USE OF A WEB-BASED DELPHI FOR IDENTIFYING CRITICAL COMPONENTS OF A PROFESSIONAL SCIENCE MASTER'S PROGRAM IN BIOTECHNOLOGY

A Dissertation

by

JEANNINE WELLS KANTZ

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

December 2004

Major Subject: Agricultural Education

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Approved as to style and content by:

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ABSTRACT

Use of a Web-based Delphi for Identifying Critical Components of a Professional Science Master's Program in Biotechnology. (December 2004)

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The primary purpose of this research was to develop a model for a professional science master's program combining biotechnology and business. The objectives were to identify stakeholder preferences for various dimensions of a professional science master's program combining biotechnology and business and to identify differences in priorities between subgroups. A secondary purpose was to examine user preferences between Web-based and traditional methods of conducting a Delphi study and the panelist's impressions of its usefulness for program development.

Prior to the first round, demographic data were collected on panelists regarding their gender, age, years experience in their current field, position title and education levels. Round 1 started with eight open-ended questions designed to investigate (a) learning objectives, (b) internships, (c) thesis vs. non-thesis degrees, (d) program focus (e) possible entry level positions, (f) roles for the industry advisory board, (g) recommended hours of hands-on experience and (h) other issues of importance. The final round ended with three questions to assess the panelists' perception of the usefulness of the Delphi for program development in higher education. Twenty-four panelists started Round 1 and participation in subsequent rounds varied from 17 in Round 2 to 11 in Round 4. Education level varied and included all levels of education in science and business.

Issues emerged early in the study regarding development of different program tracks and the program goals, which were clarified in subsequent rounds. Significant differences occurred between industry and academic subgroups for two tracks, six skills designated for tracks, method of evaluating the internship, and entry-level positions appropriate for new graduates. When analyzed by level of confidence (high confidence vs. low confidence), significant differences occurred for (a) the number of semesters of hands-on experience students should have upon graduation, (b) skills recommended for core curriculum, (c) skills recommended for tracks, (d) compensation level and (e) entry level positions for new graduates. Perceived usefulness of the Delphi for program development was varied with only 10 panelists responding--five in favor, three undecided, and two against.

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CHAPTER I

INTRODUCTION

When I received a bachelor of science degree in biology in the mid 70's, my undergraduate advisor told me that I should get a teaching certificate if I was not planning to go to graduate school because there would be "nothing else I could do with only a bachelor's degree." I ignored his sage advice, determined to prove him wrong. After several years of less-than-satisfying jobs out of my field, I finally gave in and went back to school and earned a teaching certificate in secondary science. At that time, government or academic jobs seemed to be the most likely career paths for aspiring young biologists and they were hard to come by with only a bachelor's degree and little experience. I did work in a soils testing laboratory for a short time, but it was a temporary position and required only a high school education.

Career options for today's students are much brighter. The growth of the life science industries over the past twenty years has created a growing demand for scientists at all levels, community college through doctorate. Many opportunities are opening up in nontraditional fields, such as sales and business development, for persons with a scientific background. But these opportunities

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This dissertation follows the style of the *Journal of Agricultural Education*.

also require knowledge and skills in business, communication, and other fields that are more common in a corporate science environment than an academic environment.

Traditionally, academic programs in the sciences have not emphasized other fields in their curricula. However, external and internal pressures are motivating colleges and universities to change their approach to education. In response to this, the Sloan Foundation began an initiative to support the development of professional science master's (PSM) degrees in 1997 (Alfred P. Sloan Foundation, 1999). There are now over 100 different professional science master's programs supported by universities or by the Sloan Foundation (Smith, Swanson, & Tobias, 2004). These changes in education and the growth of the life science industries combined to create the impetus for the development of an interdisciplinary professional science master's program at Texas A&M University in 1999.

Statement of the Problem

Significant changes are occurring in graduate science education, due in large part to the rapidly increasing number and variety of science-based industries and decreasing enrollments of domestic students in advanced science degrees. However, there is little actual research on graduate education that documents the impact of those changes, other than reports of increasing or decreasing enrollments and increasing or decreasing job markets in different fields. Participants in a recent National Science Foundation workshop (Office of Legislative and Public Affairs, 2003) noted that there was a significant lack of research literature on graduate education and that it would be increasingly difficult to make decisions unless measures were taken to encourage that research and to develop a body of literature in graduate education. With emerging trends in education, such as interdisciplinary professional science master's programs, research in graduate education is needed now more than ever.

Purpose of Study

The purpose of this study was to identify industry and academic priorities in the development of a model appropriate for a professional science master's program combining biotechnology and business. Specific objectives were to identify the importance assigned by each group to various aspects of a professional science master's program combining biotechnology and business and to identify differences in priorities between subgroups. Additionally, this study sought to examine user preferences between Web-based and traditional methods of conducting a Delphi study.

Significance of Study

This study could help define the critical components of a model for a professional science master's program combining biotechnology and business.

Those components have not been previously defined through research and this information could be valuable in program development. This study could demonstrate the usability of the Delphi method for program development in higher education, particularly for those programs that are emerging between disciplines and that have no well-defined curricular standard.

The Research Questions

The study addressed the following questions:

1. What outcomes or learning objectives (knowledge, skills or attitudes) should be expected of a graduate from a professional science master's program in biotechnology?
2. What factors would constitute the ideal internship?
3. Which is more important--the hands-on laboratory experience gained while doing research for a thesis or the completion of the thesis itself (design, application and documentation)?
4. To what extent should a professional science master's program be focused on local, regional or national workforce needs?
5. What entry-level positions would be appropriate for a recent graduate of a professional science master's program in biotechnology?
6. What roles are appropriate for an industry advisory committee for a professional science master's program in biotechnology?

7. What is the minimum number of hours of practical laboratory experience that a new graduate of a professional science master's program in biotechnology should have to be considered employable?
8. What other issues should be addressed that were not discussed in previous questions?

A secondary purpose of this study was to evaluate the participants' perceptions of the usefulness of the Delphi for program development. Panelists were asked three questions at the end of the study:

1. Why did you choose this format?
2. How useful do you think this Delphi process was in designing a new degree program?
3. What recommendations do you have for improving the process?

Definition of Terms

An **Associate of Applied Sciences** degree (A.A.S.) is typically a two-year degree awarded to students in occupational or vocational programs. Students earning this degree generally seek employment following graduation, though some degrees can allow for transfer to a four-year college.

Biotechnology is defined by the Biotechnology Industry Organization as "…a collection of technologies that capitalize on the attributes of cells, such as their manufacturing capabilities, and put biological molecules, such as DNA and proteins, to work for us (Biotechnology Industry Organization, 2004, ¶ 6).” Their definition goes on to say that the term should be used in the plural, biotechnologies, to really understand it.

Consensus refers to unanimous agreement within a group regarding a decision made. “When a decision is made by consensus, all members understand the decision and are prepared to support it. That means that all members can rephrase the decision to show that they understand it, that all members have had a chance to tell the group how they feel about the decision, and that those members who continue to disagree or have doubts will nevertheless say publicly that they are willing to give the decision a try for a period of time” (Johnson & Johnson, 2002). Procedures such as “majority voting, tossing a coin, averaging and bargaining (p. 297)” must be avoided and minority opinions and conflict should be encouraged. However, as the review of literature will reveal, the definition and acceptable level of agreement varies between disciplines, being quite high (90-100%) in conflict management, but somewhat lower in other fields and varying widely within a field. For purposes of this study, items that did not receive “strongly disagree” from any member of the panel were considered to have reached consensus.

The **Delphi method** is a specific set of procedures developed by the RAND Corporation to elicit and process group opinion. It is particularly useful when face-to-face meetings are not feasible because the members of the group are geographically distant (Dalkey & Rourke, 1971).

The Texas Healthcare and Bioscience Institute (Texas Healthcare and Bioscience Institute, 2001) uses the term, ***life science industries,*** to encompass the pharmaceutical, biotechnology, agricultural biotechnology, environmental and other sectors. These industries use the products of living organisms to develop products and processes to benefit mankind.

Many different technical terms are used in this document that may be unfamiliar to anyone not involved in the biotechnology industry. Human Factors testing, clinical testing, Points to Consider documents, 21CFRX00, Guidance documents, Good Laboratory Practice, Good Manufacturing Practice, Good Clinical Practice, Good Tissue Practice (U.S. Food and Drug Administration, 2004) and the International Conference on Harmonisation (International Conference on Harmonisation, 2004) are all related to the federal and international regulatory processes that govern the production of medical devices and pharmaceuticals. ISO 9000 is an international standard developed by the International Organization for Standardization to establish quality standards for production and manufacturing (International Organization for Standardization, 2004). More detail on the various laboratory skills listed can be found at the Biotech Life Sciences Resource Web site (University of Texas Institute for Cellular and Molecular Biology, 1999).

Assumptions and Limitations

It was assumed that participants of this study would be aware of the knowledge, skills and abilities necessary to be successful as an employee in an industry environment. As well, participants were assumed to have a relatively positive attitude toward master's degrees and professional science master's degrees. However, being that people tend to be more in tune with the needs of the present than the needs of the future, this study may be limited in its application to programs developed at a different time or in a different place. Because the Delphi is an assessment of expert opinion, rather than empirical data, that opinion will change with the makeup of the group, the time of the study or the subsequent changes in knowledge and attitudes of the panelists over time. Linstone (1975) lists eight basic pitfalls of Delphi studies which should be carefully considered when designing a study or interpreting results—discounting the future, the prediction urge, the simplification urge, illusory expertise, sloppy execution, optimism-pessimism bias, overselling, and deception. Several of these could come into play in this study due to the unpredictable nature of human beings or the lack of expertise of the designer.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Significant changes are occurring in graduate science education, due in large part to the rapidly increasing number and variety of science-based industries and decreasing enrollments of domestic students in advanced science degrees. However, there is little actual research on graduate education, other than reports of increasing or decreasing enrollments or changing job prospects in different fields, to document the impact of those changes. A recent National Science Foundation workshop (Office of Legislative and Public Affairs, 2003) concluded that there was a significant lack of literature on graduate education, and that it would be increasingly difficult to make decisions unless measures were taken to encourage research and develop a body of literature in this area. With emerging educational trends such as interdisciplinary professional science master's programs, that research is needed now more than ever.

Changes Occurring in Graduate Education

In 1995, the Committee on Science, Engineering and Public Policy Report (COSEPUP) (National Academy of Sciences Committee on Science Engineering and Public Policy, 1995) widely disseminated the conclusions of a joint study by the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine. The overall emphasis of the study pointed out that "more employment options are available to graduate scientists and engineers who have multiple disciplines, minor degrees, personal communications skills and entrepreneurial initiative" (Riggs & Galas, 1998). The report also recommends that graduate students be provided with experiences that enhance career skills, such as the ability to communicate complex ideas to non-specialists and the ability to work well in teams. Off-campus internships in industry and government were described as useful in developing those skills. These recommendations are supported by numerous other sources (Fiske, 1998; Jensen, 1997; Kreeger, 1995; McCollum, 1998; McCormick & Hodgson, 1993; Mertl, 1998; National Academy of Sciences & National Academy of Engineering, 1996). However, there is little integration between development of academic standards and skills standards, though supposedly they have the same goals--to prepare the students for their chosen career path (National Governors Alliance, 1998).

In response to the COSEPUP report, the Association of Graduate Schools (AGS) made three general recommendations (Association of Graduate Schools):

- Offer a broader range of academic options, in part due to the shift away from academic employment and toward industry positions. The AGS position was that some disciplines were becoming too specialized, but the integrity of the Ph.D. as a research degree should not be diluted.

- Provide better career information and guidance, including establishing a national database to collect information on time to degree, financial aid, placement and career paths that would be available to advisors and students.
- Devise a national human-resource policy for advanced scientists and engineers.

When compiling a list of successful programs and policies, AGS (Association of Graduate Schools, 1996) evaluated these programs based on

- Increased breadth designed to give graduates greater versatility.
- Reduced time to degree.
- Improved career advising and placement.
- Professional skills training.
- Improved program promotion and evaluation.
- Overall student experience.

However, the focus of the AGS documents appeared to be only on Ph.D. programs, with no mention of improving master’s degree programs specifically, though master’s students would benefit from most of the changes. No mention was made of encouraging disciplines to place more value on the master’s degree.

Traditionally, higher education in the US has focused on young, residential students. Curriculum in the programs emphasized academic disciplines rather than the needs of workers or employers (Ferguson, 1995), but in the early 1990's, only 25% of persons enrolled in higher education fit that traditional mold. In 1991, 32% of 12,000 adults participating in a national survey were enrolled in classes of some kind, the majority career-related (Ferguson, 1995). In 1993, almost 15 million students were enrolled in postsecondary education, more than double 1967 enrollments. Two million degrees were awarded in that time period, with approximately one-fourth of those in science and engineering fields

Ferguson (1995) calls for a change in the current paradigm of education, with less emphasis on disciplines and more emphasis on developing new standards that better serve workforce development. Results of the Third International Mathematics and Science Study support this with the U.S. ranking consistently below average on all the tests and last on some, which explains why many new employees lack the most basic skills needed for success (Hoover, 1999).

Stronger alliances between business and higher education will be necessary if Ferguson's "new paradigm" is to be achieved. Partnerships are formed for a variety of reasons, but successful partnerships have certain key elements (Charp, 1998) --visionary leadership, thorough needs assessment, consensus building, inclusiveness across the population, effective public relations, clearly defined roles and responsibilities, effective strategic planning, shared decision making that benefits all stakeholders, sufficient resources and expertise, and long term commitment. When partnering with industry, particularly for program or curriculum development, industry advisors must be chosen carefully. Many managers do not have the necessary understanding of knowledge and skills needed by their employees unless those managers came up through the ranks of a company and actually supervised or worked in the positions in question (Stasz, Ramsey, Eden, Melamid, & Kaganoff, 1996).

With increasing public pressure for accountability, universities must shift their focus more toward teaching and undergraduate education to better prepare students for entry into the workforce (National Academy of Sciences & National Academy of Engineering, 1996). Funding agencies are starting to promote more interdisciplinary graduate education and research training with emphasis on professional development that goes beyond the technical skills needed to finish a thesis (Mertl, 1998). This is in response to employer perceptions that new graduates, even at the doctoral level, lack skills in communication and multidisciplinary teamwork (Mertl, 1998). Complicating this task is the fact that as many as 80% of incoming freshmen in community colleges and universities may need remedial education in at least one subject (Rae Dupree, 1997). The National Science Board (1998) found that over 20% of minority students planning a major in the biological sciences or engineering thought they would need remedial work in science.

Ausubel (1996) and others (Bowen, 1996; Committee on Education & Human Resources, 2003; Massy & Goldman, 2001; National Science Board, 2003) believe that we are producing too many Ph.D.s in a system that recruits students primarily for its own benefit with little thought given to students' postgraduate careers. Ausubel goes on to say that universities are too focused on faculty research and not focused enough on teaching, with too many offering very similar degrees. The demand for graduate students too often is driven by the needs of the university research enterprise, where students do research and, in many cases, teach for much less money than would be required for new faculty. The number of Ph.D.s produced was directly related to the number of professors on the graduate faculty and the number of years many new graduates were spending in post-doctoral positions was expanding, particularly in the life sciences (Ausubel, 1996). One point Ausubel (1996) makes is that the value of the master’s should be increased, particularly in the life sciences, rather than being viewed as a consolation prize for students who aren't successful in a Ph.D. program.

Going back in the literature for ten years or so, there were many references regarding the over- or under- production of scientists, namely Ph.D.s (Bowen, 1996; Committee on Education & Human Resources, 2003; Greenberg, 2003; Massy & Goldman, 2001; National Science Board, 1998, 2003). In all fairness, however, those sources calling for a reduction in Ph.D.s don't always clarify whether the perceived overproduction is based on the ranks of all Ph.D.s or only those who don’t have tenure track jobs five to eight years after graduation. Most graduate programs are designed to prepare students to become faculty and carry on independent research, yet the reality is that only

12% will find positions as faculty (McCollum, 1998). The opinions and data on this seemed to vary widely and would be a worthy subject of a meta-study.

Greenberg (2003) reported that this country has never trained enough American-born scientists. We've always depended on science talent from other countries. According to him, NSF reports produced in 1997 stated that foreign scientists accounted for 44% of US Ph.D.s in engineering, 30% in mathematics, 29% in chemistry, and 25% in biology. More than half remain in the US either temporarily or permanently. The underlying problem is that American students don't choose science as a career. His conclusion was that there are better ways to make a living and scientists in this country are not properly rewarded for what they contribute. Scientists spend years in low-paying post-doctoral positions while other fields provide more lucrative rewards (Greenberg, 2003).

One interesting study regarding students with bachelor's degrees in biology was that they were the most likely of any major to enroll in graduate school and were the least likely to be employed full-time one year after graduating with their bachelor's degree (Barton & Lapointe, 1995). Of those biology majors who were employed full-time, 42% were in jobs that did not require a degree and only 27% were in a job related to their field. Could this be due to the mindset that only the Ph.D. has any real value? Or could it be that our undergraduate life science programs still subscribe to the traditional paradigm of preparing students for graduate and professional school rather than for entering the workforce?

Universities are increasingly faced with accusations of declining quality of undergraduate programs and the perception that they lack effective strategies for evaluating departments, institutions, systems and missions for the purpose of distributing ever-decreasing resources (Benjamin & Carroll, 1996). Universities are experiencing increased pressure to solve national and local problems. Undergraduate science, mathematics and engineering programs are expected to prepare science educators, professional scientists, and business leaders. They must teach not only science facts, but the process of scientific decision making, communication of complex concepts, and working in teams to solve complex problems (Advisory Committee to the National Science Foundation Directorate for Education and Human Resources, 1996). The National Science Foundation is calling for government, industry, education, and professional organizations to work together for the necessary improvements (Advisory Committee to the National Science Foundation Directorate for Education and Human Resources, 1996).

According to Graham and Nicholas (2001), universities traditionally evaluate programs on inputs rather than on outcomes, and have a poor track record of publicly reporting data about their performance. Organizations that rank universities, like the U.S. News and World Report (2004), base their rankings on inputs rather than outcomes, which reinforces the practice. Universities strive to provide the data that the ranking agencies will use, and the ranking agencies use those data because that is the standard process for evaluation in higher education (Graham & Nicholas, 2001). Some educators see this as a cycle that needs to change and, in 1999, piloted the National Survey for Student Engagement (NSSE) (Kuh, 2003). They suggest that universities be evaluated on benchmarks that support student learning rather than institutional resources and reputation.

The objective of the NSSE study was to collect data annually on student participation in programs and activities developed based on best practices in undergraduate education that support desired outcomes. At the end of the fourth round of data collection in 2003, over 1,300 different colleges and universities had participated with results being widely distributed on campuses to encourage improvement in undergraduate education (National Survey of Student Engagement, 2004b). Four-hundred seventy-three colleges participated in the spring 2004 round of data collection (National Survey of Student Engagement, 2004a).

The Kellogg Commission (Kellogg Commission, 1999) provided an in-depth profile of a truly engaged institution. The engaged institution should work harder to provide internships, practicum, and service-learning opportunities for all students (p. 29). Engagement would address current issues such as improving employability skills, the career ladder for entry-level workers, and the shortage of scientists and engineers (p. 32-34). One way to accomplish this would be through specialized programs to meet the needs of industry. In summary, the report stated that the engaged institution must respond to the needs of the current and future students, enrich the curriculum with learning and experiential opportunities that better prepare students for the work world they will enter, and work on community problems (p. 24).

In a survey conducted by the American Society for Cell Biology (Belden, Russonello, & Stewart, 1998), 25% of the members said they would not pursue a Ph.D. in their field if given the chance to start over. Most of this 25% were trainees, Asian scientists, or had graduated from a second or third tier university. The members agreed that too many Ph.D.s were being trained and that more permanent technician and research scientist positions should be created in the university so faculty would not be dependent on graduate students. The members also recommended that more diverse curricula be offered to broaden career options because the profession had changed over the years, with increases in industry and nontraditional positions, lack of research positions and lack of funding.

A study conducted by the Biomedical Association of Stanford Students (BioMASS) found that 40% of Ph.D. students graduating from the School of Medicine and the Department of Biological Sciences in 1996 were planning academic careers and 16% industry research careers (Hays, 1997). Twenty-five percent wanted careers that did not involve research and 58% were considering alternative careers. Seventy percent of the students surveyed were interested in dual discipline programs that involved a non-science field and 70% said their interest shifted away from academia while they were in graduate school. Twenty percent would not pursue a Ph.D. if they had the choice again. BioMASS recommended that students have better career counseling, alternative career advice, more diverse course work, experience outside their major department, and better mentoring.

A national study of master's programs involving 781 people, associated with 47 different programs across the US, found certain common characteristics of high quality master's programs (Conrad, Haworth, & Millar, 1993).

1. Faculty, administrators and students understood and agreed on goals and had strong ownership in the program.
2. Faculty, administrators and students formed a learning community that encouraged exploration, individuality and informal learning experiences.
3. Structured around core course work that is offered on a regular basis.
4. Opportunities for constant interaction between students and faculty
5. Experiential learning opportunities
6. Individualized attention for students
7. Students produced tangible products that benefited them as well as their field
8. Informal learning experiences and activities
9. Institutional support through facilities, equipment, and promotion and tenure policies.
10. Departmental support, both financial and through faculty commitment.
11. Strong faculty involvement

12. Faculty with work experience outside the university
13. Committed students with diverse backgrounds.
14. Strong, committed leadership

The National Academy of Sciences (1995 p. 20) recommended more flexibility with less focus on an academic career, better career guidance, shortening of time to degree, and more training grants that were not tied directly to faculty research. The Education Imperative (National Academy of Sciences, 1997), supports linking partners in post-secondary education to provide high quality education and training to people in various stages of their careers, rigorous assessment of educational goals within departments and programs, rewards balanced between teaching, research, service and professional activities, and graduate education that prepares students for an "..increasingly interdisciplinary, collaborative, and global job market" (National Academy of Sciences, 1997 p. 11).

The National Science Foundation hosted a series of workshops in the 90's that made similar recommendations: more opportunities for experiential and applied experiences, training for alternative careers, combined B.S./M.S. degrees for students interested in industry careers, and better job placement and follow up (National Science Foundation, 1996). Other sources voiced similar concerns and placed increased emphasis on the value of the master's degree to satisfy the workforce needs (Bowen, 1996). Bowen made the interesting statement that this was in part based on the National Academy of

Sciences findings that only one third of scientists and engineers with Ph.D.s had achieved tenure-track positions five to eight years after graduation.

The “typical” graduate student has also changed (Syverson, 1996). More than half were women, married, working full time, and one-fourth had dependents. There were more students in arts and sciences programs and at research-intensive institutions pursuing their degree full time. The average age was 33 and three-fourths were employed-16% of master’s students were employed on campus and 50% of doctoral students. A higher percentage of physical and life science students (70%) were employed at universities. From 1990 to 2000, engineering master’s degrees increased by 7%, only 1% average annually, but life science master’s degrees increased 29% or 3% average annually (Syverson, 2003) Master’s degrees in engineering peaked in 1994 and had decreased by 11% by 2000. Women made up the majority of new master’s degree recipients.

In studies conducted with citizens and business people across Texas specifically for graduates of Texas A&M University, some recommendations were that curricula be broader and more multidisciplinary, internal internships and co-op programs for students be created with at least two semesters of experience, increased interaction with industry for faculty, students and for curriculum development, teach "…values, ethics, corporate culture, teamwork, learning skills, and adaptation to change…(Zey, Luedke, & Murdock, 1999)”, how to interview, interpersonal skills, how to handle themselves in professional social settings, and how to communicate honestly with prospective employers (Zey et al., 1999).

Global competition for the science and engineering (S&E) workforce is increasing, which means the US cannot rely on international professionals as it has in the past (Committee on Education & Human Resources, 2003). Recommendations to counter this were that the federal government should direct more resources to encourage undergraduate study in science and engineering fields, provide more support for graduate education to respond to economic needs of students and promote a wider range of educational options in response to national skill needs, invest more in innovative approaches to doctoral and master's education and lead a national effort to gather information on current status of S&E workers, national S&E skill needs, and strategies that attract high-ability students and professionals in S&E careers. Yet according to some sources, there is currently an oversupply of biomedical science Ph.D.s (Committee on Education & Human Resources, 2003).

