, the National Collegiate Inventors and Innovators Alliance (NCIIA) and the Association of University Technology Managers (AUTM). Future studies will focus on further exploration of the issues highlighted in this study as well as the development and dissemination of best practices.

References

1. L. Shuman, M. Besterfield-Sacre and J. McGourty, The ABET "Professional Skills"—Can they be taught? Can they be assessed?, *Journal of Engineering Education*, **94**, 2005. pp. 41–55.
2. C. J. Creed, E. M. Suuberg and G. P. Crawford, Engineering entrepreneurship: An example of a paradigm shift in engineering education, *Journal of Engineering Education,* **91**, Apr 2002, pp. 185–195.
3. D. H. Streeter and J. Jaquette, P. John, University-wide entrepreneurship education: Alternative models and current trends, *Southern Rural Sociology*, **20**, 2004, pp. 44–71.
4. National Science Foundation (2011), *Engineering innovation center brings together tools to launch future entrepreneurs*. Available: http://www.nsf.gov/news/news_summ.jsp?cntn_id=121178
5. H. Etzkowitz, A. Webster, C. Gebhardt and B. R. C. Terra, The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm, *Research Policy*, **29**, 2000, pp. 313–330.
6. M. Farrell, *Universities that turn research into revenue*. Available: http://www.forbes.com/2008/09/12/google-general-electric-ent-tech-cx_mf_0912universitypatent.html, February 25, 2008.
7. *United States Patent and Trademark Office*, Available: http://www.uspto.gov/main/faq/stopfaq.htm, August 6, 2012.
8. D. C. Mowery, R. R. Nelson, B. N. Sampat and A. A. Ziedonis, The effects of the Bayh-Dole Act on U.S. university research and technology transfer: An analysis of data from Columbia University, the University of California, and Stanford University, presented at the The U.S. and Japanese Research Systems, Kennedy School of Government, Harvard University, 1998.
9. Subcommittee on technology and innovation hearing—Best practices in transforming research into innovation: Creative approaches to the Bayh-Dole Act, in *Subcommittee on Technology and Innovation*, June, 19, 2002 ed, 2012.
10. P. D. Blumberg, From 'publish or perish' to 'profit or perish': Revenues from university technology transfer and, in *University of Pennsylvania Law Review* vol. 145, 1996, pp. 89.
11. K. Evans, Supporting the entrepreneurial mindset: Establishing intellectual property infrastructure to encourage student innovation, presented at the 2011 NCIIA Open Catalyzing Innovation Conference, Washington, DC, 2011.
12. J. G. Thursby and S. Kemp, Growth and productive efficiency of university intellectual property licensing, *Research Policy*, **31**, 2002, pp. 109–124.
13. Association of University Technology Managers, *U.S. licensing activity survey highlights: FY2010*. Available: http://www.autm.net/AM/Template.cfm?Section=FY_2010_Licensing_Survey&Template=/CM/ContentDisplay.cfm&ContentID=6874, 2011, 3/15/2012.
14. L. Pressman, D. Roessner, J. Bond, S. Okubo and M. Planting, The economic contribution of university/nonprofit inventions in the United States: 1996–2010, Biotechnology Industry Organization, 2012.
15. D. Myers, P. Speser, F. Erbisch and M. Morton, An IP policy primer, Paper Presented at the National Collegiate Inventors and Innovators Annual Conference, 2009.
16. T. Miller, D. Keltie, A. Tharp, J. Wilson and P. Hoon, *Report*

of the College of Engineering ad hoc intellectual property policy committee. Available: http://www.engr.ncsu.edu/ip-policy/, 2004.
17. C. Silvernagel, R. R. Schultz, S. B. Moser and A. Marie, Student-generated intellectual property: Perceptions of ownership by faculty and students, *Journal of Entrepreneurship Education*, **12**, 2009, p. 21.
18. K. J. Nordheden and M. H. Hoeflich, Undergraduate research and intellectual property rights, *IEEE Transactions on Education*, **42**, November 1999, p. 4.
19. N. Duval-Couetil and B. Barrett, Work in Progress—Undergraduates and intellectual property: Trends, policies, and practices, presented at the Frontiers in Education, Rapid City, SD, 2011.