Problems arising in graduate S&E education are linked to the declining interest of domestic students in critical areas (physical, math and computer sciences), large increases in S&E retirements in the near future, the projected rapid growth in S&E occupations in the next ten years, new demands as a result of increased national security and severe pressure on state and local budgets (Committee on Education & Human Resources, 2003). From 1993 to 1997, the number of researchers in the thirty member countries of the Organization for

Economic Co-operation and Development (OECD) increased 23%, but in the US those numbers only increased 11.8% (Committee on Education & Human Resources, 2003). In 1975, the US ranked third in the ratio of natural science and engineering (NS&E) degrees to the 24-year-old population, but currently, 16 countries outrank the US. From 1989 to 1998, bachelor's degrees in NS&E fields increased by 16.6%, but if biological and agricultural sciences are removed, other fields dropped by 7.9%. Twenty-five to thirty percent of freshmen surveyed intended to major in S&E fields, but less than half actually completed degrees within five years (Committee on Education & Human Resources, 2003).

Student loan debt has doubled in the past eight years and as a result only 27% of undergraduates are traditional students (Committee on Education & Human Resources, 2003). Students unable to attend full-time have difficulty in S&E fields because of prerequisites required, limited course offerings at accessible times and places and the necessity of laboratory work. Recommendations for retaining students were improved quality of teaching, changing the nature of introductory classes, facilities to support new teaching methods, and more effective academic support (Committee on Education & Human Resources, 2003). The report also recommended that universities should improve career guidance, increase training grants, voluntarily reduce enrollments in oversupplied fields, and broaden student experiences. Finally, the authors recommended that more financial support be put into academic research to develop more adequate models of domestic supply and demand for S&E skills (Committee on Education & Human Resources, 2003).

Future development of graduate education is hampered by the lack of a significant body of research (Office of Legislative and Public Affairs, 2003). Changes occurring in graduate education such as online learning, mobile student populations, for-profit colleges and professional master's degrees are projected to become more prevalent. Graduate students of the future will seek more targeted opportunities for learning instead of traditional degree programs. Corporations will emphasize just-in-time learning. Studies are needed to evaluate outcomes and mechanisms for institutionalizing change and the graduate community needs a better understanding of what works for new students (Office of Legislative and Public Affairs, 2003).

Professional Science Master's Programs

As a result of these many years, and pages, of recommendations for changes in graduate education, the Sloan Foundation began an initiative to support the development of professional science master's (PSM) degrees in 1997 (Alfred P. Sloan Foundation, 1999). There are now over 100 different professional science master's programs supported by universities or by the Sloan Foundation (Smith et al., 2004). To date, the focus of the Sloan Foundation has been on two-year programs that emphasize course work and require an internship. In practically all these programs, course work in a professional field is combined with science and a professional internship.

Model PSM programs take three forms: 1) deepening student knowledge beyond what can be learned in a baccalaureate program, while staying within a discipline; 2) fusing scientific fields beyond what can be achieved in an undergraduate program; or 3) integrating disciplines such as science or math with training in management, law or other professions (Sciencemasters.com, 1997). Programs typically have “more science than an MBA, more informatics and computation than an MBA or science master’s…, more education in professional fields…, and closer interaction with employers” (Sciencemasters.com, 1997) through experiential education opportunities.

The programs may combine scientific fields, such as life sciences and information sciences, (bioinformatics) or provide in-depth knowledge in one domain. Many PSM programs are in cross-disciplinary or emerging fields. All have "professional" components--business basics, law, regulatory affairs, skills-building modules or courses in management, negotiation, or communication (Ausubel & Tobias, 2002). A key element is the industry advisory committee set up before launching a program. These advisory committees take an active part in the process, especially in the planning stages. Students are exposed to cutting-edge research through experiences such as laboratory rotations. Most programs emphasize basic employability competencies such as writing and teamwork.

Management of these programs requires an industry liaison, rigorous assessment and quality control, follow-up with graduates and contact with similar master's programs. PSM directors see value in their contacts with local and regional firms and exposure to real-world problems and state-of-the-art instrumentation. These new master's degree are being promoted by others as an alternative to the academic Ph.D. for those students who are planning careers in the life science industries (M. N. Jensen, 1999; Kumagia, 1999).

PSMs first began in the 1980s, but disciplinary associations in the life sciences did not take much notice until 1997, when the William M. Keck Foundation and the Alfred P. Sloan Foundation independently began to launch PSMs. The guidelines recommended by these foundations were (a) analysis of local workforce needs preceding development of the program, (b) active involvement of industry advisors, and (c) programs of at least two-year duration, including a three to six month internship. Two years were recommended as the minimum program length because it was believed faculty didn't take one-year students seriously enough, the second year students mentor the first year, and two years in the department would generate a greater sense of community and loyalty to the institution (Ausubel & Tobias, 2002). PSMs typically target recent baccalaureate degree holders who want a short, full-time, professional level program or part-time professionals who will take only one or two courses at a time (Tobias, 1999). Because most of these programs are relatively new and vary considerably, systematic evaluation is difficult (Tobias, 1999).

Unlike the traditional science programs, PSMs typically do not offer assistantships, but instead expect students to pay their own way (Kumagia, 1999). However, unlike MBA or law programs, which have excellent reputations backed by 100-year track records, there are not droves of students willing to pay. Perhaps because they are new, PSMs are at a disadvantage and many must supplement their students with teaching assistantships or other support. These programs are small. Within two to three years after the program is started, they try to graduate at least ten students per degree program per year. The programs conduct distinctive orientations and provide cross-departmental activities for students, provide special advising and placement, and track graduates over the long term. Though currently there are no skill standards for these programs, national standards may arise as programs grow. To have a significant impact on the national economy, thousands must be graduated. Contrary to many who feared otherwise, these programs do not compete with doctoral programs, but rather the courses benefit all students in the department and the PSM students can provide a pool for teaching assistants (Ausubel & Tobias, 2002). Tracking graduates will be critical to determining the success of these programs (Kumagia, 1999).

PSMs usually conform to local tuition and rules of revenue return, but some follow professional school models of charging more (Ausubel & Tobias, 2002). Many use startup funds to hire professional staff to coordinate faculty, for targeted recruiting, student services, and as a liaison to business. Since most do not offer financial assistance, some means of reducing costs to students is needed. More favorable distribution of state resources is also needed to encourage increased number and variety of programs. Ausubel and Tobias (2002) believe that state economic development agencies should support PSMs because of their value as workforce incubators.

Science and technology industries need more focused, industry-responsive and timelier education opportunities. Graduates should be knowledgeable in their scientific discipline, be able to work across cultures and disciplines, communicate across departments and with customers, and work well in team settings. Demand is increasing for people who have technical knowledge and who can plan and manage a project to completion (Kumagia, 1999). The traits most frequently mentioned were “leadership, project management, team building, communication skills, planning and organizing, interpersonal skills, adaptability, and multi-cultural competencies” (Simmons, 2003). They need the "science equivalent of an MBA" (Simmons, 2003) and the typical Ph.D. is too narrowly specialized to provide this. Ph.D.s, and often MBAs, end up in jobs far from their interests and qualifications. In contrast, 91% of PSM graduates surveyed at twelve universities landed positions in their chosen field after graduation (Simmons, 2003). They ranked their degree highly, 41% believing it was competitive with an MBA. Sixty-six percent said their salary was $50,000 or higher and 12% exceeded $70,000. This exceeds most traditional master's graduates, particularly in the life sciences where the average was $33,500 (Simmons, 2003).

From 1984 to 2000, the total number of Ph.D.s granted in the math, physical and life sciences went from 7,500 to 10,000, but master's degrees awarded in these fields stayed flat at about 14,000 (Ausubel & Tobias, 2002). In 2002, there were over 40 universities with PSMs and in the February, 2003, newsletter from the Sloan Foundation, there were 67 PSM programs-twelve single track bioinformatics programs and the rest multi-track (Sciencemasters.com, 2003). Of the current enrollees, 80% are full time, 33% are women, 8% underrepresented minorities, and 84% are US citizens, with programs in the biosciences being the most popular.

Changes in Employer Demands

Industry is becoming the primary employer of graduates with bachelor's degrees. In 1995, 72% of those earning bachelor's degree in1993-94 were working full-time (Tsapogas et al., 1999), but the author did not provide figures on how many of those were in jobs related to their field or if any of those counted as unemployed had chosen to continue their education. Two-thirds of those employed full-time were in US industries and the remaining one-third were employed in education, government, or nonprofit organizations. One-third of the science graduates worked in companies with fewer than 500 employees. Life science graduates were more likely to be working in their field if they were employed by a small business. Biotechnology was one of several technical fields that showed higher than average growth of new companies in the early 1990s. This demonstrates increasing opportunities for life science graduates in private industry.

The National Academy of Sciences, National Academy of Engineering, and Institute of Medicine Committee on Science, Engineering, and Public Policy (National Academy of Sciences & National Academy of Engineering, 1996) reported that the numbers of science and engineering Ph.D. recipients working in fields other than academics has increased steadily for the past twenty years, while the number of academic positions available has remained steady, or in some cases, decreased. Changes in society (e.g. the end of the Cold War, globalization, and advances in technology) have had a significant impact on the job market for scientists and engineers. Small and medium size companies are increasing their R&D expenditures and creating more employment opportunities for recent graduates with multidisciplinary skills, particularly those who have strong minors or dual master's degrees. Scientists and engineers are increasingly being recruited into nontraditional fields such as finance and companies are expecting more than technical knowledge from the scientists they hire. As companies become more global, they look for science professionals with multi-lingual skills, management skills, flexibility and the self-motivation to be a life-long learner (National Academy of Sciences & National Academy of Engineering, 1996).

Soft skills (ethics, intrapersonal, stress management, etc.) (Caudron, 1999) and basic skills (communication, computer skills, problem solving, etc.) (Laab, 1993) are becoming as important as technical skills. Increased emphasis is being placed on employability competencies that are common to employees in all levels and fields such as skills in reading, math, higher order thinking, and teamwork (Cotton, 1993). Employees must continually update their knowledge to stay abreast of new developments in areas of science that change rapidly. Employers are recognizing that employee success is more dependent on personality characteristics and behavioral skills than technical skills (Cusack, 1994).

Cusack (1994) points out that people with an internal locus of control and the belief that success comes from effort rather than ability are more successful and that these traits are often learned in childhood rather than as adults. This could have implications for elementary and secondary education-reward for effort rather than meeting a set academic standard, development of problem solving skills, self-esteem, optimism and resilience.

In the Massachusetts medical therapeutics sector, larger companies which had entered clinical or commercial manufacturing of one or more products were expanding product and manufacturing bases, developing marketing and sales divisions and had plans to continue expansion over the next 10-15 years (Dahms & Bourque, 2001). In 2001, there were about 1,300 biotechnology companies in the US industry, 350 of them publicly traded, with a combined market capitalization greater than $450 billion and annual revenues of about $28 billion (Dahms, 2001b). There were approximately 130 products in commercialization and more than 50 publicly traded companies that were profitable. The industry was largely made up of emerging companies with more than $15 billion in research and development and more than 1,400 products in various stages of clinical development. These companies employed more than 180,000 and grew at a rate of 9% to17% annually (Dahms, 2001b). The workforce could grow to one million by 2015. Competitive advantage relied on corporate technology, patents, strategic position and how companies developed and managed their workforce.

In 2001, the US technical force was 19% Ph.D., 17% M.S., 50% B.S., and 14% A.A.S. (Dahms, 2001b). Almost 10% of people in the US biotechnology workforce (~17,000) had H-1B visa status (Dahms, 2001b). Skilled labor was the second or third item on a list of a dozen or so significant hurdles that companies had to clear to move into commercialization (Dahms, 2001a).

As companies grow from an R&D base to production, they must develop their workforce for the shift. Employees must possess knowledge in business development, management, regulatory compliance, quality assurance, Good Manufacturing Practice, technology management, project management, data management, product creation, and drug development and approval. They also need soft skills such as leadership, teamwork, and management (Dahms, 2001a).

The National Science Board created three key science and technology policy goals. One of those was to address the current and future needs for a well-trained workforce, from basic science literacy to advanced degrees in science and engineering (National Science Board, 1996). They foresaw an increasing demand for a technically skilled workforce.

In 1995, 55% of academic R&D expenditures were in the life sciences (National Science Board, 1998). Academic patenting, especially in biomedical fields, increased from 250 in the early 70s to 1,800 in 1995 (National Science Board, 1998). Pharmaceutical companies R&D expenditures tripled between 1985 and 1995 with the most significant increase in biotechnology research. More than one-third of drug companies R&D projects were biotechnology related.

Because of this rapid increase, graduate education is being closely examined for effectiveness in the career preparation of students. The demand for an educated workforce in science and engineering is expected to increase by 1.36 million jobs between 1996 and 2006 with an increase of 41,000 jobs just in the life sciences (National Science Board, 1998).

Baccalaureate and master's level scientists provided much of the workforce in R&D laboratories of pharmaceutical firms, biotechnology companies, and chemical suppliers (Gwynne, 2001). Forty to 50% of jobs in a company may be non-research, but require a B.S. or M.S. in science. Other opportunities for careers in clinical trials, regulatory affairs, sales, marketing, technical assistance and other fields were available for those who didn't want to stay at the research bench. Demand is expected to increase as current technologies based on genome sequencing continue to mature (Gwynne, 2001). In 1995, 72% of scientists and engineers with bachelor's degrees and 59% with master's degrees were employed in a private for-profit company (National Science Board, 1998). In 1999, 62% of S&E master's degrees were employed in for-profit companies (Committee on Education & Human Resources, 2003).

Master's level graduates were in demand for positions in three distinct areas: business, operations, and clinical (Jensen, 1996). Working in an industry environment required people skills, ability to work in multidisciplinary teams, focus on goals, timelines and results. This fosters an environment where the independence typical in academia is not appreciated (Jensen, 1997).

All too often in the life sciences, the master's degree is just a stepping stone to the doctorate, unlike engineering programs where the master's can be a terminal professional degree that leads to a career in industry. In technical industries, master's level professionals oversee the majority of development, marketing and operations work and their numbers can promote or limit corporate growth (Riggs & Galas, 1998). In 1995, engineering schools granted 28,000 master's degrees, an increase of 20% from 1990, while life science schools granted only 5,400 master's of science degrees, an increase of only 11% from 1990.

Master’s level scientists are needed because most undergraduates lacked the necessary training in science or management to be team leaders and Ph.D. level scientists are not typically trained to take discoveries from laboratory to marketplace. Riggs and Galas (1998) stated specifically that the life science industries needed a master’s degree that combined “…an understanding not only of fundamental biology, but also of chemistry, engineering, computing methods, ethics and business “(p.41). They go on to say that communication and teamwork skills across multiple departments were more important than research skills and specialization.

Surveys conducted by the North Carolina Biotechnology Center in 1992 determined that 55% of B.S./M.S. level technicians were hired from within the industry, but only 28% were hired straight from college (Kennedy, 1993a). Reasons given for this were that employers placed a high premium on experience working in an industry environment, new graduates lacked basic laboratory skills and only large corporations had full-time staff devoted to in-house training. The survey also found that students’ chances to find jobs right out of college could be enhanced by increased opportunities for practical laboratory experience in the undergraduate curriculum, cooperative education experiences, summer jobs or internships in industrial laboratories, undergraduate research projects or jobs in academic laboratories, and exposure to the Good Laboratory Practice (GLP) or Good Manufacturing Practice (GMP) standards in college laboratories. Startup companies were more heavily invested in R&D and their workforce was primarily above the level of B.S. (Kennedy, 1993a).

Generally, according to the NCBC study (1993), the most desirable preparation for biotechnicians included training in analytical instrumentation (HPLC, GC, all kinds of spectroscopy), biochemistry, microbiology, and computer literacy. (A word of caution here, however, as this was ten years ago and the industry has evolved rapidly since that time.) Workers at all levels needed strong basic abilities in communication, math, and problem solving. Once again, employers also cited abilities such as teamwork, creativity, critical thinking and initiative.

In a related study (Kennedy, 1993b), the most common deficiencies cited for new graduates at all education levels (high school, A.A.S., B.S., M.S., Ph.D.) were poor written and oral communication skills. While A.A.S. and B.S. level graduates were more commonly perceived as lacking problem solving and practical laboratory skills, interpersonal and teamwork skills were more of a problem for people with graduate degrees and older AAS students.

In many fields, there is more demand for B.S. and M.S. level than Ph.D. level employees (McCormick & Hodgson, 1993). Steve Aeby (as cited in McCormick & Hodgson, 1993) expressed the need for people experience in moving products through production and clinical trials. He emphasized the need for experience with GLP (Good Laboratory Practice), communication skills, flexibility, organization skills, teamwork, junior management skills and self motivation.

Growth of the Texas Industry

Internationally, the current biotechnology marketplace includes approximately 2,500 firms, most of them in the US. There were more than 1,500 companies in the US with 190,000+ employees in 2001 (Griffith & Martinez, 2003), with most of them centered in industrialized areas due to a need for proximity to top research universities and a highly-educated workforce. Between 1992 and 2001, biotechnology industry revenues totaled $28.5 billion, an increase of more than 350%.

There are four major regional concentrations for the biotechnology industry in Texas: Austin, Dallas-Fort Worth, Houston, and San Antonio (Griffith & Martinez, 2003; Texas Healthcare and Bioscience Institute, 1998). From 1990-1997, employment in this sector grew 3% annually, compared with 1.7% nationally for that sector and 2.9% annually overall in the state. More than 50,000 people were employed statewide in 2001 (Griffith & Martinez, 2003), with the largest segment (52%) being laboratory and research services. Twenty-four percent of jobs were in science and engineering (Texas Healthcare and Bioscience Institute, 2001).

Intellectual property in Texas generated $12.4 million in income for Texas health related institutions in 1997, up from $4.2 million in 1993. Small Business

Innovation Research awards (SBIR) to Texas companies working in the life sciences were $41.5 million in 2001 (Griffith & Martinez, 2003). Federally funded R&D expenditures in Texas institutions nearly tripled from 1986 to 1998, equivalent to a 9.0% average annual increase (Texas Healthcare and Bioscience Institute, 1998). NIH expenditures in Texas grew 58% from 1990 to 1996, reaching $456 million, but were significantly lower than California, Massachusetts, and New York. Venture capital investments in Texas companies reached $403.5 million between 1995 and 2002, but this is an inconsistent source of funding (Griffith & Martinez, 2003). The strongest shaper of the business environment is government support, a highly trained workforce and favorable business climate (Griffith & Martinez, 2003).

Eighty-four percent of firms surveyed in 1997 noted that Ph.D. and master's degrees in life sciences were important to continued growth (Texas Healthcare and Bioscience Institute, 1998). Fifty-seven percent of companies surveyed noted that workforce skills and specific training resources were extremely important to continued growth. Seventy percent of respondents noted that employees with engineering and other technology related degrees were important to growth. About one-fourth of employees in the cluster were professionals, such as engineers, clinical technologists and scientists.

Patents related to healthcare technology in Texas increased from 6.6% to 8.1% in 1997 (Texas Healthcare and Bioscience Institute, 1998). Patent activity in pharmaceuticals, biotechnology, medical equipment, and medical electronics has increased more than 92% since 1990. Biotechnology patents increased from 7% to 20% of total healthcare technology patents between 1990 and 1997 while pharmaceutical patents increased from 24% to 29%. Between 1993 and 1997, income generated from royalties, licensing, or other transactions related to intellectual property increased 38% at Texas health-related institutions, from just $4.2 million to $12.4 million. From 1997 to 2001, approximately 1,820 biomedical patents originated from Texas (Griffith & Martinez, 2003).

The Texas A&M Center for Business and Economic Analysis estimated that the healthcare technology industry in Texas encompassed 500 companies with $6.5 billion in annual sales and more than 38,000 private sector jobs with an average salary of $40,000 in 1997 (Texas Healthcare and Bioscience Institute, 1998). Average company R&D expenditures were $3.1 million a year and there were at least 396 new products in development at that time.

In the area of academic research, which feeds this growing industry, Texas possesses a wealth of resources. Texas public and private higher education research institutions spent $1.8 billion on life sciences research in 2001 (Griffith & Martinez, 2003). Of that, $682.6 million went to medically-related research. Life science degrees awarded in Texas increased 56% between 1989 and 1995 (Texas Healthcare and Bioscience Institute, 1998). Texas Health Science Centers awarded 218 doctoral degrees in life sciences and 1,300 professional degrees in 2001 (Griffith & Martinez, 2003).

The Texas Science and Technology Report (Texas Science and Technology Council, 1998) stated that workforce issues were the largest barrier to continuing the economic growth of Texas' technology-based economy. Recommendations from that report were to significantly expand the high school Advanced Placement program to increase the number of high school graduates with high level math and science skills and adoption of a high technology curriculum in community colleges across the state to help train and re-train students and workers for available jobs.

The Council on Science and Biotechnology Development was created in 2001 when the 77th legislature appropriated $800 million for science, engineering, research and commercialization activities (Griffith & Martinez, 2003). The purpose of the Council was to create a seamless system of innovation from the laboratory to the marketplace in rapidly developing areas of biotechnology, such as biopharmaceutical development, bioinformatics, genomics and nanotechnology (Perry, 2001). The mission of the council was to work to create a partnership between institutions of higher learning, industry and government to promote biotechnology as an economic development tool. As an example of the benefits of such a cooperative effort, Governor Rick Perry (2001) noted that more than 400 biotech companies have been created in the San Diego area in the past 10 years, resulting in billions of dollars poured into the local economy. The Council was charged with identifying legal barriers to technology transfer, recruiting existing companies and facilities to Texas, and creating incentives to ensure that faculty, departments and universities were rewarded for commercializing technology. A subcommittee of that Council was established specifically to address workforce issues, which were seen as a barrier to continued growth of the industry (Perry, 2001).

The Delphi Method

The Delphi method was chosen for this study because it is recognized for its effectiveness in reaching consensus on curricular content and for developing curriculum in emerging fields (Finch & Crunkilton, 1999). According to Finch, the strength of the Delphi method lies in "allowing stakeholders and experts to speculate individually and reach consensus collectively on necessary content when there are few trained workers in a field (p.158-159)." It is used in education for cost effectiveness, curriculum and campus planning, establishing institutional and general goals and objectives, and reaching consensus on evaluation elements (Judd, 1972). When determining priorities for educational planning, factors such as availability of resources and people affected must also be taken into consideration (Caffarella, 1994), which can be accomplished with a Delphi as well.

Three distinct characteristics of the Delphi method are anonymity, controlled feedback and statistical group response (Dalkey, 1967; Turoff & Hiltz, 1995). In a typical Delphi, an initial questionnaire requests a list of content from panelists, which is ranked in terms of importance in successive rounds, allowing members of the panel to give opinions on each round. When more focus is needed on a specific issue, a modified version of the Delphi, which begins with a set of examples instead of general questions, is used (Scheele, 1975). The Delphi method can be used when no other data is available to determine curriculum content.

Scheibe et al. (2002) compared methods of ranking, rating scales, and pair-comparisons to determine which was most likely to provide interval data. Likert-like rating scales and rankings were the most likely to be interval. Rating scales were preferred by participants. However, he cautions that results may not be conclusive due to the difficulty of comparing successive rounds in a Delphi.

Use of pen-names allows respondents to be identified with their contributions, while maintaining their anonymity for purposes of voting or providing subjective information (Turoff & Hiltz, 1995). Two other important aspects of a Delphi are that respondents should know that they do not have to respond to every question, taking a “no judgment” view, and they should be asked to rate their level of confidence in their answer (Dalkey, 1967). Overall, group judgments were found to be 45% more accurate than individual judgments in studies done with factual data and similar studies with value judgments support that rule (Dalkey & Rourke, 1971).

The Delphi method is commonly applied to groups of 30 to 100 people that cannot meet easily face to face, allowing members of the panel to participate asynchronously. Delphi works better than structured face-to-face meetings because answers are more accurate (Dalkey, 1967). Numerous studies by psychologists have demonstrated serious difficulties in face-to-face interactions due to the influence of dominant individuals, communications centered on individual and group interests rather than problem solving, and group pressure for conformity (Dalkey, 1969). This method provides the individual with the greatest freedom of individuality or freedom of expression (Turoff, 1971).

The advantage of having large groups is that individuals with different perspectives or differing abilities can contribute to those parts of a complex problem for which they have appropriate knowledge and problem solving skills (Turoff & Hiltz, 1995). According to the authors, this aspect of the Delphi is one of its most important--allowing an individual to choose what part of the problem to deal with at any time in the group problem solving process. This is easier to accomplish with a computer system than paper and pencil, which holds much promise for computer-based Delphi (Turoff & Hiltz, 1995).

Panelists should have a firm idea of a group's identity, but anonymity reinforces the panelists’ self concept as impartial observers. When the panel is drawn from one field or discipline, interaction can quickly move to theoretical discussion rather than action. Scheele (1975) also recommends that panels be composed of stakeholders (those who are or will be directly involved), experts (those who have applicable specialty or relevant experience) and facilitators (those who have skills in clarifying, organizing, synthesizing, stimulating and when appropriate can supply alternative viewpoints) for the best combination of expertise. Participants should be chosen by starting with a small group and asking for names of others who would be good panelists in each role. Minority, as well as majority viewpoints, should be considered. Prestigious sponsors, publicity value, and attractive and stimulating peers can provide incentives for participation (Scheele, 1975). Suggesting that key participants collect and review feedback from their staff or students is another opportunity for publicity or recognition. Creating expectation and awareness among people important to the panelists can also serve as an incentive.

Web-based Delphi

One of the most significant potentials for automation of Delphi is the incorporation of real time analysis aids (Turoff & Hiltz, 1995). The moderator can tailor the group process to create activities at any point in the discussion. The addition of graphics, animation, video clips and audio offers possibilities in survey design that cannot be accomplished with a paper and pencil questionnaire (Dillman, 2000). However, this increased technical ability also introduces another source of survey error if the level of technology used is too sophisticated for the respondent to receive and respond to. Surveys must be designed with the lowest level of technology in mind and tested using different browsers, operating systems, and computers.

Consensus

The Delphi is not necessarily a method to produce quick consensus, but is intended to be a means of encouraging critical discussion (Turoff & Hiltz, 1995). It can uncover hidden issues just as easily as it can lead to agreement (Turoff, 1971), and should be considered a means of exploring differences rather than a just a tool for reaching consensus (Linstone & Turoff, 1975).

The stability of group opinion is sometimes measured instead of consensus because it allows for more information to be collected and can show consensus within subgroups rather than consensus of the group as a whole (Scheibe, Skutsch, & Schofer, 2002). Being that one of the original objectives of the Delphi method was to identify differences as well as agreement, the use of opinion stability, rather than consensus, is considered a better measure of success by some.

A problem that emerges with Delphi studies is the lack of agreement on the definition of “consensus”. Fink et al. (1984) stated that consensus definitions can vary, but that justifiable levels should be agreed upon before the study is started. They mention that items on which there is two-thirds agreement after fifteen minutes of discussion should be considered consensus items. However, in literature related to conflict management, a minimum of 90% is recommended and 100% preferred (Susskind, 1999). Other sources indicate that even among professional facilitators, there is not common agreement on consensus (Freeman, 2002), so the definition and use of consensus seems to vary with different fields. Johnson and Johnson (2002) list seven methods of group decision making, describing Delphi as an example of decision by averaging individual opinions, while the consensus method is described separately. However, the authors' description of Delphi indicates they are not well-versed in the Delphi method or the research supporting it. One comment made was that the "opinions of the least knowledgeable members may annul the opinions of the most knowledgeable members (p. 294-295)", which was addressed in some of Dalkey's later studies where he recommended that data be analyzed by subgroups, including having panelists rank their level of confidence in their answer (Dalkey, Brown, & Cochran, 1969).

There also seems to be some distinction between methods for reaching consensus and the consensus method, the Delphi being frequently described in the literature as a method for reaching consensus while the consensus method is always described as a face-to-face process involving considerable give and take and unanimous or near unanimous acceptance of a decision (Butcher, 2002; Freeman, 2002; Susskind, 1999). Powell (2003) reviewed numerous studies and concluded that the failure to address assumptions concerning consensus was a common problem in Delphi studies, with levels ranging from 55% to 100% and in many cases, not mentioned at all.

Sandow (1972) proposed a model for a focus Delphi that emphasized the differences that occur between groups rather than consensus. He did not seem to be familiar with the early history and intent of a Delphi or chose to ignore it.

He did make several interesting points that for educational planning, all stakeholders should be represented rather than choosing "experts". Differences in priorities of each group should be examined, as well as their perceptions of who has the power to bring about change and their reaction to changes. This allows policy makers to plan for resistance that might be encountered and to know the priorities of the different groups that will be affected. He recommended providing the interquartile range (IQR) of each group in each round and the median of all groups. Minority reports should always be included for any Delphi (Scheele, 1975).

Summary of Review of Literature

Changes in graduate science education have been advocated by government and industry sources for many years. In response to this, professional science master’s programs have been developed that emphasize (a) more science than an MBA, (b) more informatics and computation than an MBA or traditional science master’s, (c) more education in professional fields, and (d) closer interaction with employers through experiential education opportunities. These recommended changes, coupled with the growth of the biotechnology industry, have led to the development of a model for a master’s program combining scientific and business knowledge.

The Delphi technique is recommended for program development in emerging fields. It allows the systematic gathering and analysis of expert opinion for a field in which there is no widely accepted curriculum. Use of the Web-based Delphi allows panelists to easily access the survey from any networked computer and simplifies compiling data or providing supplemental materials. The Delphi can be used to develop consensus within a group or to identify issues where there is broad disagreement. A definition of ‘consensus’ should be determined before the study begins.

CHAPTER III

METHODOLOGY

The purpose of this study was to identify stakeholders' priorities in the development of a professional science master's degree in biotechnology. The specific objectives of this study were to identify stakeholders priorities for various aspects of a professional science master's in biotechnology; to identify differences in priorities between subgroups; and to examine user preferences between Web-based and traditional methods of conducting a Delphi study.

A modified Delphi study was designed based on methods recommended by Dalkey and Scheele (Dalkey, 1967, 1969; Scheele, 1975). The Delphi method is recommended for program and curriculum development, particularly in emerging fields where there is no recognized standard for curriculum (Finch & Crunkilton, 1999; Judd, 1972)

The Round 1 instrument consisted of eight open-ended questions (Appendix A). The first question was modified with a list of twelve skills. Panelists were allowed to add or remove skills on the list (Scheele, 1975). Additional issues emerged in Round 1 and were clarified via email exchange with the panelists before continuing to Round 2. Responses were organized into themes in Round 2 and ranked on a continuum. Panelists indicated where their answers fell on the continuum. Round 2.1 was used to clarify emergent issues relating to tracks and goals before continuing to Round 3, where panelists were given the chance to indicate their level of agreement on each item. In Round 4, medians and IQRs from Round 3 were provided for each item and panelists were allowed to reconsider their answer and make additional comments. In Round 5, the last two questions were completed and panelists were asked to evaluate the Delphi process with three open-ended questions.

Description of Sample

The methods used during each round of the Delphi study are reported in chronological order below. Two groups of academic and industry professionals were asked to nominate as many as three experts each to serve on the Delphi panel (Scheele, 1975). The first group was affiliated with an existing professional science master's program, either as an academic or industry advisor. Administrators of other professional science master's programs were also contacted and asked to participate and provide three nominations. We received 33 referrals and contacted them via email (Appendix B) to explain the rationale and design of the study. Of the initial 33, 24 agreed to participate. Purely by chance, 12 of these were from universities and 12 were working in the life science industries.

The list of participants, with information on their titles and affiliations, was submitted to a third party for validation. This person was director of a national biotechnology training project with many years experience working with industry and higher education to prepare students for biotechnology careers.

Description of Survey Instrument

This study used Web-based forms to collect the data. The initial instrument consisted of a password protected sign in page (Appendix A-1), an informed consent form (Appendix A-2), a brief demographic form (Appendix A-3), and a welcome page listing the eight open-ended questions with links to individual pages for each question (Appendix A-4). The programming language used for the interactive web site was Active Server Pages (ASP). All panelists were offered the option of printing out the entire survey and returning it by mail in the first round. No panelist chose to use this alternate method.

Instruments developed for Delphi research are emergent, meaning that the questions for each round are developed from the results of the previous round (Linstone & Turoff, 1975). Dillman's principles of Web survey layout and question design were used and respondents were provided the option of using a Web-based form or printing and returning the survey (Dillman, 2000).

Data Collection Procedures

Preparation

Panelists were provided a pen name at the beginning of the survey so that their answers could be identified while they remained anonymous to each other (Turoff & Hiltz, 1995). All responses were treated as confidential.

Panelists were told that they could discuss the questions with others in order to improve their responses. They were asked to confer with employees, associates or their students, if desired, to form answers for the questions (Scheele, 1975). Panelists were asked to provide their level of confidence in answering each question in the first round (Dalkey et al., 1969). Research has shown that the Delphi process can be improved by using self-ratings of confidence to form subgroups of very confident, confident and unconfident responses. Unexpected information can emerge when results are examined by subgroups such as gender, field of expertise, or other common factors (Dalkey, 1969).

Round 1

Round 1 consisted of eight questions. The first question was modified by providing 12 examples of skills that graduates of the program would be expected to have and asking panelists to delete from or add to the list. The remaining seven questions were open ended and addressed internships, the importance of hands-on experience versus writing the thesis, regional or national focus, entry level positions appropriate for graduates, different roles for the industry advisory board, and minimum hours of laboratory experience that should be expected (Appendix A-4). These questions were chosen based on my years of experience with a professional master's program and the inconsistencies or lack of information in these particular areas, particularly as it applied to an interdisciplinary graduate program.

In Round 1, four panelists expressed the opinion that the program should offer different tracks. An email was sent to all panelists (Appendix C) at the end of Round 1 asking them if two or more tracks should be offered. Those responses were incorporated in the development of Round Two.

Round 2

Results of the initial round and the clarifying email were summarized and returned to the panelists in Round Two (Dalkey, 1967, 1969) (Appendix D). A color coding method was used to identify common themes (Dooley, 1995). In Question 1, panelists were asked to list tracks they thought would be appropriate and indicate whether knowledge, skills and abilities identified in Round 1 should be part of the common core curriculum or included in a track. For Questions 2, 3, 4 and 7, themes emerged and responses were grouped according to theme. These thematic responses were organized into different levels within each theme to form a continuum. Panelists were asked to consider the information provided and determine where their answer fell within this continuum.

In Question 5, responses regarding entry-level positions for graduates of the program revealed that panelists were apparently using different titles for the same position. In response to this, a published list of job titles (Dahms & Bourke, 2001) was provided and panelists were asked to provide additional titles if they were not included on the list. For Question 6, panelists were asked to indicate their level of agreement for the roles identified for the industry advisory board using a five-point Likert scale (Dunn-Rankin, 1983). In Question 8, panelists were given a list of 10 issues from Round 1 and asked to choose those they thought should be considered in this study.

A second issue relating to program goals emerged in Round 2 that required further clarification before continuing on to the third round. This required an additional, brief literature review on use of the Delphi to clarify goals. According to Rutherford (1973), a Goals Delphi should start by asking panelists to suggest objectives, then sorting those objectives into goals in later rounds. Objectives were easier for panelists to identify than more nebulous goals. Goals are usually formed by committees, which typically suppresses conflict and tends only to seek agreement on general issues rather than ironing out specifics (Rutherford, 1973). Good program objectives can be learning objectives or operational objectives and they should be rational, concrete, practical, achievable, and ideally, measurable. Unlike learning or operational objectives, program objectives may or may not be measurable (Caffarella, 1994).

In order to further clarify the issues that emerged relating to separate program tracks and program goals, a brief clarifying round, 2.1, was initiated. Round 2.1 consisted of two questions relating to tracks and program goals. Panelists were given one week to complete it. They were given an open-ended question and asked to list up to five objectives for the program. Each objective was printed on a card and cards were then sorted into themes to identify goals.

Panelists were given a list of the tracks identified in Round 2 and chose those they considered appropriate for the program. Tracks receiving a simple majority of responses were retained for Round 3. Results from this clarifying round, Round 2.1, were combined with results from Round 2 to develop questions for Round 3.

Round 3

In this round, the two emerging issues were combined and added to Question 1 with the data collected on knowledge, skills, and abilities (Appendix E). The question of hands-on experience, originally Question 3, was also added to Question 1 because we believed that it could be affected by the issue of different program tracks. Using a five-point Likert scale, panelists were asked to indicate their level of agreement with each goal on the list, each suggested track, and whether all students, regardless of track, should have hands-on laboratory experience. If they agreed that all students should have hands-on experience, they were asked to indicate how many semesters should be required (Question 3 in Round 1). They were also asked to indicate if hands-on experience should be required for each of the different tracks (Question 7 in Round 1). A text box was provided for additional comments.

Skills were presented in two tables, one listing skills identified as those that should be included in the core curriculum for all students and one listing those skills that were appropriate for specialized tracks, with frequencies from

Round 2 provided. Only those skills that had been chosen by 50% or more of respondents were retained from Round 2. Panelists indicated their level of agreement that each was appropriate for core or track.

For Question 2, different levels on a continuum for the four different themes that emerged for the internship were placed in separate tables and ranked in order by the frequency with which they were chosen by panelists, highest to lowest. Panelists were then asked to rank their choices for each within each theme, starting with ‘1’ as the most desirable choice.

Question 3 addressed national, regional or local focus for the program. Five themes emerged and were listed in order by frequency. Panelists were then asked to rank their choices for each, with “1” as the most desirable choice and “5” the least desirable.

Question 4A listed those entry-level positions that were chosen as most appropriate for recent graduates by 50% or more of respondents. Frequencies for each position were provided and panelists were asked to indicate their level of agreement that the position was appropriate for a new graduate on a five-point Likert scale. Question 4B listed additional titles identified in the previous round and panelists responded “yes”, “no”, or indicated that it was “fundamentally the same” as a title listed in Part A.

For Question 5, medians and IQRs from Round 2 were provided and panelists had the opportunity to consider their previous response, make any changes they chose, and provide additional comments. For Question 6, only one issue was carried forward from the previous round. Panelists were asked to discuss possible innovations in curriculum and teaching for professional programs.

Round 4

In this round, medians, interquartile ranges (IQR), comments and each panelist's response from the previous round were provided as feedback (Dalkey, 1967, 1969) (Appendix F). Panelists were allowed the opportunity to reconsider their answer and make additional comments.

Round 5

Hands-on experience for all students and suggested entry-level positions were the only questions requiring further discussion in Round 5 (Appendix G). Medians, IQRs, comments and responses from the previous round were provided and panelists were allowed the chance to reconsider their answer.

The panelists were asked open-ended questions regarding their choice of the paper or Web-based version of the Delphi and allowed to respond by email or traditional mail. Three questions were asked:

1. Why did you choose this format (paper version or Web-based)?
2. How useful do you think this Delphi process was in designing a new degree program?
3. What recommendations do you have for improving the process?

Data Analysis

Descriptive statistics for each round were computed using SPSS 11.0. Subgroups were identified and analyzed based on affiliation (industry or academic) and level of confidence in their answer. Those persons indicating a confidence level of 4 or 5 on each question were considered "high" and treated as a subgroup. Consensus was considered to be achieved if no one chose "disagree strongly" on the Likert scale. The SPSS features Frequencies and Descriptives were used to calculate frequencies, medians, IQR and variability of the variables, including bar graphs. Boxplots were generated to visualize all results.

The Crosstabs feature was used to calculate Pearson's Chi square and Fisher's Exact for comparison of industry versus academic preferences. One-Way Analysis of Variance was performed to compare means between panelists having a high level of confidence in their answers and the group as a whole, with an alpha level of $p<.10$. We believed this was appropriate given that this was an exploratory study with a small sample size.

Summary of Research Procedure

This study identified stakeholders' priorities in the development of curriculum and a program of study appropriate for a professional science master's degree in biotechnology. It identified differences in priorities between subgroups; and examined user preferences between Web-based and traditional methods of conducting a Delphi study. Panelists were chosen using a snowball technique. Twenty-four participated in the first round, but numbers varied in subsequent rounds.

A modified Delphi study began with one modified question and seven open-ended questions. The modified question had a list of 12 skills gleaned from the numerous sources. Panelists were allowed to add or remove skills on the list.

Issues emerged in Round 1 concerning different tracks and were clarified via email exchange with the panelists before continuing to Round 2. Responses were organized into themes in Round 2 and ranked on a continuum. Panelists indicated where their answers fell on the continuum. Round 2.1, lasting one week, was used to clarify both issues before continuing to Round 3. Panelists were given the chance to indicate level of agreement on each item in Round 3, using a five-point Likert scale. In Round 4, medians and IQRs from the previous round were provided for each item and panelists were allowed to reconsider their answer and make additional comments. In Round 5, the last two questions were completed and panelists were asked to evaluate the Delphi process with three open-ended questions.

For this study, consensus was defined as no item receiving ‘disagree strongly’ from any panelist. SSPS 11.0 was used for data analysis. Frequencies, percentiles, medians, and IQRs were used for initial data analysis. Pearson’s

Chi Square, Fisher's Exact and One-Way Analysis of Variance were used to analyze differences between groups.

CHAPTER IV

RESULTS

The primary purpose of this research was to develop a model for a professional science master's program combining biotechnology and business. The objectives were to (a) identify stakeholder preferences for various dimensions of a professional science master's combining biotechnology and business and (b) to identify differences in priorities between subgroups. A secondary purpose was to examine user preferences between Web-based and traditional methods of conducting a Delphi study and their impressions of its usefulness for program development.

Prior to the first round, demographic data was collected on panelists regarding their gender, age, years experience in their current field, position title and education levels. Round 1 started with eight open-ended questions designed to investigate (a) learning objectives, (b) internships, (c) thesis vs. non-thesis, (d) program focus (e) possible entry level positions, (f) roles for the industry advisory board, (g) recommended hours of hands-on experience and (h) other issues. The final round ended with three questions to assess the panelists' perception of the usefulness of the Delphi for program development in higher education.

Further analysis was done to determine if there were significant differences in priorities of academic and industry panelists. An a priori probability level of 0.10 was chosen because of the small sample size and the exploratory nature of the study. Significant differences occurred between groups for two tracks, six skills designated for tracks, the method of evaluation, and three entry level positions.

Results were analyzed to determine if there were significant differences based on panelists' level of confidence in their responses using a one way ANOVA. Again, an a priori probability level of 0.10 was chosen because of the small sample size and the exploratory nature of the study. Significant differences occurred for (a) the number of semesters of hands-on experience recommended, (b) one skill recommended for core curriculum, (c) eight skills recommended for tracks, (e) compensation level, and (d) positions appropriate for new graduates.

Each of the questions will be addressed in the order listed, following each question through the entire Delphi process. Only those items which were found to be significantly different for the analysis between industry and academic subgroups and/or high and low confidence levels are provided in tables.

At the beginning of Rounds 3, 4 and 5, panelists were provided with a definition of consensus. For the purposes of this study, any item not receiving a rating of “disagree strongly” would be considered a consensus item.

Demographics of Responding Sample

Using a snowball technique (Lincoln & Guba, 1985), thirty-three referrals were gathered and from this list, twenty-four agreed to participate (Linstone & Turoff, 1975) (Table 1). The original panel consisted of 12 faculty, some in administrative positions associated with professional master's programs, and 12 members in management positions in the life science industries. The panelists ranged in age from 28 to 66 years. They averaged 20 years experience in their field, ranging from a low of 4 years to a high of 38 years. There were 9 females and 15 males that agreed initially to participate in the study.

Participation varied on each round. Twenty-four panelists started Round 1, but one withdrew midway through the first round and did not participate in subsequent rounds. Seventeen panelists participated in Round 2, 15 in 2.1, 14 in Round 3, 11 in Round 4 and 13 panelists in Round 5. Reasons for nonparticipation varied during the 10 months of the study due to schedules being conflicted by end of semester workloads, between semester breaks, summer vacations, travel out of the country, and many other reasons.

When looking at the highest degree achieved by panel members, there were 11 with Ph.D.s in science, 2 with Ph.D.s in business, 1 with a Ph.D. in higher education, 3 with Master of Science degree, 3 with MBAs, and 3 with a B.A. or B.S. degree. All three MBAs had undergraduate degrees in science. Science disciplines represented were biochemistry, genetics, physics, mathematics, molecular and cellular biology, ecology, wildlife biology, plant biology, plant physiology, plant pathology, chemistry, and biology. They resided in California, Texas, Michigan, Pennsylvania, New York, District of Columbia, Arizona, New Jersey, and Minnesota.

Table 1

Demographics of Delphi panel.

Title	Education	Years Exp	Gender	Rounds Completed	Industry-Academic
Sales Manager	B.S. Chemistry Penn State Univ, M.S. Chemistry UCLA, Certificate in Human Resources Loyola Marymount	4	F	1,2,2.1,4,5	I
Director, Assoc. Professor	B.S. Biochemistry TAMU, M.S. Molecular Cell Biology UT-Dallas, Ph.D. Molecular Cell Biology UT-Dallas	7	F	1	A
Research Professor	B.S. Biology, M.A. Biology, M.S. MIS, Ph.D. Plant Pathology	10	F	All	A
Principal Consultant/ President	B.S. Wildlife Biology, Texas A&M University	13	F	1,2,5	I
Director	B.S. Biology (magna cum laude), M.S. Biology, Ph.D. from the Ecology Program	15	F	All	I
President	B.S. Biology, Texas Wesleyan University, M.S. Biology (Human Genetics), University of North Texas	18	F	1,2,2.1,3,5	I

Table 1 continued.

Title	Education	Years Exp	Gender	Rounds Completed	Industry-Academic
Plant Biotechnologist	B.A. Sociology, University of Oklahoma, M.S. Botany, Oklahoma State University, Ph.D. Plant Biology, Washington University in St. Louis	20	F	1,2,2.1,3,4	I
Author Consultant	B.A. history and literature, M.A. history, Eight honorary doctorates	25	F	1,2.1	A
Professor of Education	B.A. English, M.A. Media Ecology, Ph.D. Higher Education	33	F	1,2,2.1,3	A
District Manager / Managing Director	B.S. Chemistry	7	M	1,2,2.1,3,5	I
Director, Corporate Liaison	B.A. Chemistry, Albion College, Ph.D. Physical Chemistry, Kansas University	8	M	All	A
Senior Scholar in Residence	B.A. Chemistry, M.S. Physical Chemistry, Ph.D. Physical Chemistry	12	M	All	A
President & CEO	B.A. Physics, MBA	12	M	1	I
Associate Professor	B.S. Biology, Ph.D. Biology	22	M	1,2,3,4	A
President	B.S., M.S., MBA	23	M	1,2,2.1,5	I

Table 1 continued.