Nathalie Duval-Couetil is the Director of the Certificate in Entrepreneurship and Innovation Program, Associate Director of the Burton D. Morgan Center for Entrepreneurship, and an Associate Professor in the Department of Technology Leadership and Innovation at Purdue University. Duval-Couetil is responsible for the launch and development of the university's multidisciplinary undergraduate entrepreneurship program which enrolls over 1000 students from all majors. Her research has focused on the assessment of entrepreneurship education, the impact of entrepreneurship education on engineering students, IP policy as it relates to undergraduates, and women and leadership. Prior to her work in academia, Duval-Couetil spent several years in the field of market research and business strategy consulting in Europe and the United States with Booz Allen and Hamilton and Data and Strategies Group. She was recently elected to the board of the United States Association for Small Business and Entrepreneurship in the position of Vice President for Research. She received a BA from the University of Massachusetts at Amherst, an MBA from Babson College, and M.S. and Ph.D. degrees from Purdue University.

Jessamine Pilcher is a Project Manager in the Office of Technology Commercialization at Purdue University. Pilcher's responsibilities include managing cases and technology transfer involved in the life sciences, biotechnology and biomedical fields. She assesses the commercial viability, marketing strategies, negotiation of licensing agreements, and suitable strategic partners. She also oversees the drafting and prosecution of the intellectual property, serve as a liaison between the inventor and attorneys, and work to educate the faculty, staff and students on Purdue's intellectual property policies and opportunities. Pilcher received her M.S. degree in bioengineering and technology and two B.S. degrees in genetics and development from Purdue University.

Elizabeth Hart-Wells is Assistant Vice-President and Director of the Office of Technology Commercialization at Purdue University where she is responsible for managing the commercialization of Purdue's intellectual property assets. She previously managed the University of Maryland, Baltimore's Commercial Ventures and Intellectual Property Group where she oversaw the university's intellectual asset portfolio. Hart-Wells served as a Congressional Fellow for the American Association for the Advancement of Science where she served on the professional legislative staff for the ranking member of the Energy and Commerce Health Subcommittee. She also served as a patent agent for Fulbright & Jaworski LLP and was a research associate for the National Academy of Sciences where she executed policy analysis of postdoctoral programs in academia, government and industry to aid the National Academies' Committee on Science Engineering and Public Policy. Hart-Wells earned a doctorate in chemistry from Rice University where she was a Turner Outstanding Graduate Student in organic chemistry, a Harry B. Weiser Research Scholar and a Robert A. Welch Foundation Fellow. She earned a bachelor's degree in chemistry from Indiana University. She is a member of the American Chemical Society, the American Association for the Advancement of Science and the U.S. Patent Bar.

Phil Weilerstein is Executive Director of the National Collegiate Inventors and Innovators Alliance a non-profit organization that stimulates and supports innovation and entrepreneurship at universities and colleges. Weilerstein has designed and oversees programs which encourage curricular innovation and student venture creation, provides resources for faculty and student entrepreneurs, and organizes conferences and workshops for faculty and students with a focus on encouraging socially beneficial application of technological innovations and the improvement of entrepreneurship and innovation education in higher education. As an entrepreneur in a not-for-profit organization, he has grown the NCIIA from a grassroots group of enthusiastic faculty to a nationally known and in-demand knowledge base and resource center. Mr. Weilerstein received his BS from the University of Massachusetts Amherst.

Chad Gotch is a Research Associate and Clinical Assistant Professor in the Department of Educational Leadership & Counseling Psychology at Washington State University. Gotch's interests center on maximizing effective and proper use of educational and psychological measurements. To this end, he studies assessment/measurement literacy among teachers, score reporting, and building validity arguments from both technical and non-technical evidence. These complimentary lines of research inform the life cycle of assessment, from development to use and policy. Gotch received his Ph.D. from Washington State University, his M.S. from the University of Idaho, and a B.S. from Virginia Tech.