Title	Education	Years Exp	Gender	Rounds Completed	Industry-Academic
Biotechnology Consultant Principal	B.S., Biology; M.Sc., Biology, Molecular Genetics; Executive MBA (currently enrolled)	23	M	1	I
Director, Quality Systems	B.S. Microbial Genetics - U. Mass-Amherst	25	M	1,2,2.1,3,4	I
CTO	B.A. Chemistry, Ph.D. Biochemistry	25	M	1,2,3,4,5	I
CEO	B.S. Zoology, M.S. Biochemistry	26	M	All	I
Executive Director	Ph.D.	31	M	1	A
Director	B.A. Mathematics Millersville University Ph.D. Management	32	M	All	A
Professor of Management	B.S. in economics, Kent State University, MBA Kent State University, Ph.D. in management, University of Washington	34	M	1	A
Research Director	B.S. Forestry Iowa State University, M.S. Soil Science University of Wisconsin, Ph.D. Plant Physiology University of Wisconsin	37	M	1,2,2.1,3,5	A
Professor of Mathematics	B.Sc. Ohio State University (Mathematics), M.Sc. Ohio State University (Mathematics), Ph.D. University of Michigan (Mathematics)	38	M	1	A

Stakeholder Priorities for a Professional Science Master's Program

Knowledge, Skills and Abilities

Panelists were asked to list the knowledge, skills or abilities expected of graduates of a professional science master's program combining biotechnology and business. They were given an initial list of twelve skills gleaned from the literature and an industry advisory board for a biotechnology program (Chang, 1999; Howard, 1999; McGrath, 1999; Moyer, 1999, personal communication; National Academy of Sciences, 1995) and asked to add to or delete from that list.

An issue emerged in Round 1 that significantly influenced the design of the questions in subsequent rounds. In comments, five panelists suggested that the program should have tracks. A follow up email to all panelists resulted in responses from eighteen. Fifteen agreed that the program should have at least two tracks emphasizing alternative curricular areas. In Round 2, panelists were asked to suggest tracks that would be appropriate. Eighteen panelists responded in Round 2, identifying twenty-three different tracks (Table 2).

Table 2

Suggested tracks.

Suggested Track	Frequency
Manufacturing	7
Science	6
Preclinical and Clinical Development	6
Business Development	4
Regulatory	4
Drug Discovery	4
Management	4
Marketing	3
Product development	3
Lab Management	3
General Business	2
Quality Assurance	2
Operational Management	1
Intellectual Property	1
Entrepreneurship	1
Pharmacological Economics	1
Bioinformatics	1
Forensics	1
Technology transfer	1

Table 2 continued.

Suggested Track	Frequency
Human factors	1
Project management	1
Financial analysis	1
Discovery technologies	1

Round 2.1, lasting one week, was designed to further address the tracks issue in order to develop questions for Round 3. In Round 2.1, panelists were asked to evaluate each suggested track and indicate if it should be maintained as a track, combined with another track or was not appropriate for the program. Four tracks received a simple majority from the 15 respondents (Table 3).

Four respondents indicated that the science track was too general and should be more specialized, so in subsequent rounds “science” was divided into molecular biology, biochemistry and cellular biology. We chose these disciplines because, realistically, science at the university is categorized by discipline and department and these are most relevant to biotechnology. In Round 3, two panelists commented that this was too discipline specific and that classes from each of the disciplines should be combined to form a track more appropriate for industry. Medians, IQR and an indication of consensus are in Table 3.

Table 3

Tracks recommended for a professional science master's program.

Track	Freq	Median R3	IQR R3	Median R4	IQR R4
Preclinical/Clinical Development	10	1.00	1.00-2.00	1.00	1.00-2.00
Manufacturing	9	1.50	1.00-2.25	1.00	1.00-2.00
Business Development	8	1.50	1.00-3.00	1.00	1.00-2.00
Molecular biology*	8 (Science)	1.00	1.00-2.25	2.00	1.00-2.00
Biochemistry*		2.00	1.00-3.00	2.00	1.00-3.00
Cell biology*		2.00	1.00-3.00	2.00	2.00-3.00

Note: Scale used was 1=Agree strongly and 5=Disagree strongly. Consensus was not reached on items marked with *.

When results of the academic and industry subgroups were compared, tabulated values were significantly different from expected values for the Preclinical/Clinical track and the Business Development track (Table 4). More industry panelists chose "agree strongly" than "agree" that Preclinical/Clinical Development and Business Development should be tracks. More academic panelists chose "agree" than "agree strongly".

Table 4

Actual and expected counts of level of agreement of faculty and industry panelists for a preclinical/clinical development and business development track.

Preclinical/Clinical Research Track		**Level of Agreement**			***df***	***X^2***	***p***
		1	2				
Academic	O	1	3*		1	4.055	.088[b]
	E	2.5	1.5				
Industry	O	6*	1				
	E	4.5	2.5				
Business Development							
Academic	O	0	2*	2*	2	8.119	.017[a]
	E	2.2	1.1	.7			
Industry	O	6*	1	0			
	E	3.8	1.9	1.3			

Note: The scale used was 1=agree strongly and 5=disagree strongly. a = Pearson Chi Square and b = Fisher's Exact. E=expected frequencies. O=observed frequencies.

*p<0.10.

In Round 1, 116 different skills were identified (Appendix H). In Round 2, panelists were asked to evaluate each skill and indicate if it should be part of core curriculum for all students or a specialized track. If a competency was not appropriate for core or track or was outside a person's area of expertise, they were asked to leave it blank. Skills were categorized based on a simple majority of 50% or higher. If they received less than 50%, they were not carried to the next round. Forty skills were categorized as core curriculum, 52 as appropriate for tracks and 23 were dropped because they did not have a simple majority. "Basic finance" was an exact tie between track and core, so was not carried forward since it did not have a clear majority.

In Round 3, panelists were asked to indicate their level of agreement on a five-point Likert scale for the different tracks, skills designated for core curriculum and skills designated for tracks. In Round 4, panelists were given their response from Round 3, the median and IQR and asked to indicate their choice a second time, using the same five-point scale. If their response in Round 4 was outside the IQR, they were asked to give an explanation. Any item which did not receive a "Strongly disagree (5)" was considered to have reached consensus.

In Table 5, core skills are listed with frequencies, final medians and IQR and an indication of consensus. They are ordered first by frequency, then by final median. Critical thinking, problem solving and a variety of skills related to competency in communication received a ranking of 1 (agree strongly).

Table 5

Skills identified for core curriculum for all students.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Critical thinking skills	17	1.00	1.00	1.00	1.00
Present findings with PowerPoint type presentation	17	1.00	1.00-2.00	1.00	1.00-2.00
Time management	17	2.00	1.00-2.25	2.00	1.50-2.00
Writing on, speaking about and presenting technical material to a variety of audiences with varying levels of knowledge in the field	16	1.00	1.00	1.00	1.00
Problem solving skills	16	1.00	1.00	1.00	1.00
Interpersonal skills-ability to work with diverse cross-section of people	16	1.00	1.00-2.00	1.00	1.00-2.00
Ethics of research and business	16	1.00	1.00-2.00	2.00	1.00-2.00
Teamwork in scientific investigation	14	2.00	1.00-2.25	1.00	1.00-2.00
Working on teams with professionals who are not trained in biology or biotechnology	14	2.00	1.00-3.00	1.50	1.00-2.25
Scientific and technical writing	13	1.00	1.00-2.00	2.00	1.00-2.00

Table 5 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Writing brief trip reports	13	1.50	1.00-2.00	2.00	1.00-2.00
Resume writing	13*	2.00	1.75-3.00	2.00	2.00-3.00
How biotechnology is used in different fields-agriculture, environmental, human health, etc.	13	2.00	1.75-3.00	2.00	2.00-3.00
Intellectual property issues	13	2.00	1.00-2.00	2.00	1.00-2.00
Understanding drug discovery & development	13	2.00	1.00-3.00	2.00	1.00-3.00
Survey of biotechnology industry	13*	3.00	2.00-3.00	3.00	2.00-3.00
Understanding other people's research	12	2.00	2.00-3.00	2.00	2.00-3.00
Understand value and role of corporate culture	12	2.00	2.00-3.00	2.00	2.00-3.00
Laboratory safety	12	2.00	1.00-3.00	2.50	1.75-3.00
Work both as an individual and as a productive member of a research team	12	2.50	1.00-3.00	3.00	1.00-3.00
Interviewing skills	12*	2.00	1.00-3.50	3.00	2.00-4.00
Keeping laboratory notebooks	12	2.50	2.00-3.00	3.00	2.00-3.00

Table 5 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Literature review skills	11	2.00	1.00-3.00	2.00	1.00-2.25
Eagerness to adapt to new directions	11*	2.00	1.75-3.00	2.00	2.00-3.00
Awareness of history, current state and direction of the field	11	2.00	1.75-3.00	2.00	2.00-3.00
Chemical safety	11	2.00	1.00-3.00	2.00	1.00-3.00
Radiation safety	11	2.00	1.00-3.00	3.00	2.00-3.00
Preparing an abstract for a meeting	10*	1.50	1.00-2.00	1.00	1.00-2.00
Interpretation of scientific literature	10	1.50	1.00-2.25	2.00	1.00-3.00
Reading a balance statement	10	2.00	1.50-3.00	2.00	2.00-3.00
Knowledge of gene expression	10	2.00	1.00-3.00	2.00	1.00-3.00
Federal regulatory process	10	2.00	1.00-2.00	2.00	1.00-2.00

Table 5 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Proposal writing	10	2.50	1.00-3.00	3.00	2.00-3.00
Trouble shooting	9	2.00	1.75-3.00	2.00	2.00-3.00
How to read a profit and loss statement	9	2.00	1.00-3.00	2.00	1.00-3.00
Good Laboratory Practice (GLP)	9	2.00	1.00-2.00	2.00	1.00-2.00
Good Manufacturing Practice (GMP)	9	2.00	1.75-2.25	2.00	1.00-2.00
Basic Information Technology (IT) and MIS needs for biotech companies	9*	2.00	2.00-3.00	2.00	1.00-3.00
Knowledge of clinical trials process	9	2.00	1.50-2.50	2.00	2.00
Present a business plan for a biotechnology company	9	3.00	1.75-3.00	3.00	2.00-3.00

Note: The scale used was 1=agree strongly and 5=disagree strongly. Consensus was not reached on items marked with *.

Only one skill was significantly different when compared by confidence level. Respondents who indicated a high level of confidence in their response for including knowledge of gene expression in core curriculum were significantly different from respondents indicating a low level of confidence (Table 6). The group of respondents with a high confidence level had a mean score of 2.43. The group with a low confidence level had a mean of 1.33.

Table 6

One-way analysis of variance comparing high and low confidence level groups for skills that should be included in core curriculum.

Item	Confidence Level	Mean	*df*	*F*	*p*
Knowledge of gene expression	Low High	1.33 2.43	1	2.519	.064*

Note: The scale used was 1=agree strongly and 5=disagree strongly.

*p<0.10

There were no significant differences observed between industry and academic groups in skills designated for core curriculum. ‘Agree strongly’ was unanimously chosen by all panelists for ‘Critical Thinking’ and as a result, there were no Chi Square values.

Panelists were asked to indicate which skills were appropriate for specialized track, rather than core curriculum. However, they were not asked to sort those skills out into particular tracks because that would have complicated this study far beyond what was originally intended. In Table 7, skills identified as appropriate for tracks are listed with frequencies, final median and IQR and an indication of consensus. They are ordered first by frequency, then by final median.

Table 7
Skills identified as appropriate for specialized tracks.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Product development	15	2.00	1.25-3.00	2.00	1.00-3.00
Sales skills	15	2.00	1.00-3.00	3.00	1.00-3.00
Clinical testing	13	2.00	1.00-2.50	2.00	1.75-2.00
Developing partnerships	13	2.00	1.00-3.50	2.00	1.00-3.00
Marketing	13*	2.00	1.00-3.00	2.00	1.00-2.25
Medical writing	13	2.00	1.00-2.50	2.00	1.00-2.00

Table 7 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Preclinical testing	13	2.00	1.00-2.00	2.00	1.00-2.00
Human Factors testing	13	2.00	1.00-3.00	2.50	1.00-3.00
Acquiring funding for biotech companies	13	2.00	1.25-3.00	3.00	1.00-3.00
Conducting market research	13*	3.00	1.00-4.00	3.00	2.00-4.00
Good Clinical Practice (GCP)	12	2.00	1.00-3.00	1.00	1.00-2.00
Contract law	12	1.00	1.00-2.50	1.50	1.00-2.75
Good Tissue Practice (GTP)	12	2.00	1.00-2.00	2.00	1.00-2.00
Poly(A) RNA isolation	12	2.00	1.00-3.00	2.00	2.00-3.00
Transfection	12	2.00	1.00-3.75	2.00	2.00-3.00

Table 7 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Know about medical devices under development	12	2.50	2.00-3.00	2.50	2.00-3.00
Facility design and engineering (*Basic understanding of HVAC, water systems, facility layout and design)	12	2.00	1.00-4.00	3.00	1.25-4.00
Know about current drugs under development	12	3.00	2.00-3.00	3.00	1.75-3.00
In vitro translation	11	2.00	1.00-2.75	2.00	2.00
In-vitro transcription	11	2.00	1.25-2.75	2.00	1.00-2.00
ISO 9000	11	2.00	1.00-3.00	2.00	1.00-3.00
Microeconomics of a firm	11*	2.00	1.00-4.00	2.00	1.00-4.00
Quality Assurance	11	2.00	1.50-3.00	2.00	1.00-3.00
Site directed mutagenesis techniques	11	2.00	1.00-3.00	2.00	1.00-3.00

Table 7 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Points to Consider documents	11	3.00	1.25-3.00	3.00	1.00-3.00
Tissue and organ replacement	11	2.50	1.00-4.00	3.00	3.00-4.00
Understanding venture capital process	11*	2.00	1.00-3.00	3.00	2.00-3.00
21CFRx00	10	2.00	1.00-3.00	2.00	1.00-2.50
Basic accounting principles	10	2.00	1.00-3.00	2.00	1.00-2.50
Biostatistics	10	2.00	1.00-3.00	2.00	1.00-3.00
Biotechnology market knowledge	10	2.00	1.00-3.00	2.00	2.00-3.00
Cell therapies	10	2.00	1.00-3.75	2.00	2.00-3.00
Experimental design	10	2.00	1.00-3.00	2.00	1.00-2.00
How to write a business plan	10*	2.00	1.00-3.00	2.00	1.00-3.00

Table 7 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
In situ hybridization	10	2.00	1.25-3.00	2.00	1.00-3.00
Microbial screening	10	2.00	1.00-3.00	2.00	2.00-3.00
Non-isotopic labeling techniques	10	2.50	1.25-3.00	2.00	2.00-3.00
Project management	10*	2.00	1.50-3.50	2.00	2.00-2.75
Proteomics	10	2.00	1.25-2.00	2.00	1.00-2.00
RNA amplification	10	2.00	1.00-2.00	2.00	1.00-2.00
RNA isolation	10	1.50	1.00-2.00	2.00	1.00-2.00
Use of bacteria	10*	2.00	1.00-3.00	2.50	1.00-3.00
National and International Scope of Interest	10	2.50	2.00-3.75	3.00	2.00-4.00
Transformation	10*	2.00	1.00-3.75	3.00	1.75-3.00
Bioinformatics	9	2.00	1.00-3.00	2.00	1.00-3.00
cDNA library construction	9	2.00	1.00-2.00	2.00	2.00
PCR-Real time	9	2.00	1.00-2.75	2.00	1.00-2.00

Table 7 continued.

Skill	Freq	Median R3	IQR R3	Median R4	IQR R4
Reverse transcription	9	2.00	1.00-2.00	2.00	1.00-2.00
Risk management	9	2.00	1.00-3.50	2.00	1.75-2.25
SDS-PAGE	9*	2.00	1.00-3.00	2.00	1.00-3.00
Viral and non-viral gene therapy	9	2.00	1.00-2.75	2.00	1.00-2.00
Guidance documents	9	2.50	1.00-3.00	2.50	1.00-3.00

Note: Consensus was not reached on items marked with *.

Tabulated values were significantly different from expected values for six skills designated as appropriate for curriculum for tracks. Only those items that were significantly different are included in Table 8. In general, industry panelists agreed more strongly that these skills should be in tracks. In particular, industry panelists chose ‘agree strongly’ or ‘agree’ for ‘Conducting market research’, but academic panelists chose ‘disagree’ or ‘disagree strongly’.

Table 8

Actual and expected frequency counts for level of agreement between faculty and industry subgroups for six skills designated for tracks.

		Level of Agreement					*df*	*Value*	*p*
Experimental Design		1	2	3	4	5			
Academic	O	0	4*	1*	-	-			
	E	1.8	2.7	.5	-	-	2	5.622	.060[a]
Industry	O	4*	2	0	-	-			
	E	2.2	3.3	.5	-	-			
How to write a business plan									
Academic	O	0	3*	1	-	1			
	E	2	1.5	1.0	-	.5	3	8.000	.046[a]
Industry	O	4*	0	1	-	0			
	E	2.0	1.5	1.0	-	.5			
Conducting Market Research									
Academic	O	0	0	1	3*	1*			
	E	.9	1.4	.9	1.4	.5	4	8.983	.062[a]
Industry	O	2*	3*	1	0	0			
	E	1.1	1.6	1.1	1.6	.5			
In situ Hybridization									
Academic	O	1	0	4*	-	-			
	E	1.8	.9	2.3	-	-	2	4.748	.093[a]
Industry	O	3*	2*	1	-	-			
	E	2.2	1.1	2.7	-	-			

Table 8 continued.

		Level of Agreement					*df*	*Value*	*p*
SDS-PAGE		1	2	3	4	5			
Academic	O	0	3*	2*	-	0	3	8.311	.040[a]
	E	1.8	1.4	1.4	-	.5			
Industry	O	4*	0	1	-	1*			
	E	2.2	1.6	1.6	-	.5			
Quality Assurance									
Academic	O	0	3*	2*	-	-	2	6.967	.031[a]
	E	1.8	1.4	1.8	-	-			
Industry	O	4*	0	2	-	-			
	E	2.2	1.6	2.2	-	-			

Note: Scale used was 1=agree strongly and 5=disagree strongly. a= Pearson Chi Square and b= Fisher's Exact. E=expected frequencies. O=observed frequencies.

*p<0.10

The level of agreement of respondents with a high level of confidence in their response for skills that should be included in curriculum for different tracks was significantly different from that of respondents indicating a low level of confidence for eight skills (Table 9).

Table 9

One-way analysis of variance to compare means for high and low confidence groups for skills that should be included in different tracks.

Item	Confidence Level	Mean	*df*	*F*	*p*
Product development	Low High	2.67 1.71	1	3.721	.090
Basic accounting principles	Low High	1.00 2.14	1	4.978	.061
Microeconomics of a firm	Low High	1.33 3.13	1	4.056	.075
SDS-PAGE	Low High	3.67 1.63	1	12.512	.006
Transformation	Low High	3.67 2.14	1	5.185	.052
Use of bacteria	Low High	4.00 1.88	1	6.513	.034
ISO 9000	Low High	3.00 1.75	1	5.579	.042
Quality assurance	Low High	3.00 1.63	1	9.581	.013

Note: The scale used was 1=agree strongly and 5=disagree strongly.

$p<0.10$

Skills that did not receive a majority for core or track in Round 3 were analyzed to determine if there were any significant differences between industry and academic panelists in how those skills were designated. There were significant differences in 13 laboratory skills-agarose gel electrophoresis, automated sequencing, Northern blot, Southern blot, Western blot, cloning genes, DNA isolation, DNA sequencing, microarrays, making reagents, polyacrylamide gel electrophoresis, polymerase chain reaction (PCR), and tissue culture. Panelists were asked to choose 'blank' if they thought the skill was outside their expertise or if it should be eliminated from the program. Summarized frequencies for blank, track and core are in Table 10.

Table 10

Summary of frequencies for thirteen laboratory skills eliminated from skills list because they lacked a majority.

	Academic			**Industry**		
	Blank	**Track**	**Core**	**Blank**	**Track**	**Core**
Combined frequencies for thirteen laboratory skills	66	27	11	11	61	58

Dimensions of the Internship

In the first round, panelists were asked to describe the ideal internship. Four themes emerged-length of internship, level of responsibility, level of compensation and the method for evaluating the internship.

Length of internship. The length of time identified initially varied from one month to one year. For Round Two, responses were categorized as 0-3 months, 4-6 months and over 6 months. Responses representative of each group were provided. Panelists were asked to consider each group of responses and indicate which best reflected their choice.

In Round 3, frequencies for each category were provided and panelists were asked to rank them, with 1 being the most desirable choice and 3 the least desirable. Results from that round indicated that 0-3 months, or one semester, was ranked first with a median of 1.0.

In Round 4, panelists were given medians, IQRs and their response from the previous round. Panelists were asked to consider results and confirm or change their response. If their response was outside the IQR and they chose not to change it, they were asked to explain their choice. The rankings changed after this round and 4-6 months (two semesters) emerged as most desirable with a median of 1.50 (Table 11).

Table 11

Recommended length of internship.

Length of Internship	Freq Round 2	Median R3	IQR R3	Median R4	IQR R4
4-6 months (2 semesters)	5	2.00	1.00-2.00	1.50	1.00-2.00
0-3 months (1 semester)	6	1.00	1.00-3.00	2.00	1.00-3.00
7-12 months (1 summer + 1 semester up to1 year)	6	2.00	2.00-3.00	3.00	1.25-3.00

Note: The scale used was 1=most desirable and 3=least desirable.

***Level of responsibility*.** The level of responsibility identified initially varied from apprentice level to just below that of an entry level employee. For Round 2, responses were categorized as low level (apprentice), moderate level and high level (just below entry level). Responses representative of the responses for each category were provided. Panelists were asked to consider each group of responses and indicate which best reflected their choice.

In Round 3, frequencies for each category were provided and panelists were asked to rank them, with ‘1’ being the most desirable choice and ‘3’ the least desirable. Results from that round indicated that a high level of responsibility was ranked first with a median of 1.0.

In Round 4, panelists were given medians, IQRs and their response from the previous round. Panelists were asked to consider results and confirm or change their response. If their response was outside the IQR and they chose not to change it, they were asked to explain their choice. The rankings did not change after this round (Table 12).

Table 12

Level of responsibility expected of an intern.

Level of responsibility	Freq Round 2	Median R3	IQR R3	Median R4	IQR R4
High level of responsibility (about a half step below the position that the student would be hired for)	12	1.00	1.00-2.00	1.00	1.00-2.00
Start low (apprentice level) and move to higher level commensurate with intern's personality and abilities and company's policies	4	2.00	1.00-3.00	2.00	1.00-3.00
Moderate level	1	3.00	2.00-3.00	2.50	2.00-3.00

Note: The scale used was 1=most desirable and 3=least desirable.

Evaluation of internship. The methods for evaluating an internship identified in Round 1 varied from verbal evaluation from the internship supervisor to a project comparable to a thesis. For Round 2, responses were categorized as qualitative, quantitative or a combination of the two. Responses representative of the responses for each category were provided. Frequencies were provided for each category. Panelists were asked to consider each group of responses and indicate which best reflected their choice.

Quantitative evaluation was defined as culminating in a written product such as a written report or an evaluation form where students were assigned a numerical score. Qualitative was defined as performance reviews, verbal evaluation or a letter from the supervisor. Panelists were asked to consider each group of responses and indicate which best reflected their choice.

In Round 3, frequencies for each category were provided and panelists were asked to rank them, with ‘1’ being the most desirable choice and ‘3’ the least desirable. Results from that round indicated that a combination of qualitative and quantitative was ranked first with a median of 1.0.

In Round 4, panelists were given medians, IQRs and their response from the previous round. Panelists were asked to consider results and confirm or change their response. If their response was outside the IQR and they chose not to change it, they were asked to explain their choice. The rankings did not change after this round. A combination of qualitative and quantitative evaluation was the most desired choice (Table 13).

Table 13

Methods of evaluating an internship.

Evaluation method	Freq Round 2	Median R3	IQR R3	Median R4	IQR R4
Combination of qualitative and quantitative	7	1.00	1.00-2.00	1.00	1.00
Qualitative only	6	2.00	2.00-3.00	2.00	2.00-3.00
Quantitative only	4	3.00	2.00-3.00	3.00	2.00-3.00

Note: The scale used was 1=most desirable and 3=least desirable.

When differences in academic and industry subgroups were analyzed, tabulated values were significantly different from expected values for ‘Qualitative Evaluation’ and ‘Quantitative Evaluation’. Neither was ranked as ‘most desirable’ by any panelist. ‘Agree strongly’ was unanimously chosen by all panelists for ‘Combination of Qualitative and Quantitative Evaluation’ and as a result, there were no Chi Square statistics. All three are included in Table 14 for comparison.

Table 14

Differences between subgroups for methods of evaluation.

		Level of Agreement					*df*	*Value*	*p*
Qual & Quan Evaluation Combined		1	2	3	4	5			
Academic	O	4	-	-	-	-			
	E	4	-	-	-	-	-	-	No statistics
Industry	O	7	-	-	-	-			
	E	7	-	-	-	-			
Qualitative Evaluation Only									
Academic	O	-	1	4*	-	-			
	E	-	2.9	2.1	-	-	1	5.182	.045[b]
Industry	O	-	6*	1	-	-			
	E	-	4.1	2.9	-	-			
Quantitative Evaluation Only									
Academic	O	-	4*	1	-	-			
	E	-	2.1	2.9	-	-	1	5.182	.045[b]
Industry	O	-	1	6*	-	-			
	E	-	2.9	4.1	-	-			

Note: The scale used was 1=most desirable and 3=least desirable. a=Chi Square and b=Fisher's Exact. E=expected frequencies. O=observed frequencies.

*p<0.10

Level of compensation. The level of compensation identified in Round 1 varied from zero to just below that of an entry-level full-time person in that position. For Round 2, responses were categorized initially as $0-$10/hour, $10-$15/hour and near non-student full time equivalent (FTE). Responses representative of each category were provided. Frequencies for the number of responses in each category were provided and panelists were asked to provide a number for a monthly salary.

As we examined the responses from Round 2, it became apparent that some of the differences in the salary numbers provided could be due to the varying locations of the panelists. In light of this, we revised the question to account for location, cost of living and other factors by creating categories for one-fourth of FTE, one-half of FTE, three-fourths of FTE and full FTE pay levels (Table 15). Panelists were asked to consider each group of responses and indicate which best reflected their choice.

In Round 3, panelists were asked to rank each category, with '1' being the most desirable choice and '5' the least desirable. Results from that round indicated that compensation should be ½ or ¾ of an entry level FTE, with each having a median of 2.0 and IQR of 1.00-3.00.

In Round 4, panelists were given medians, IQRs and their response from the previous round. Panelists were asked to consider results and confirm or change their response. If their response was outside the IQR and they chose not to change it, they were asked to explain their choice. The medians did not change after this round (Table 15) though the IQRs did change slightly. Responses are arranged in order by median.

Table 15

Level of compensation for interns.

Level of Compensation	Median R3	IQR R3	Median R4	IQR R4
Pay should be equal to ½ entry level FTE	2.00	1.00-3.00	2.00	1.00-3.00
Pay should be equal to ¾ entry level FTE	2.00	1.00-3.00	2.00	1.00-2.75
Pay should be equal to ¼ entry level FTE	3.00	2.75-4.00	3.00	3.00-4.00
Pay should be equal to an entry level FTE	4.00	1.00-5.00	4.00	2.25-4.75
0-Internships should not be paid	5.00	4.00-5.00	5.00	5.00

Note: The scale used was 1=most desirable and 5=least desirable.

The level of agreement was significantly different for respondents indicating a high level of confidence in their response for a level of compensation equivalent to a full time employee for interns and that of respondents indicating a low level of confidence (Table 16). However, with only one respondent indicating a low level of confidence, this may not be an accurate comparison.

Table 16

One-way analysis of variance comparing means for high and low confidence groups for full time equivalent level of compensation for interns.

Item	Confidence Level	Mean	*df*	*F*	*p*
FTE (Full time equivalent pay)	Low	1.00	1	4.213	.067
	High	3.73			

Note: Scale used was 1=agree strongly and 5=disagree strongly.

Other factors were mentioned in Round 1 that were not related to these four themes, but that could be important to consider in an internship program. In Round 2, panelists were asked to rank each issue as (1) not important, (2) important but not necessary or (3) important and necessary. In Round 3, panelists were provided their choice and the IQR from the previous round and asked to confirm or change their choice. Medians did not change between rounds and there was only slight variation in IQRs (Table 17).

Table 17

Other factors to consider in an internship program.

Other Factors to Consider	Median R2	IQR R2	Median R3	IQR R3
Working with a company that is familiar with the science master's' curriculum and goals.	2.00	2.00	2.00	2.00
Good supervision provided by the company.	3.00	3.00	3.00	3.00
Both individual and team experiences should be provide during the internship.	2.00	2.00-3.00	2.00	2.00-2.75
The student and the school should evaluate the position each time to be sure it should be continued within the program.	3.00	2.50-3.00	3.00	2.00-3.00

Note: The scale used was 1=not important, 2= important but not necessary and 3=important and necessary.

Hands-on Experience vs. Writing a Thesis

Two themes emerged for this question from the responses in Round 1- emphasis on psychomotor skill development and emphasis on cognitive development, rather than any emphasis on thesis vs. non-thesis. Eighteen out of 24 responses emphasized the need for a learning experience that culminated in some type of written product. Six of those 18 said specifically that the traditional academic thesis was not particularly useful, but that some kind of product such as a research report, case study, or technical document with an industry focus should be required.

In Round 2, responses were grouped as emphasizing psychomotor skills, thesis option or cognitive abilities. Respondents were given frequencies and representative examples of comments from Round 1 for each group and asked to restate their position.

When Round 2 results were analyzed from the viewpoint of experiential education, it was found that all respondents agreed there should be an experiential component with a written product that emphasized critical thinking, organizing information, presenting information, etc. The only point of disagreement seemed to be whether or not all students in the master's program should be required to have hands-on laboratory experience as a component of their graduate program. Given that information, we changed the question in Round 3 to ask if all students in the program, regardless of track, should be required to have hands-on wet laboratory experience, which could be acquired either as an undergraduate before entering the program or during their graduate program. We also asked how many semesters should be required for every student, which could be acquired in their graduate program or as an undergraduate.

In Round 4, panelists were given the median, IQR, their response from the previous round and comments from all panelists. They were then asked to consider their response and make any changes they thought necessary. If their response was outside the IQR, they were asked to provide an explanation to better understand their position. Since no panelists chose “disagree strongly”, this question reached consensus. There was little change between Rounds 3 and 4 (Table 18).

Table 18

Hands-on experience required for all students, regardless of track.

Question	Median R3	IQR R3	Median R4	IQR R4
Hands-on experience for all	1.50	1.00-2.00	1.00	1.00-2.00
Number of semesters	1.00	1.00-2.00	1.00	1.00-2.00

Note: The scale used for ‘hands on experience for all’ was 1=agree strongly and 5=disagree strongly.

When results were analyzed for differences between academic and industry subgroups and level of confidence, only level of confidence was significant. The mean number of semesters recommended for hands-on experience by respondents indicating a high level of confidence in their response was significantly higher than that of respondents indicating a low level of confidence (Table 19).

Table 19

One-way analysis of variance comparing means for high and low confidence level groups for number of semesters of hands-on experience that students should have by graduation.

Item	Confidence Level	Mean	df	F	p
Number of semesters hands-on experience	Low High	1.13 1.75	1	1.042	.030

Focus of Program

Five themes emerged in Round 1-national focus, national overview with tracks to meet student goals, national overview with regional specializations, regional focus and local focus. In Round 2, panelists were given frequencies and representative examples of comments from Round 1 for each theme and asked to choose the group of responses that best stated their position.

In Round 3, the themes were ranked in order from most to least frequent and frequencies were provided. Panelists were asked to rank each program focus, with ‘1’ being the most desirable and ‘5’ being the least desirable.

In Round 4, panelists were given the median, IQR, their response from the previous round and comments and asked to consider their response and make any changes they thought necessary. If their response was outside the IQR, they were asked to provide an explanation to better understand their position. Unfortunately, they were given the wrong scale, so even though there was little change between rounds, the results are not definitive. The scale for Round 4 should have been a ranking of ‘1’ being “most desirable” and ‘5’ being “least desirable”. Mistakenly, panelists were given the scale of ‘1’ being “agree strongly” and ‘5’ being “disagree strongly” (Table 20).

Table 20

Focus of program.

Program Focus	Freq R2	Median R3	IQR R3	Median R4	IQR R4
National overview with tracks to meet student goals	4	1.5	1.00-2.00	1.5	1.00-2.00
National focus	4	2.5	2.00-3.00	2	2.00-3.00
National overview with regional specializations	3	3	1.00-3.00	2	1.00-3.00
Regional emphasis	2	4	4	4	4
Local emphasis	2	5	5	5	5

Entry Level Positions Appropriate for New Graduates

The results of Round 1 indicated that we needed to simplify the question. Panelists were apparently using different titles for very similar positions. We selected an article that listed job titles and degree levels based on research with the biotechnology industry in California (A. S. B. Dahms, J., 2001). We chose 27 titles for master's and bachelor's level with 0-3 years experience and provided those in a table for Round 2. We provided a PDF copy of the article online for panelists to read if they desired. Panelists were asked to choose those titles they agreed with and add any that they felt were not represented by the list. Sixteen titles received a simple majority and 14 additional titles were suggested.

In Round 3, frequencies were provided for each of the original 16 titles and panelists were asked to indicate their level of agreement on a five-point Likert scale. The additional titles were provided in a separate list. Panelists were asked to indicate whether the suggested title was an appropriate entry level position with a simple choice of 'yes' or 'no' and were also given the option to indicate if they thought it was fundamentally the same as a title in the first list.

In Round 4, the original titles were provided ranked in order by median. Panelists were given median, IQR, and their choice from the previous round. They were asked to make any changes they thought necessary based on feedback using the same five-point Likert scale. If their response fell outside the IQR, they were asked to provide an explanation. Results were ranked first by frequency, then by median in the last round (Table 21).

Table 21

Position titles taken from the literature.

Position Title	Freq R2	Median R3	IQR R3	Median R4	IQR R4
Marketing research analyst	16	2.0	1.00-3.00	1.50	1.00-2.00
Business development research analyst	14	2.00	1.00	1.50	1.00-2.75
Research associate	13	1.00	1.00-2.00	1.00	1.00
Manufacturing associate	12	1.00	1.00-2.00	1.00	1.00-1.75
QC analyst	12	2.00	1.00-3.00	1.50	1.00-2.00
QC microbiological	12	2.00	1.00-3.00	2.00	1.00-2.00
Process development associate	11	1.00	1.00-2.00	1.00	1.00-1.75
Clinical data associate	11	1.00	1.00-2.25	1.50	1.00-3.00
Technical service rep	11	2.00	1.00-2.25	1.50	1.00-2.00
Junior position in licensing/tech transfer	11	2.00	1.00-3.00	1.50	1.00-2.00
QA documentation specialist	11	2.00	1.00-3.00	2.00	1.00-2.00
QA documentation coordinator	11	2.00	1.00-3.00	2.00	1.00-3.00
Aseptic fill associate	10	2.00	1.00-3.00	1.50	1.00-2.00

Table 21 continued.

Position Title	Freq R2	Median R3	IQR R3	Median R4	IQR R4
QS technical writer	9	2.00	1.00-3.00	1.00	1.00-2.00
Documentation assistant	9	2.00	1.00-3.00	2.00	1.00-2.75
Product management associate	9	2.00	1.00-3.00	2.00	1.00-3.00

Note: QA is ‘quality assurance’. QC is ‘quality control’.

In Round 4, panelists were given frequencies of ‘yes’ and ‘no’ for the additional titles suggested. The additional titles were ranked in order by the difference between yes and no (N_{yes}-N_{no}) and equivalent titles that were suggested were provided. Panelists were asked to indicate their level of agreement on a five-point Likert scale that the positions were appropriate for a new graduate. No action was taken on the equivalent titles. In Round 5, panelists were given medians, IQRs, and their response from the first round and allowed to make any changes they thought necessary based on the feedback provided. If their response was outside the IQR, they were asked to provide an explanation for their choice. In Table 22, results are organized first by difference (N_{yes}-N_{no}) and then by final median. None received a ranking of ‘agree strongly’.

Table 22

Positions suggested by panelists in addition to those from the literature.

Position Titles	Frequencies R3 Yes	Frequencies R3 No	$N_{yes}-N_{no}$	Median R4	IQR R4	Median R5	IQR R5
Clinical research associate I	12	2	10	2.00	1.00 - 2.25	2.00	2.00 - 3.00
Associate product manager	11	3	8	2.00	1.00 - 3.00	2.00	2.00 - 3.00
Data management coordinator	9	4	5	2.00	2.00 - 3.00	2.00	2.00 - 3.00
Pharmaceutical technical writer	9	4	5	3.00	2.00 - 4.00	2.50	1.25 - 3.75
Document analyst	8	4	4	2.00	1.75 - 3.00	2.00	2.00 - 3.00
Licensing associate	8	5	3	2.00	1.00 - 3.00	2.00	1.50 - 3.00
Application scientist	7	5	2	2.00	1.00 - 2.00	2.00	2.00
Regulatory analyst	7	6	1	2.50	1.00 - 3.00	2.00	2.00 - 3.00
Analytical scientist, knowledge management	7	6	1	2.00	1.75 - 3.25	3.00	2.00 - 3.00
Biological database administrator	7	7	0	4.00	3.50 - 5.00	4.00	2.50 - 4.00
Biotechnology patent writer	4	10	-6	2.50	1.00 - 3.00	3.00	3.00 - 4.00

Table 22 continued.

Position Titles	Frequencies R3 Yes	No	N_{yes} - N_{no}	Median R4	IQR R4	Median R5	IQR R5
Plant quality compliance manager	2	10	-8	4.00	2.00-4.25	4.00	3.00-4.00
Clinical manager, scientific communications	2	11	-9	3.00	2.00-3.00	3.00	3.00-5.00
Sr. knowledge analyst	1	10	-9	4.00	2.00-5.00	4.00	3.00-5.00

Note: The scale used was 1=agree strongly and 5=disagree strongly.

When results were analyzed for differences between subgroups, significant differences occurred for the industry and academic subgroups and for the confidence level subgroups. Industry and academic subgroups differed significantly on three positions. The ‘high confidence level’ subgroup differed significantly on four positions.

For the industry and academic subgroups, tabulated values were significantly different from expected values for ‘manufacturing associate’, ‘clinical data associate’, and ‘QA document coordinator’. These three are included in Table 23 for comparison.

Table 23

Significant differences between industry and academic groups occurred for three positions appropriate for new graduates.

		Level of Agreement					df	Value	p
		1	2	3	4	5			
Manufacturing Associate									
Academic	O	2	3*	-	-	-	1	5.600	.045[b]
	E	3.8	1.3	-	-	-			
Industry	O	7*	0	-	-	-			
	E	5.3	1.8	-	-	-			
Clinical Data Associate									
Academic	O	0	2*	3*	-	-	2	10.000	.007[a]
	E	2.5	1	1.5	-	-			
Industry	O	5*	0	0	-	-			
	E	2.5	1.0	1.5					
QA Document Coordinator									
Academic	O	0	1*	2*	1*	1*	4	8.983	.062[a]
	E	2.3	.9	.9	.3	.3			
Industry	O	5*	1	0	0	0			
	E	2.7	1.1	1.1	.5	.5			

Note: The scale used was 1=agree strongly and 5=disagree strongly. a=Chi Square results and b=Fisher's Exact results. O=observed and E=expected counts.

*$p<0.10$.

Results were analyzed to determine if significant differences occurred between those respondents who had a high level of confidence in their answer and those who did not. 'High confidence level' respondents were significantly closer to "agree strongly" in their responses for four different job titles (Table 24).

Table 24

One-way analysis of variance comparing means for high and low confidence groups for entry level positions appropriate for new graduates.

Item	Confidence Level	Mean	df	F	p
Manufacturing Associate	Low High	1.50 1.00	1	5.000	.049
Clinical Data Associate	Low High	2.33 1.00	1	10.240	.013
QA Document Coordinator	Low High	3.00 1.20	1	7.364	.024
Marketing Research Analyst	Low High	2.17 1.17	1	8.182	.017

Note: The scale used was 1=agree strongly and 5=disagree strongly.

$p<0.10$

Roles for the Industry Advisory Board

Nine roles for an industry advisory board were identified in Round 1. Initially, "Advising on funding" and "Providing funding" were combined. However, we separated them in subsequent rounds due to the observation by three panelists that it was not the role of industry to provide funding. Medians and IQRs changed little between rounds. No panelist chose “disagree strongly”, so all items were in consensus. Frequencies, medians and IQRs are provided (Table 25).

Table 25

Roles identified for the industry advisory board.

Role	Freq R1	Median R 2	IQR R2	Median Round 3	IQR Round 3
Needs assessment & curriculum review	16	1.50	1.00-2.00	2.00	1.00-2.00
Internship development	9	1.00	1.00-2.00	1.00	1.00-2.00
Suggest or provide seminars, team projects, case studies, etc. to supplement faculty teaching	8	2.00	1.00-2.00	2.00	1.00-2.00
Student job placement	6	2.00	2.00	2.00	2.00-3.00
Identifying issues & trends in industry	5	1.50	1.00-2.00	2.00	1.00-2.00
Program evaluation through feedback on success of interns and graduates hired.	4	2.00	1.00-3.00	2.00	2.00-3.00
Establishing university/industry ties	2	2.00	1.00-2.00	1.50	1.00-2.00

Table 25 continued.

Role	Freq R1	Median R 2	IQR R2	Median Round 3	IQR Round 3
Represent a cross-section of industry through diverse membership	2	2.00	1.00-2.00	2.00	1.00-2.00
Advising on private sources of funding	1	2.00	2.00-4.00	2.50	2.00-4.00
Providing private sources of funding	1	2.00	2.00-4.00	2.50	2.00-4.00

Note: The scale used was 1=agree strongly and 5=disagree strongly.

Minimum Hands-on Experience Required for New Graduates

Two themes emerged from Round 1 regarding the minimum amount of hands-on experience that should be required for every new graduate. Some panelists focused on actual clock hours of experience, with responses ranging from zero at the graduate level with students required to have laboratory experience coming in to one year of full-time experience. Other responses focused on outcomes rather than actual hours.

When results from Round 2 were examined, it became evident that the amount of hands-on experience required would be affected by the issue of tracks that had emerged earlier. We combined this question in subsequent rounds with the question identifying specialized tracks. In Round 3, this question was rephrased to ask how much hands-on laboratory experience should be required in each track. Panelists were asked to answer a simple yes or no and if yes, give the number of semesters recommended.

In Round 4, panelists were given frequencies of yes and no for each track. The tracks were ranked in order by the difference between yes and no (N_{yes}-N_{no}) and the mean number of semesters suggested for each track was provided. Panelists were asked to indicate their level of agreement on a five-point Likert scale for the amount of hands-on experience required for each track. In Round 5, panelists were given medians, IQRs, and their response from the first round and allowed to make any changes they thought necessary based on the feedback provided. If their response was outside the IQR, they were asked to provide an explanation for their choice. In Table 26, results are organized first by N_{yes}-N_{no}, then by final median and IQR.

Table 26

Minimum semesters of hands-on experience that should be required of all students.

Track	N_{yes}-N_{no}	# Sem	Median R4	IQR R4	Median R5	IQR R5
Science	14	3	2.00	1.00-3.00	2.00	1.00-2.50
Preclinical/Clinical Development	10	2	2.50	1.00-3.00	2.00	1.50-3.00
Manufacturing	7	2	2.50	1.00-3.75	2.00	2.00-3.00
Business Development	2	1	2.00	2.00-4.00	2.00	2.00-3.50

Note: The scale used was 1=agree strongly and 5=disagree strongly.

Other Issues

In the first round, panelists were asked to list other issues they thought should be considered in this study. Ten issues were identified. In Round 2, panelists were asked to choose the issues they thought should be included in this study. Two issues received a simple majority. Twelve of 18 panelists said that the goals of the program should be clarified in this study and nine selected teaching innovations.

We decided to address goals in Round 2.1 before we developed the questions for Round 3 because of the effect it could have on all the questions in the study, particularly tracks and skills. A scenario (Appendix I) was provided and panelists were asked to state up to five objectives for the program, which were sorted into goals for Round 3. Five goals emerged as a result of Round 2.1 (Table 27).

Many people emphasized specific industry knowledge and skills for goals. However, no one topic or discipline predominated. Because of that, we decided to classify them under one goal (Goal 5) that emphasized a broad range of industry topics.

In Round 3, panelists were asked to indicate their level of agreement on a five-point Likert scale for each goal. Medians and IQR were calculated for each. In Round 4, panelists were given their response from Round 3, the median and IQR and asked to indicate their choice a second time, using the same five-point scale. If their response in Round 4 was outside the IQR, they were asked to explain their response.

Table 27

Goals identified by Delphi panel.

Goal	Median R3	IQR R3	Median R4	IQR R4
Students will demonstrate mastery of written and oral communication skills [literature review, writing in a variety of business and scientific formats, oral presentations supported by visual aids for technical and nontechnical audiences, communication for interpersonal and supervisory situations.]	1.00	1.00-2.00	1.00	1.00-1.25
Students will participate in experiential learning opportunities that focus on working in the industry environment, including at least one internship in an industry setting.	1.00	1.00-2.00	1.00	1.00-2.00
Students will demonstrate mastery in the theories and techniques of a scientific discipline basic to the biotechnology industry [molecular biology, biochemistry, cell biology].	1.00	1.00-2.00	1.00	1.00-2.00
Students will have a functional understanding of basic business principles in: 1. Marketing 2. Finance 3. Accounting 4. Management 5. Project management	1.50	1.00-2.00	2.00	1.00-2.00
Students will have knowledge of the current issues and trends that are important to the biotechnology industry and important to their success in the industry.	2.00	1.00-2.00	2.00	1.00-2.00

Note: The scale used was 1=agree strongly and 5=disagree strongly.

We asked panelists to make recommendations for the second issue, teaching innovations, but only four responded. Those comments are listed in Table 28. We did not go further into this issue due to limits of time and the lack of response in Round 3.

Table 28

Comments made in response to recommendations for teaching innovation.

Industry/ Academic	Comment
A	“Develop a cross-disciplinary course with business students where students work in teams to analyze and evaluate businesses.”
I	“This is not a good area for me to comment on. However, I feel strongly that whatever methods are utilized, they should teach the most relevant information available to meet the industry needs. Therefore, the fingers of the program should be on the pulse of the industry, preferably through the knowledge of the advisory board.”
I	“I am preparing a mini [Company Name] MBA. 2 hours each of three days. It covers (VERY QUICKLY) all MBA topics you would normally be exposed to in any US MBA program. All the examples used are from real [Company Name] data, from NPVs to valuations to buy vs lease examples. It makes the connection between book knowledge and the practical application of MBA topics. Maybe something like this would also benefit a M.S. Biotech program.”
A	“Outcomes assessment”

Assessment of the Delphi Technique

At the end of Round 5, panelists were asked three questions:

1. Why did you choose this format (paper version or Web-based)?
2. How useful do you think this Delphi process was in designing a new degree program?
3. What recommendations do you have for improving the process?

Of eight responses to question one, seven were positive. All panelists used the Web-based model, though they were given the option of using paper based at the very beginning. One panelist did not recall being given a choice at the beginning and stated that they would have preferred a paper format because they “hated computers”. Panelists’ positive comments were that the Web-based technique was the easiest form of communication, more easily accessible, more convenient and faster.

On question two, 10 panelists responded. Five responded that the process was somewhat useful in program design, though two of that group thought face to face conversations would have improved the process. Three panelists were not sure, but preferred to wait and see what the results were before determining value. Two responded that the process was not useful or was marginally useful. One panelist thought that it was too time consuming, tedious, and continuity was lost between rounds because there was so much time from one round to another in some cases. The second thought the topic was too broad and complex to address in a Delphi study.

Several comments were made in response to question three. Several related to the benefit of meeting face to face, shortening the time between rounds, and the structure of each round. Those comments are summarized below in Table 29.

Table 29

Suggestions from panelists to improve the Delphi process.

Industry/ Academic	Comment
I	The discussion would provide more reasons behind the data.
A	I have not evaluated from the program developer perspective. I think it was fine for a contributor.
I	If you use a Delphi process again, questions must be very short with quick answers. Also, I'm not sure this process is truly helpful for developing curriculum because there are too many extenuating circumstances for answers - I think it needs to be done in person so that the person analyzing the data has all information - not just what the person answering has time to type in.
I	Allow participant to choose their own password-so they do not have to keep track of one that is assigned. Provide more clarification in the questions- rather than writing a paragraph of what to do to answer the questions, perhaps provide brief instructions and then RESTATE the question in bold before asking for ratings: Example:? To WHAT level do you agree that ___(additional titles)__ is an entry point position for graduates of this program? (restate scale here). Provide an out line of what you hope to accomplish in the beginning to the participants, I felt very scattered each time I entered a round because I did not have a visual of what areas (internship, jobs, tracks) we were trying to come up with.

Table 29 continued.

Industry/ Academic	Comment
A	Have a higher level summary after every round to focus the issues. I did like the way the responses were layed out and we could see where ours fit. Can you ask us this question again after we get the results?
I	Live discussions, preferably face-to-face, would have been better.
I	This may not be practical but getting together mid way through the process to clarify certain positions would have been very helpful

Summary of Results

Twenty four panelists started Round 1 and participation in subsequent rounds varied from 17 in Round 2 to 11 in Round 4. Education level varied and included all levels of education in science and business. They resided in nine states spanning from east to west coast.

Round 1 started with eight open-ended questions designed to investigate (a) learning objectives, (b) internships, (c) thesis vs. non-thesis, (d) program focus (e) possible entry level positions, (f) roles for the industry advisory board, (g) recommended hours of hands-on experience and (h) other issues of importance. The final round ended with three questions to assess the panelists' perception of the usefulness of the Delphi for program development in higher education.

For Question 1, 116 skills were identified, with 40 categorized as core curriculum, 52 as appropriate for tracks and 23 dropped because they did not receive a majority in the final round. An issue emerged with the recommendation that the program should have at least two different tracks that emphasized different curriculum. Ultimately, four tracks were chosen by a simple majority (50% or higher).

When differences between industry and academic panelists were analyzed using Chi Square, tabulated values exceeded expected values for two tracks-preclinical/clinical research and business development. Tabulated values exceeded expected values for six skills designated for tracks-experimental design, writing a business plan, conducting market research, in situ hybridization, SDS-PAGE, and quality assurance. When results were analyzed by high or low confidence level, significant differences occurred between groups that knowledge of gene expression should be included in core curriculum or that product development, basic accounting, microeconomics of a company, SDS-PAGE, transformation, use of bacteria, ISO 9000 or quality assurance should be part of the curriculum for tracks rather than core curriculum.

Four considerations were identified and examined for internships-length, level of responsibility, evaluation of the student, and compensation. At the end of Round 4, four to six months emerged as the most desirable length for an internship with a high level of responsibility. A combination of qualitative and quantitative evaluation was recommended with compensation at one-half to three-quarters of what would be paid to a full-time entry-level person in that position. Chi Square analysis of results revealed that significant differences emerged between industry and academic responses for the method of evaluating the internship in what each group chose as least desirable. When results were analyzed by high or low confidence level, the recommended level of compensation was significantly different. High confidence level disagreed that interns should be paid the full time equivalent while low confidence level agreed that interns should be paid the full time equivalent.

The question of thesis versus non-thesis changed during the course of the study. All respondents agreed that there should be an experiential component emphasizing a written product, though not necessarily a thesis. The only point of disagreement was whether or not every student, regardless of the track they were in, should be required to have a minimum amount of hands on experience. The question was changed to address that in Round 3 and combined with Question 1 in subsequent rounds.

Five themes emerged initially for the focus of the program-national, national overview with tracks, national overview with regional specializations, regional and local focus. The consensus was that the program should have a national overview with tracks that allow students to specialize in different curricular areas.

The question of entry level positions appropriate for new graduates changed after Round d1 because panelists were using different titles for the same position. In Round 2, titles were chosen from the literature and a copy provided of the article with the caveat that panelists could add position titles they felt were not represented in the list provided. In the final round, thirty position titles were identified as appropriate for new graduates. When results of industry and academic responses were analyzed using Chi Square, tabulated values exceeded expected values for manufacturing associate, clinical data associate and QA document coordinator. When results were analyzed for high or low confidence level, four entry-level positions were significantly different.

Nine roles were identified for the industry advisory board. There was consensus that all roles were appropriate.

The question regarding the amount of hands-on experience that should be required of a new graduate became more complex because of the issue of tracks. It was combined with Question 1 after Round 2 and became two questions-how much experience should be required of all students regardless of track and how much should be required of students in each track. Results indicated that every student should have a minimum of one semester of hands-on experience in a research laboratory before during the master's program regardless of track. For each track identified, the number of semesters of hands-on experience varied from 3 semesters for a science track to 1 semester for a business development track. When results were analyzed by high or low confidence level, the number of semesters recommended for all students was significantly higher for panelists having a high degree of confidence in their response.

In the final question regarding other issues to be discussed, 10 were identified initially. Identifying program goals and teaching innovations appropriate for a professional science master's program were the only two that received a simple majority (50% or higher). Five goals were identified. Panelists were asked to give recommendations for teaching innovations, but only four provided comments.

Only 10 panelists, less than half the original group, responded to the questions to evaluate the usefulness of the Delphi process. Half those responses were positive with several suggestions for improving the process.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The primary purpose of this research was to develop a model for a professional science master's program combining biotechnology and business. The objectives were to identify stakeholder preferences for various dimensions of a professional science master's program combining biotechnology and business and to identify differences in priorities between subgroups. A secondary purpose was to examine user preferences between Web-based and traditional methods of conducting a Delphi study and their impressions of its usefulness for program development.

Prior to the first round, demographic data was collected on panelists regarding their gender, age, years experience in their current field, position title and education levels. Round 1 started with eight open-ended questions designed to investigate (a) learning objectives, (b) internships, (c) thesis vs. non-thesis, (d) program focus (e) possible entry level positions, (f) roles for the industry advisory board, (g) recommended hours of hands-on experience and (h) other issues of importance. The final round ended with three questions to assess the panelists' perception of the usefulness of the Delphi for program development in higher education.

Twenty four panelists started Round 1 and participation in subsequent rounds varied from 17 in Round 2 to 11 in Round 4. Education level varied and included all levels of education in science and business. They resided in nine states spanning from east to west coast.

One hundred sixteen skills were identified initially. In subsequent rounds, 40 were categorized as core curriculum, 52 as appropriate for tracks and 23 were dropped because they did not receive a majority. An issue emerged with the recommendation that the program should have at least two different tracks that emphasized alternative curriculum. Ultimately, four tracks were chosen by a simple majority (50% or higher).

Chi Square analysis revealed that tabulated values exceeded expected values for two tracks and six skills designated for tracks. Significant differences occurred between high and low confidence groups on inclusion of gene expression in core curriculum and eight skills designated for tracks.

Four considerations were identified and examined in more depth for internships. Chi Square analysis of results revealed that significant differences emerged between industry and academic responses for the least desirable method of evaluating the internship. The recommended level of compensation was significantly different when results were analyzed by high or low confidence level.

The question of thesis versus non-thesis changed during the course of the study. All respondents agreed that there should be an experiential component emphasizing a written product, though not necessarily a thesis. The only point of disagreement was whether or not every student, regardless of the track they were in, should be required to have a minimum amount of hands on experience. The question was changed to address that in Round 3 and combined with Question 1 in subsequent rounds.

Five themes emerged initially for the focus of the program-national, national overview with tracks, national overview with regional specializations, regional and local focus. The consensus was that the program should have a national overview with tracks that allow students to specialize in different curricular areas.

The question of entry level positions appropriate for new graduates changed after Round 1 because panelists were using different titles for the same position. In Round 2, titles were chosen from the literature and panelists could add position titles they felt were not represented in the list provided. In the final round, 30 position titles were identified as appropriate for new graduates. When results of industry and academic responses were analyzed using Chi Square, tabulated values exceeded expected values for three positions. When results were analyzed for high or low confidence level, four entry-level positions were significantly different.

Nine roles were identified for the industry advisory board. There was consensus that all roles were appropriate.

The question regarding the amount of hands-on experience that should be required of a new graduate became more complex because of the issue of tracks. It became two questions-how much experience should be required of all students regardless of track and how much should be required of students in each track. Results indicated that every student should have a minimum of one semester of hands-on experience in a research laboratory regardless of track. For each track identified, number of semesters of hands-on experience varied from three semesters for a science track to one semester for a business development track. When results were analyzed by high or low confidence level, the number of semesters recommended for all students was significantly higher for panelists having a high degree of confidence in their response.

In the final question regarding other issues to be discussed, ten were identified initially. ‘Identifying program goals’ and ‘teaching innovations appropriate for a professional science master’s program’ were the only two that received a simple majority (50% or higher).

Five goals were identified by having panelists list five objectives each, then sorting those into themes, which were restated as goals. Panelists were asked to give recommendations for teaching innovations, but only four provided comments.

Only 10 panelists, less than half the original group, responded to the questions to evaluate the usefulness of the Delphi process. Half those responses were positive with several suggestions for improving the process.

Evaluation of the Web-based Delphi

Several problems emerged with this particular Delphi that could be a problem in others. Originally, we told panelists the study would be completed in about eight weeks, but due to unforeseen circumstances, this stretched to ten months. We relied on a third party to program the interactive Web site, which resulted in long waits between rounds, sometimes as much as three months. Participation varied considerably from round to round, in part due to this extended length. This had a negative influence on the panelists' perceptions of the effectiveness of the Delphi. However, use of the Delphi allowed us to gather opinions from a very diverse and geographically distant group of participants. Face-to-face meetings would have been costly both in time and money.

Threats to internal and external validity should also be considered because they create the unique place and time in which this study was conducted. The snowball technique for identifying panelists was not as effective for this study as in others cited in the literature (Lincoln & Guba, 1985; Linstone & Turoff, 1975). There are no nationally recognized experts in this particular field, in part because it is still an emerging field that combines very different disciplines, disciplines that do not normally intercept.

We also had difficulty keeping panelists focused on the intended goal of developing a program that combined biotechnology and business. This could have been due to the wide variety of backgrounds and experiences. Choosing a panel with a narrower range of experience might have corrected this, but at the same time, it may not have uncovered issues like tracks or non-science disciplines that should be considered.

The political climate has changed considerably in just the past two years. The war on terror and the ups and downs of the economy could be changing the face of the biotechnology industries, particularly with the increased emphasis on biosecurity. Terror alerts, increased security, students and faculty called up to fight in the war in Iraq, and budget cuts have affected universities as well.

The unexpected length of the study affected the ability of panelists to participate consistently. A shorter time frame could have increased participation and changed the results. As the study progressed, some panelists may have become more knowledgeable about professional science master's programs, which could have affected their answers. The amount and quality of interaction between the panelists and the facilitator varied as well due to differences in interpersonal communications and familiarity. Some panelists also knew each other, and even though the identities were not disclosed during the study, may have discussed the study at some point.

Panelists were from different regions of the country, where the local biotechnology industries could be very different from those found in Texas. Many of the industry panelists were from small companies, and some of those were in Texas, where the industry is not as mature as on the east or west coast. Many of the faculty panelists were from professional science master's programs supported by the Sloan Foundation, which does set specific criteria for the programs that it will support.

A different time and different panelists could change some of the results in this study. However, given the variety of backgrounds and experience of these panelists, I think we would find that the priorities probably wouldn't change much--hands-on experience for every student, curriculum with authentic assessments that encourages critical thinking, problem solving, and communication skills, and nonscientific topics combined with more traditional science topics to prepare students as science professionals.

Knowledge, Skills and Abilities

The question relating to knowledge and skills quickly became too complicated for the scope of this particular study. The recommendation to identify goals through the group process and have at least two alternate tracks added layers of complexity that were not anticipated and could not be adequately addressed in this study.

Of the tracks that were suggested, only four received a majority, with preclinical and clinical development having the highest frequency. It was the only track that received a ranking of 1, agree strongly, through Rounds 3 and 4. There was consensus on three tracks--preclinical/clinical development, manufacturing, and business development. The suggested science tracks--molecular biology, biochemistry, and cell biology--did not reach consensus. This could be due, in part, to the view that they were too discipline specific and that topics or classes should be chosen from each to create a research track. There seems to be lack of agreement on what science skills are most appropriate for graduates planning careers in industry. The traditional disciplines may not be the best preparation.

Significant differences occurred between industry and academic panelists on two tracks. Due to the exploratory nature of the study, we differentiated between the five different levels of agreement used on the five-point Likert scale rather than lump them into categories of ‘agree’ and ‘disagree’. For the preclinical/clinical development track, industry panelists agreed strongly that it should be a track while academic panelists were not quite as strong in their agreement. For the business development track, industry panelists chose 1 (agree strongly), while academic panelists were evenly divided between 2 and 3 on the scale, indicating that they may not have agreed as strongly on this point.

It is notable that the knowledge and skills identified for core curriculum did not include specific lab skills. The lab skills were designated as track or eliminated because they did not receive a majority. Thirteen of the 23 skills eliminated after Round 2 were laboratory skills. Despite this, there was agreement that every student should have at least one semester of laboratory experience regardless of the track they were in.

Elimination of these skills could be due, in part, to a design flaw. Panelists were asked to evaluate each skill and indicate if it should be part of core curriculum for all students or a specialized track by choosing one of three radio buttons (blank, core, track). If a competency was not appropriate for core or track or outside a person's area of expertise, they were asked to leave it blank. In retrospect, this was not the best way to structure this question. Panelists should have been allowed to choose "outside expertise" or "neither core nor track" to differentiate between choices. More of these might have been retained had the question been structured for more precise answers. However, given that 18 of the 24 panelists had science degrees, it is surprising that laboratory skills did not receive a majority.

Some respondents stated that the science track was too general and should be more specialized, so in subsequent rounds "science" was divided into molecular biology, biochemistry and cellular biology. In Round 3, two panelists commented that this was too discipline specific and that classes from each of the disciplines should be combined to form a track more appropriate for industry. This indicates that there may be considerable disagreement on the particular science knowledge that students should have for the biotechnology industry.

Many of the skills and knowledge that were identified as core curriculum were not science skills. Basic business skills and industry specific topics are rarely included in science master's programs, yet predominated in core curriculum for this model. Those skills receiving an overall ranking of 1, agree strongly, focused on critical thinking, problem solving, interpersonal and communication skills. There was unanimous, strong agreement that critical thinking and problem solving skills should be emphasized in the core curriculum. Interpersonal and teamwork skills were strongly supported as were written and oral communication skills.

Six items did not reach consensus for inclusion in core curriculum. One person chose “disagree strongly” as an answer for resume writing, survey of the biotechnology industry, interviewing skills, eagerness to adapt to new directions, preparing an abstract for a meeting, and basic information technology and information systems needs of biotechnology companies.

Only one skill, Good Clinical Practice, received a rating of “agree strongly” for inclusion in a track. All other skills had medians falling between 1.5 and 3.0. Nine were not in consensus as skills that should be designated to tracks--marketing, conducting market research, microeconomics of a firm, understanding the venture capital process, how to write a business plan, project management, use of bacteria, transformation and SDS-PAGE. What is not clear is if the disagreement was that these should be in core curriculum or eliminated from the curriculum altogether, due largely to the design of the question.

There were significant differences between industry and academic panelists on six skills designated for tracks. Industry panelists agreed more strongly on experimental design, writing a business plan, in situ hybridization, SDS-PAGE and quality assurance as suitable for tracks than did academic panelists. The differences were even more notable for conducting market research, with industry panelists agreeing and academic panelists disagreeing that this skill should be part of a track.

Dimensions of the Internship

Universities frequently view internships as most appropriate for the three months in the summer. They often are not credit bearing courses and the student does not have the academic oversight of a faculty member. Many traditional life science graduate programs don’t allow a student time for an internship, particularly if they are completing research for a thesis.

At the end of Round 3, the most desirable length of time for an internship was 0-3 months, or one semester. However, by the end of Round 4, that had shifted and 4-6 months, or two semesters, was the most desirable choice. This means the internship would have to be at least a summer and fall or spring and summer, or possibly alternating semesters. This could cause problems for students because they are not on campus or may not be enrolled as a full time student during the fall or spring semester. Many traditional age students must maintain full-time student status to be covered by their parents’ medical insurance and to qualify for financial aid. It would require either that they intern locally while taking classes, which could seriously limit their opportunities, or classes be created that allow the student to be considered full time while not on campus. This would be similar to the design of some co-op programs, which may be a better model for internships for some professional science master's programs.

The level of responsibility remained fairly stable across all rounds. Panelists chose a high level, about a half-step below the position that a student could be hired for, as the most desirable level of responsibility.

Similarly, the most desirable method of evaluation was a combination of qualitative and quantitative and that stayed stable across all rounds. This would indicate that the evaluation of an internship should be a combination of written products, such as evaluation forms with a numerical scale or a written report, or both, coupled with a performance review and verbal or written feedback from the supervisor.

When the data was analyzed for differences between the academic and industry subgroups, qualitative and quantitative combined was the unanimous first choice. Qualitative was the second choice of industry panelists and quantitative third. The reverse was true of academic panelists, who rated quantitative second and qualitative third. Quantitative evaluations would be more conducive to assigning a grade. Qualitative, on the other hand, was defined as performance evaluations, verbal evaluation or supervisor's letter, which would come from the industry internship supervisor.

Level of compensation was not as clear-cut. Salaries equal to one-half or three-fourths of that paid to a full time entry-level person in that position received equal weight. The only difference between the two was that, at the end of Round

4, the IQR of three-fourths pay was narrower than the IQR of one-half, indicating that there was closer agreement. This would warrant further research because internship salaries vary widely, which could be due, in part, to a lack of experience in the industry with graduate level interns. Most internship positions are geared to undergraduates who lack the knowledge and experience of students in a professional science master's program.

Hands-on Experience vs. Writing a Thesis

Six respondents stated specifically that a thesis was not appropriate for students who plan to work in industry. All respondents agreed that there should be an experiential component that culminated in a written product that emphasized critical thinking, problem solving, and organizing and presenting information. What is not clear is to what extent that writing product should be based on laboratory research or if satisfactory products could be developed for non-laboratory experiences. Alternative products should be identified or developed that would be more beneficial to the specific career development of the students. This would require close collaboration with industry and it is unknown how involved industry advisory boards are with these professional science master's programs. Having an advisory board and effectively involving an industry advisory board are two very different situations. Current models for working with industry advisory boards should be examined closely to determine if a satisfactory model exists for a professional science master's program.

The question of tracks evolved to address how much hands-on laboratory experience should be required of every student in this professional science master's program, regardless of what track they chose. The consensus, with strong agreement, was that every student should have at least one semester of laboratory experience, but that it could be gained as an undergraduate before entering the program. This should be investigated more closely on a case by case basis. Again this is where an industry advisory board, if used effectively, could help clarify the minimum that would be expected of the graduates that they are expected to hire.

Program Focus

A mistake occurred between Rounds 3 and 4 for this question. In Round 3, panelists were given the scale 1=most desirable and 5=least desirable, but in Round 4, they were inadvertently given two scales. At the top of the page was the original scale, but lower down in the page, they were given the scale of 1=agree strongly and 5=disagree strongly. Even though changes between rounds were small, it's hard to determine which scale panelists were referring to when giving their answers. Regardless of whether the two different scales had an effect, the top choice in each round was national overview with tracks to meet student goals, closely followed by national focus and national overview with regional specializations. However, panelists did not consider how a lack of university resources or lack of expertise in the area students were interested in could affect development of tracks.

Entry Level Positions Appropriate for New Graduates

Realistically, employment opportunities that would be available to students should be considered as they are prepared for the workforce. We might like to think we are preparing them for a management level position, but are those positions out there? Can they be found in the job banks? What skills do students need to get a job in a company and then advance on a career path of their choice? We asked this question specifically in hopes of clarifying the kinds of positions that were out there for students.

Strongest agreement for those positions taken from the literature was for research associate, manufacturing associate, process development associate, and quality assurance technical writer. Of those positions that were suggested by participants, there was no strong agreement that any were appropriate for new graduates.

When the data was analyzed for differences between the two subgroups, industry and academic, significant differences occurred for manufacturing associate, clinical data associate, and quality assurance document coordinator. The industry panelists agreed strongly on all three as appropriate for new graduates. However, agreement was not as strong for the academic panelists. In particular, academic panelists were widely divergent for the position of quality assurance document coordinator, with responses ranging from ‘agree’ to ‘disagree strongly’. This could be due, in part, to a lack of familiarity with the work involved in quality assurance and other positions unique to the biotechnology industry.

Roles of the Industry Advisory Board

There was strong agreement on only two items of the nine identified--internship development and establishing university/industry ties. The two items garnering the most disagreement were related to funding. Two panelists commented that it was not the role of industry to provide funding. The median moved more strongly toward disagreement from Round 2 to Round 3. However, there was no strong disagreement on any of the nine items, so they did reach consensus.

Given the negative reactions of industry members to the idea of providing any kind of funding, and the assumption of many academics that industry should pay to support these industry specific programs, this particular item warrants more discussion. As budgets get tighter on college campuses, other sources of funding will have to be tapped to sustain these nontraditional programs. Non-thesis programs often do not have the traditional sources of funding for students, such as assistantships. This makes it difficult to compete for and support students in these programs.

Minimum Hands-on Experience Required for New Graduates

Despite the fact that science skills were not emphasized in the core curriculum, there was agreement that every track should require at least one semester of laboratory experience for all students in that track. For the science tracks, the consensus was that there should be at least three semesters of experience. Two semesters each were recommended for the preclinical/clinical development and manufacturing tracks and one semester for the business development track. This may speak to graduate as well as undergraduate programs regarding the amount of hands-on experience that is expected when a new graduate is hired. As noted in the literature review, it is often hard for new graduates to find jobs because “they can’t even make solutions” (Kennedy, 1993a).

Other Issues

A strong majority of panelists identified program goals as an issue that should be addressed in this study. Understandably, a program really can’t be designed unless goals are clear. Goals should be articulated and written early in the development of a program. Continuity should be planned for because staff and administration can come and go.

The goal that received the strongest support was mastery of written and oral communication skills. Experiential learning and mastery of science theory and techniques were close seconds. There was agreement on basic business principles and industry specific topics, but not as strong as the first three goals. The fifth goal, having to do with knowledge of issues and trends in industry, was very broad because no particular theme or topic emerged. However, panelists were in agreement that clearly articulated goals should precede development of the program.

Teaching innovation could be a worthy study on its own. Only four panelists responded, but that may have been due to the length of the study and the loss of interest and perseverance.

In summary, this study points out the significant differences in opinion that can occur between academic professionals and the industry managers that are expected to hire the graduates from our universities. It is noteworthy that many of the participants in this study were experienced with professional science master's programs. Participants who lack that experience could offer even more divergent opinions. This emphasizes the need to use a structured process for program development and getting all stakeholders involved. It also speaks to the necessity of carefully selecting participants for a Delphi study.

Other considerations are the non-science disciplines that should be included, the tracks structure, and the emphasis on experiential education and authentic assessment. This points to a need for a new way to educate students as the life science industries continue to grow.

Recommendations for Practice

Study Design

While a Web-based Delphi may seem more convenient for panelists and more efficient for data collection, my recommendation is not to conduct a Web-based study unless you have the budget to hire a programmer dedicated to the study or you can do all the programming yourself. The lag time between rounds, waiting for the programmer, had a very negative impact on the study.

Another consideration is the questions asked. I would not recommend a study of this scope for one Delphi study. It became too cumbersome and time consuming for the participants due to the number and complexity of questions we were attempting to address. A better scenario would be to conduct a Delphi study before a program is developed and choose panelists that can help you determine what the needs are for education programs. From that, a plan could be created for developing the program model and curriculum.

Other technologies could be used to enhance the communication between panelists, such as online forums or threaded discussions, and still keep them anonymous to one another. Supporting materials or information could be provided in an online community.

Anyone considering a Delphi should read all available literature before designing the first questionnaire. Determine from the beginning how data will be analyzed, with complete agreement between all parties involved on the definition of factors like “consensus”. The method has been used, misused and modified for various purposes across many fields since the traditional Delphi was first introduced by Norman Dalkey in the 1960's. There are several good critiques of its strengths and weaknesses that should be considered (Dalkey, 1967, 1968, 1969; Dalkey et al., 1969; Dalkey & Rourke, 1971; Linstone & Turoff, 1975; Powell, 2003; Sackman, 1975).

Program Development

The issue of knowledge and skills appropriate for this model needs far more exploration than we could provide in this study. It merits a study of its own. An in-depth analysis devoted just to curriculum should be conducted as part of the development of any new program. However, given the differences in the biotechnology industries and the rapid changes that occur in platform technologies, one national study would not be appropriate. This could be better addressed by having industry advisory boards for individual programs that could advise on the most appropriate skills based on the strengths of a particular college and the growth of regional industries. Though graduates will be competing for jobs in a national market, companies typically look in their own backyards for bachelor's and master's level employees rather than conducting a national search, such as they would for a Ph.D. level person (Kennedy, 1993a). Public universities, and in particular land grant universities, are charged with supporting the development of industries and workforce in their home states first.

Regardless of student interests, the university involved has to look at the resources they can realistically garner to support a professional science master's program. This should be done in the context of national trends and what would appeal to students. However, as a graduate advisor of a professional science master's program for four years, I found that students often didn't know what opportunities were available and looked to the program to provide that information. Many thought that having a bachelor's degree in the life sciences meant that they would be working in a laboratory. They knew very little about other opportunities beyond graduate or professional school unless they had been in the workforce and were returning to school.

Goals should be clearly articulated and formally recorded early in program development. Issues of different stakeholder groups--industry, faculty, and students--should be identified early and addressed. This study demonstrated on several occasions that there could be significant differences in the priorities of industry and academic panelists. This again emphasizes the need for a model that effectively gathers information from all stakeholders.

Internships could be an important capstone for these professional programs. A six-month internship could be a summer plus one long semester, alternating semesters or parallel, allowing students to work while they take classes. It would provide ample time for students to gain practical experience and could allow them to work in different units in a company to get both business and science experience. On-campus experience, providing the necessary hands-on experience, could precede the internship, but would require development of adequate laboratory placements for all students. The longer internship would also allow time for the student to complete a major written project that would serve as an authentic assessment, emphasizing critical thinking, problem solving, and written and oral communication skills.

The combination of business, science and other topics taught in these programs provide a perfect avenue for innovation. Nontraditional approaches, such as classes that bring together students from different disciplines to work on real problems, should be explored further for all kinds of degree programs, not just professional science master's programs.

Recommendations for Research

Several recommendations for research become apparent from this study. The Delphi method could be very useful in program development, but further research is needed to refine the processes for program development and evaluation. This includes research on the effective use of technologies to support the Web-based Delphi.

And effective model for working with an industry advisory board is also needed. Community colleges have a long history of working with industry advisory boards, but those are typically more focused on vocational training. A graduate program could use similar methods, but the focus would have to change to incorporate strategies for developing core competencies in students such as critical thinking and problem solving in addition to technical and business skills. Industry advisory boards could also be instrumental in development of authentic assessments to meet the unique requirements of individual programs.

A critical area of research will be the continued assessment and evaluation of professional science master's programs and their graduates. These are still relatively young programs and take many forms. Tracking graduates for many years into their careers and carefully evaluating all aspects of programs as they mature will provide critical data needed to develop best practices for these programs, as well as document failures. These programs could be the beginning of the science equivalent of an MBA, or they could be a trend that dies out in one or two generations. Careful observation and documentation will benefit not only the professional science master's programs, but help fill the gaps in the limited literature available on graduate education.

In academia, we frequently operate under the perception that we are not preparing students for careers, but are preparing them to be well-rounded, educated citizens. As noted in the section on core curriculum, the emphasis of employers is not just on skills, but on competencies that will serve a student for life-long success as a citizen--critical thinking, problem solving, communication and working with multidisciplinary teams. Employability skills are something that can and should be integrated across the curriculum. A high quality, well-rounded education and basic employability skills should not be mutually exclusive.

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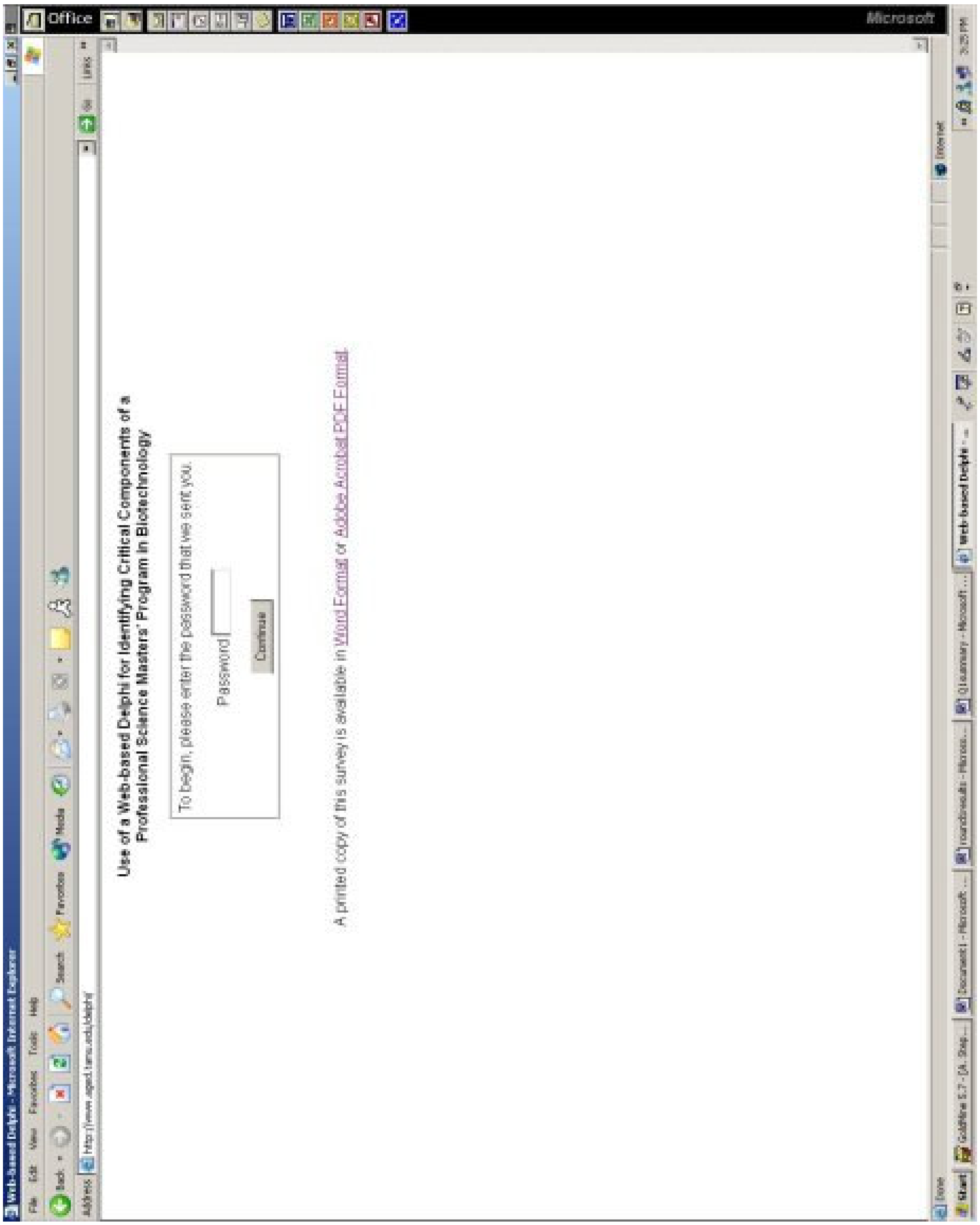
APPENDIX A

ROUND 1 INSTRUMENT


Web-based Delphi - Microsoft Internet Explorer
Office
Microsoft
Use of a Web-based Delphi for Identifying Critical Components of a Professional Science Masters' Program in Biotechnology
To begin, please enter the password that we sent you.
Password
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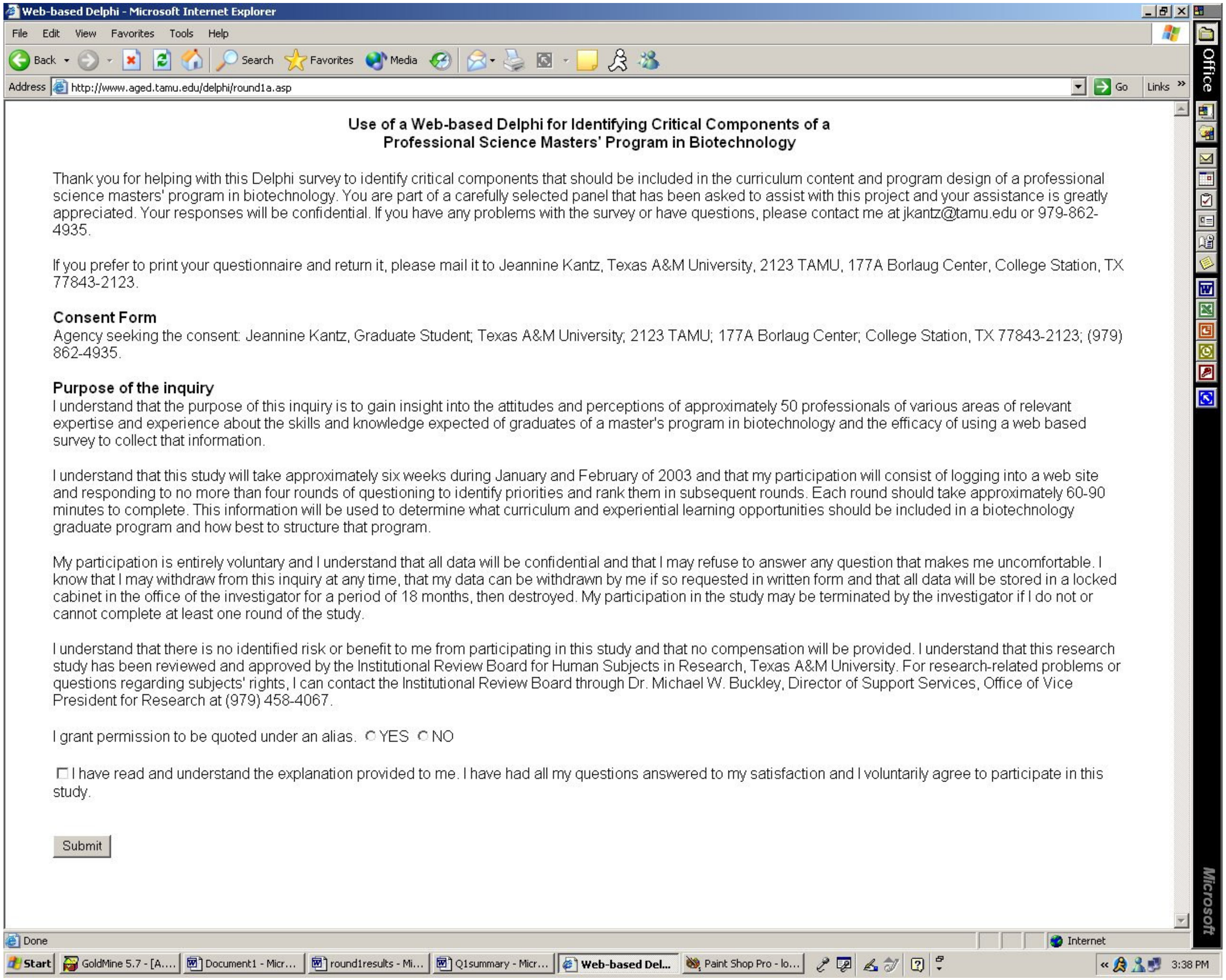
A printed copy of this survey is available in Word Format or Adobe Acrobat PDF Format



Use of a Web-based Delphi for Identifying Critical Components of a Professional Science Masters' Program in Biotechnology

Thank you for helping with this Delphi survey to identify critical components that should be included in the curriculum content and program design of a professional science masters' program in biotechnology. You are part of a carefully selected panel that has been asked to assist with this project and your assistance is greatly appreciated. Your responses will be confidential. If you have any problems with the survey or have questions, please contact me at jkantz@tamu.edu or 979-862-4935.

If you prefer to print your questionnaire and return it, please mail it to Jeannine Kantz, Texas A&M University, 2123 TAMU, 177A Borlaug Center, College Station, TX 77843-2123.

Consent Form
Agency seeking the consent: Jeannine Kantz, Graduate Student; Texas A&M University; 2123 TAMU; 177A Borlaug Center; College Station, TX 77843-2123; (979) 862-4935.

Purpose of the inquiry
I understand that the purpose of this inquiry is to gain insight into the attitudes and perceptions of approximately 50 professionals of various areas of relevant expertise and experience about the skills and knowledge expected of graduates of a master's program in biotechnology and the efficacy of using a web based survey to collect that information.

I understand that this study will take approximately six weeks during January and February of 2003 and that my participation will consist of logging into a web site and responding to no more than four rounds of questioning to identify priorities and rank them in subsequent rounds. Each round should take approximately 60-90 minutes to complete. This information will be used to determine what curriculum and experiential learning opportunities should be included in a biotechnology graduate program and how best to structure that program.

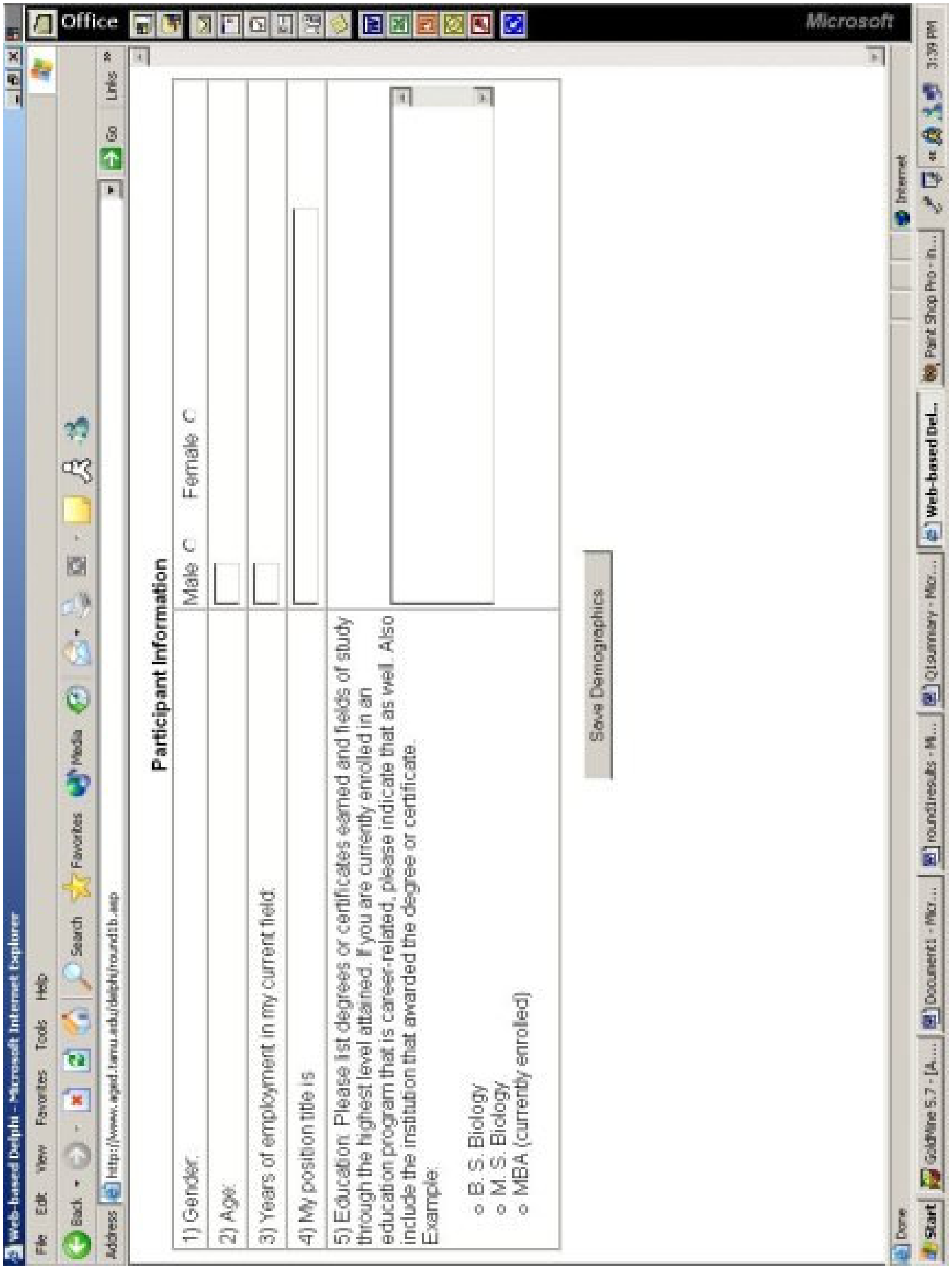
My participation is entirely voluntary and I understand that all data will be confidential and that I may refuse to answer any question that makes me uncomfortable. I know that I may withdraw from this inquiry at any time, that my data can be withdrawn by me if so requested in written form and that all data will be stored in a locked cabinet in the office of the investigator for a period of 18 months, then destroyed. My participation in the study may be terminated by the investigator if I do not or cannot complete at least one round of the study.

I understand that there is no identified risk or benefit to me from participating in this study and that no compensation will be provided. I understand that this research study has been reviewed and approved by the Institutional Review Board for Human Subjects in Research, Texas A&M University. For research-related problems or questions regarding subjects' rights, I can contact the Institutional Review Board through Dr. Michael W. Buckley, Director of Support Services, Office of Vice President for Research at (979) 458-4067.

I grant permission to be quoted under an alias. ○ YES ○ NO

☐ I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction and I voluntarily agree to participate in this study.

Submit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Go Links
Participant Information
1) Gender:
Male Female
2) Age:
3) Years of employment in my current field:
4) My position title is:
5) Education: Please list degrees or certificates earned and fields of study through the highest level attained. If you are currently enrolled in an education program that is career-related, please indicate that as well. Also include the institution that awarded the degree or certificate.
Example:
B. S. Biology
M. S. Biology
MBA (currently enrolled)
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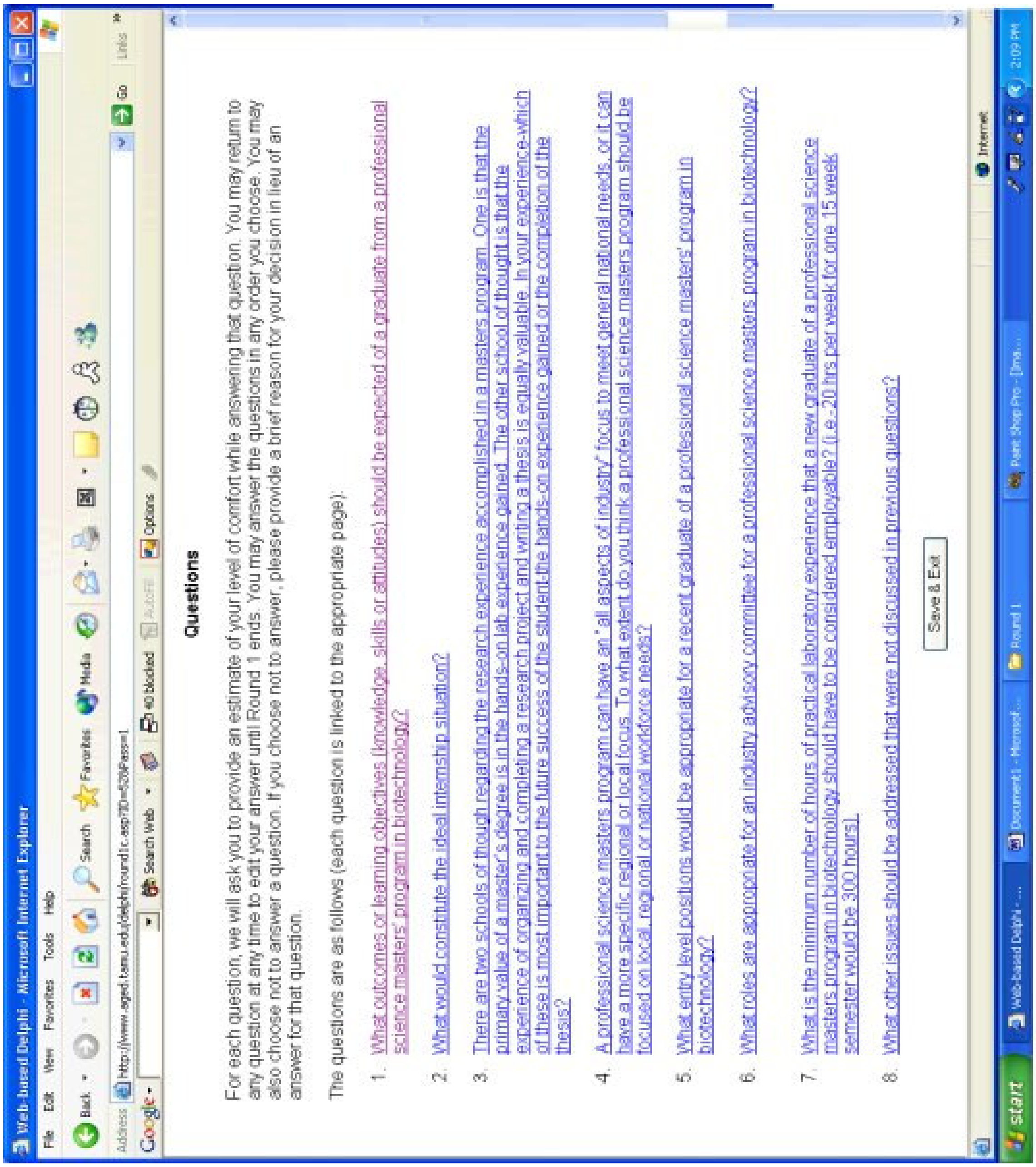
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Address http://www.aged.tamu.edu/delphi/round1c.asp?ID=&Pass=1
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Questions
For each question, we will ask you to provide an estimate of your level of comfort while answering that question. You may return to any question at any time to edit your answer until Round 1 ends. You may answer the questions in any order you choose. You may also choose not to answer a question. If you choose not to answer, please provide a brief reason for your decision in lieu of an answer for that question.
The questions are as follows (each question is linked to the appropriate page):
1. What outcomes or learning objectives (knowledge, skills or attitudes) should be expected of a graduate from a professional science masters' program in biotechnology?
2. What would constitute the ideal internship situation?
3. There are two schools of though regarding the research experience accomplished in a masters program. One is that the primary value of a master's degree is in the hands-on lab experience gained. The other school of thought is that the experience of organizing and completing a research project and writing a thesis is equally valuable. In your experience-which of these is most important to the future success of the student-the hands-on experience gained or the completion of the thesis?
4. A professional science masters program can have an 'all aspects of industry' focus to meet general national needs, or it can have a more specific regional or local focus. To what extent do you think a professional science masters program should be focused on local, regional or national workforce needs?
5. What entry level positions would be appropriate for a recent graduate of a professional science masters' program in biotechnology?
6. What roles are appropriate for an industry advisory committee for a professional science masters program in biotechnology?
7. What is the minimum number of hours of practical laboratory experience that a new graduate of a professional science masters program in biotechnology should have to be considered employable? (i.e.-20 hrs per week for one 15 week semester would be 300 hours)
8. What other issues should be addressed that were not discussed in previous questions?
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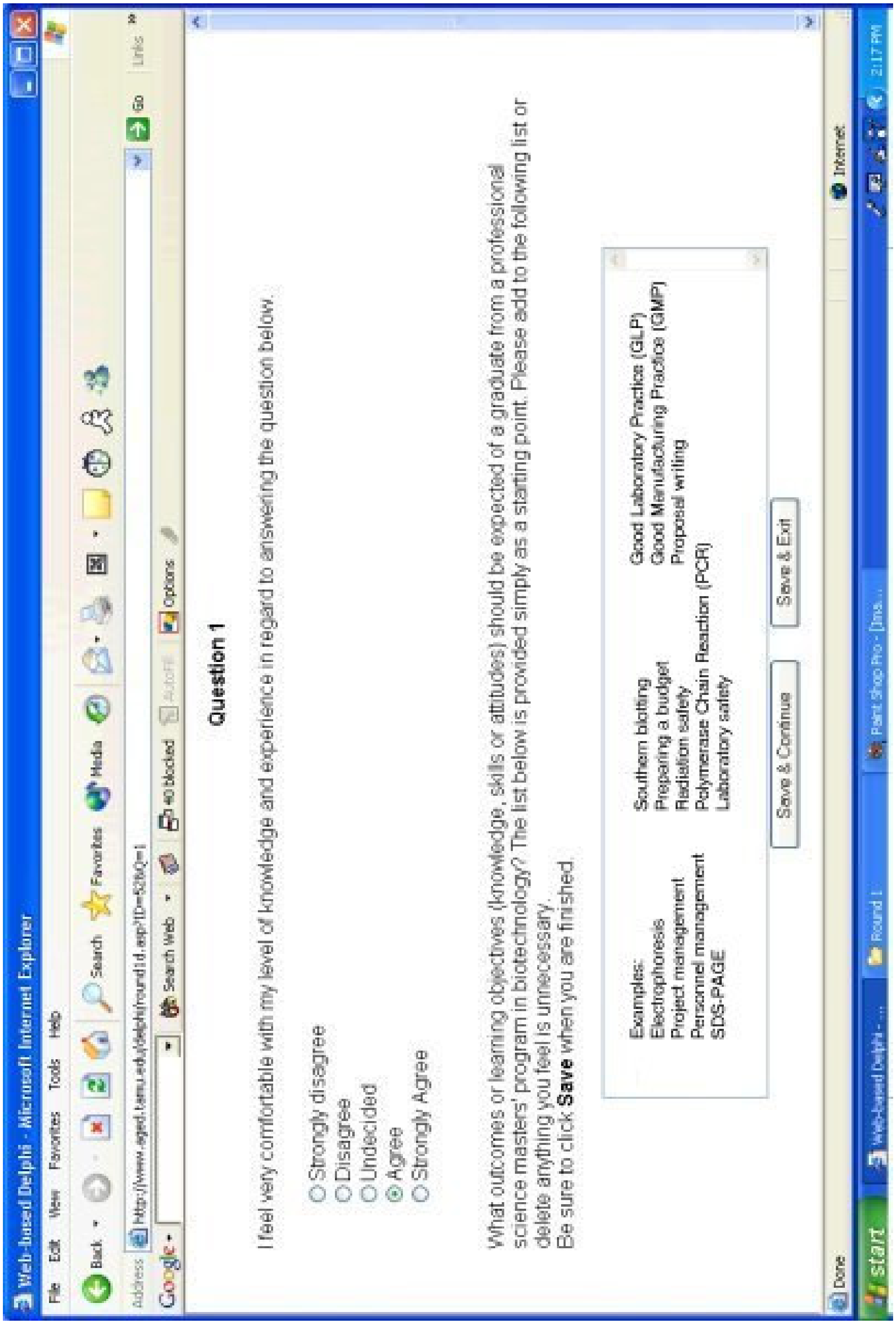
Web-based Delphi - Microsoft Internet Explorer
Question 1
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
What outcomes or learning objectives (knowledge, skills or attitudes) should be expected of a graduate from a professional science masters' program in biotechnology? The list below is provided simply as a starting point. Please add to the following list or delete anything you feel is unnecessary.
Be sure to click Save when you are finished.
Examples:
Electrophoresis
Project management
Personnel management
SDS-PAGE
Southern blotting
Preparing a budget
Radiation safety
Polymerase Chain Reaction (PCR)
Laboratory safety
Good Laboratory Practice (GLP)
Good Manufacturing Practice (GMP)
Proposal writing
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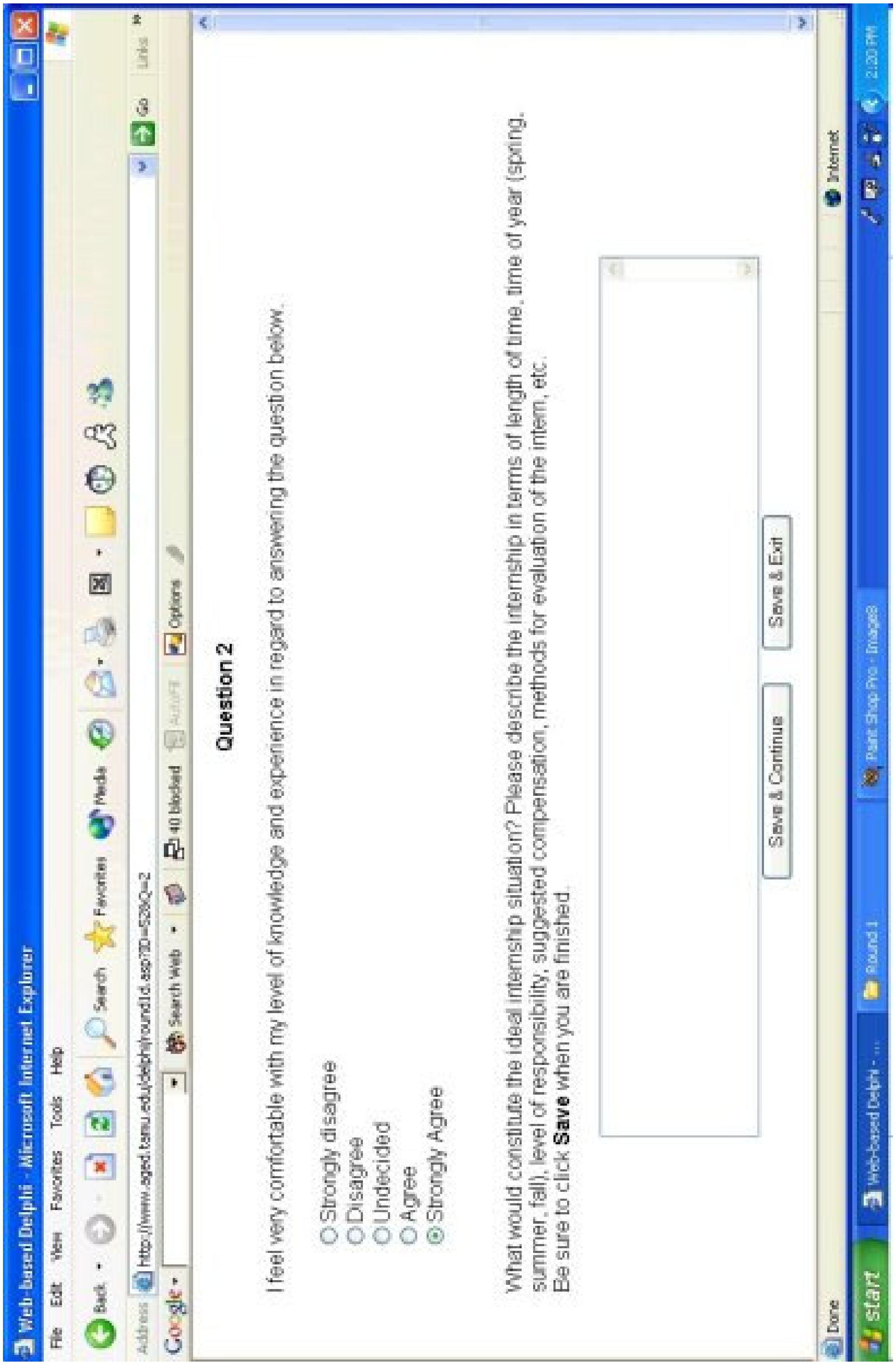
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Question 2
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
What would constitute the ideal internship situation? Please describe the internship in terms of length of time, time of year (spring, summer, fall), level of responsibility, suggested compensation, methods for evaluation of the intern, etc.
Be sure to click Save when you are finished.
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Done
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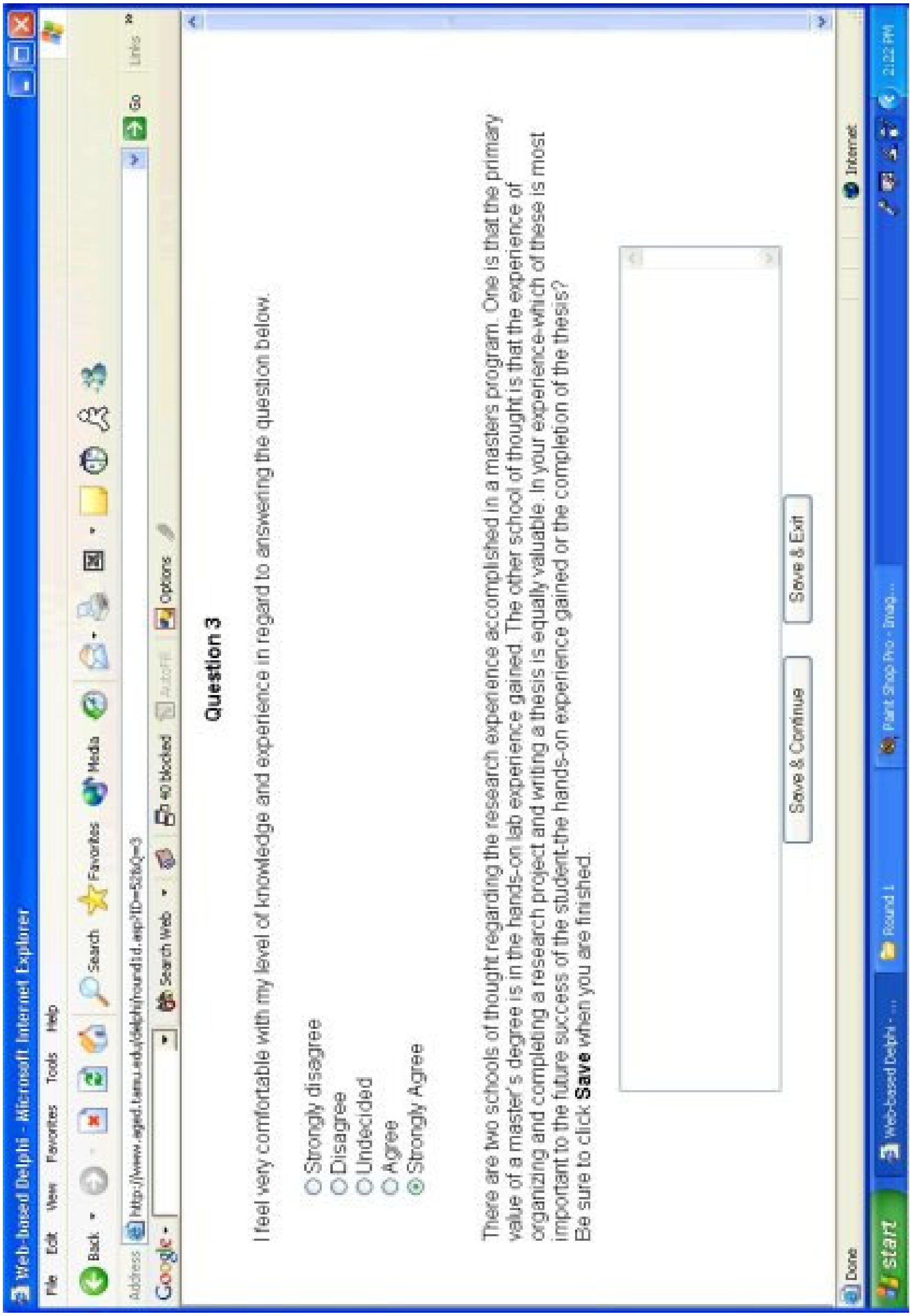
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Go
Links
Question 3
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
There are two schools of thought regarding the research experience accomplished in a masters program. One is that the primary value of a master's degree is in the hands-on lab experience gained. The other school of thought is that the experience of organizing and completing a research project and writing a thesis is equally valuable. In your experience-which of these is most important to the future success of the student-the hands-on experience gained or the completion of the thesis?
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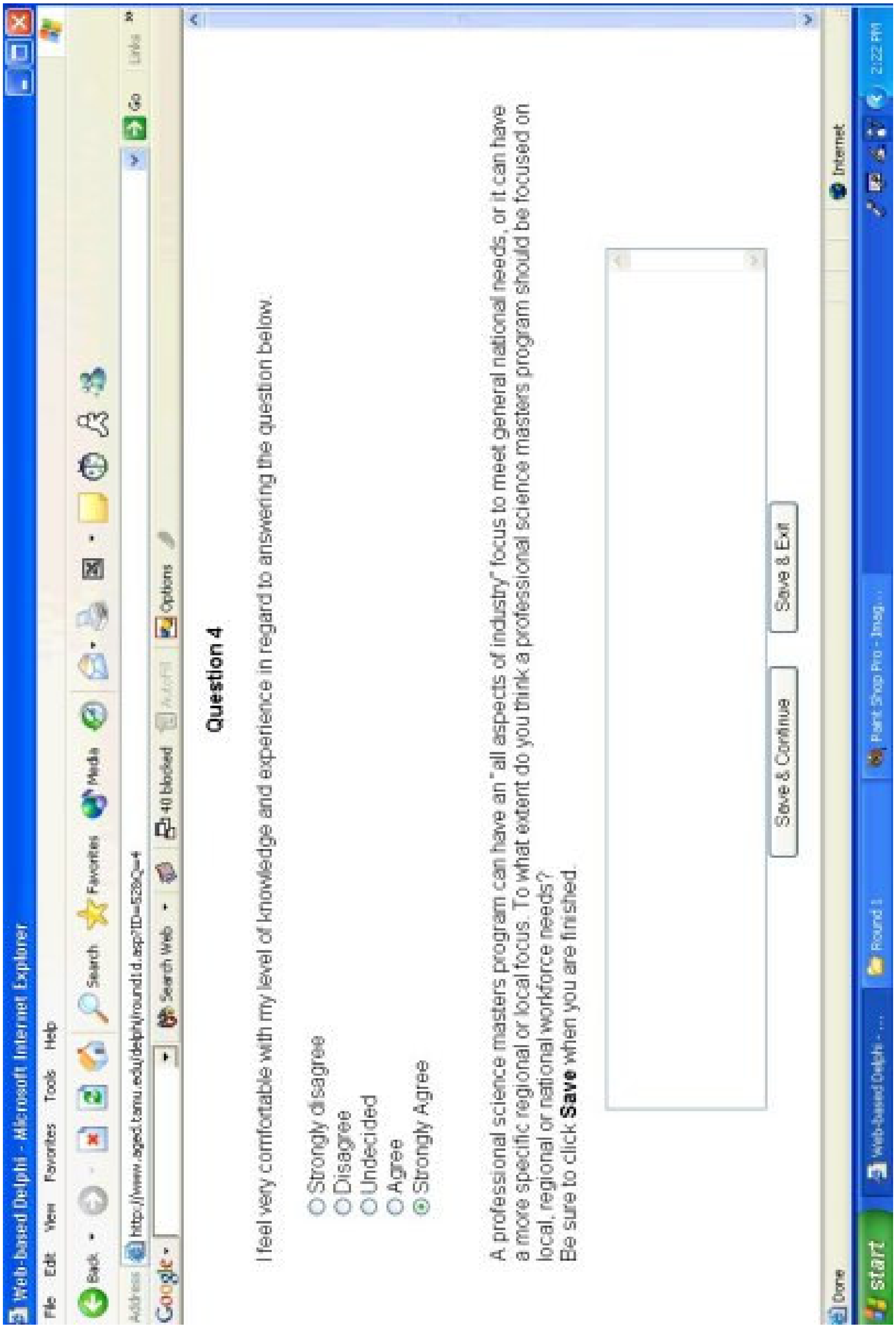
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Question 4
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
A professional science masters program can have an "all aspects of industry" focus to meet general national needs, or it can have a more specific regional or local focus. To what extent do you think a professional science masters program should be focused on local, regional or national workforce needs?
Be sure to click Save when you are finished.
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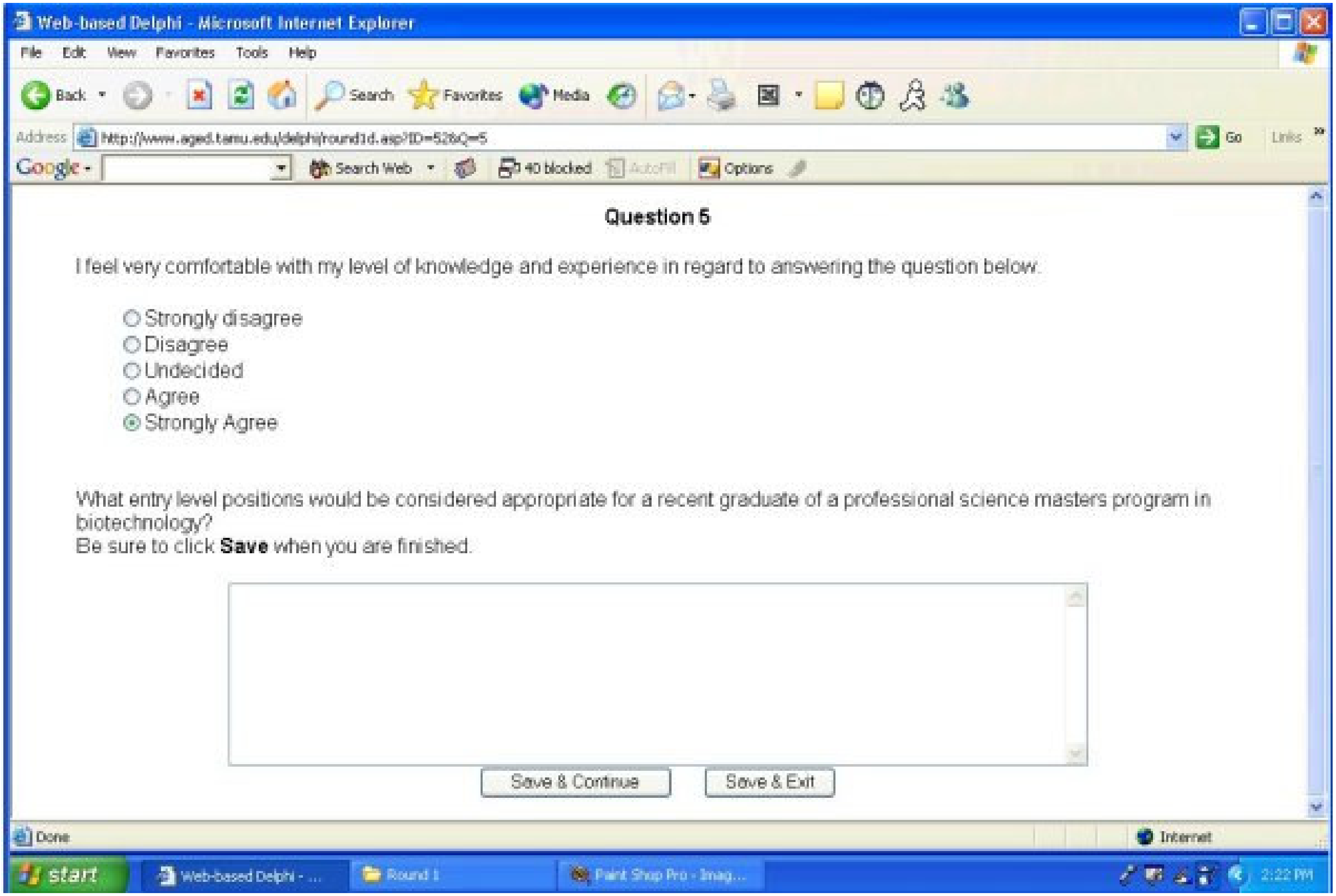
Save & Exit
Done
Internet
start



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Question 5
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
What entry level positions would be considered appropriate for a recent graduate of a professional science masters program in biotechnology?
Be sure to click Save when you are finished.
Save & Continue
Save & Exit
Done
Internet
start
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Round 1
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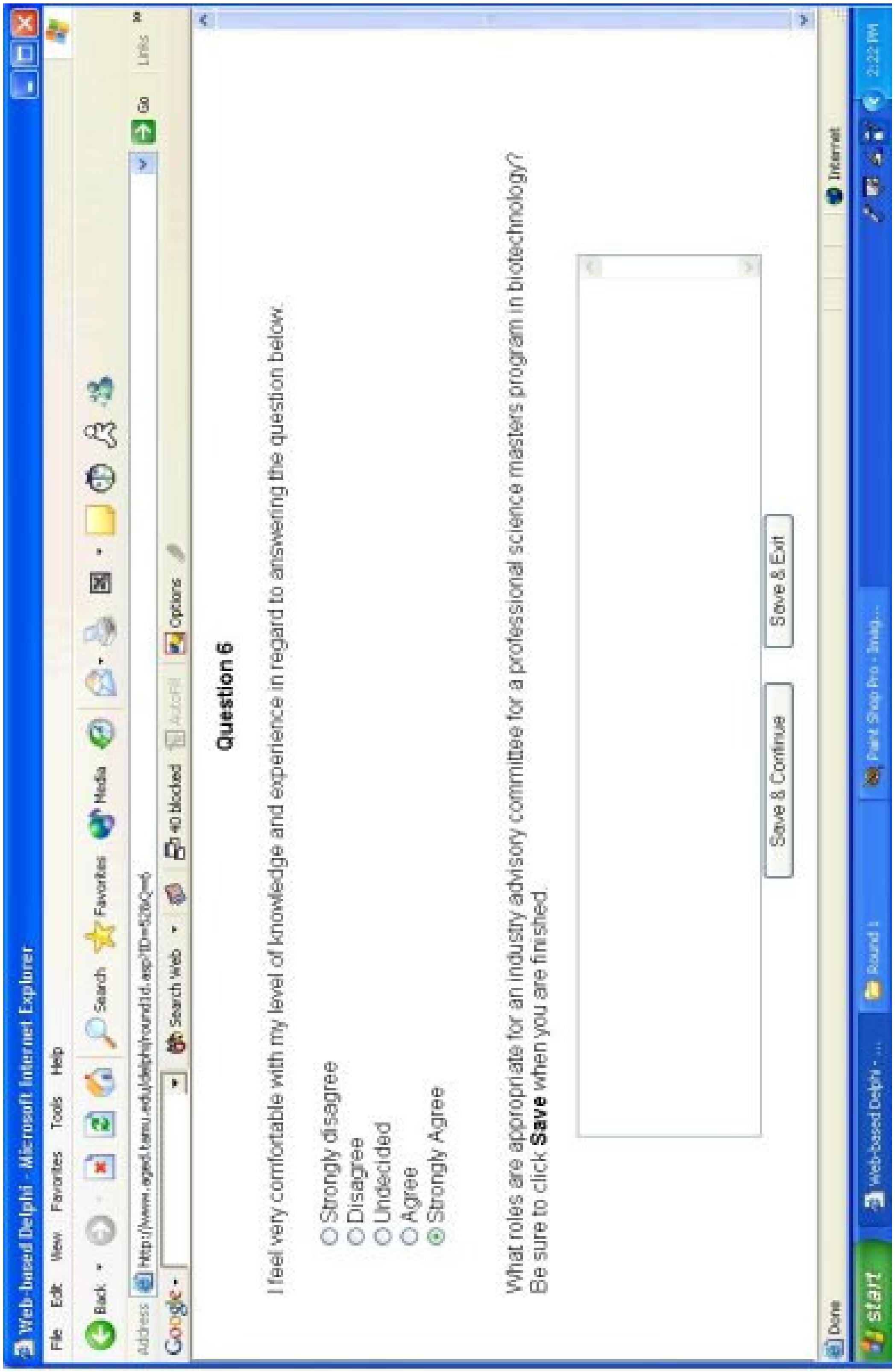
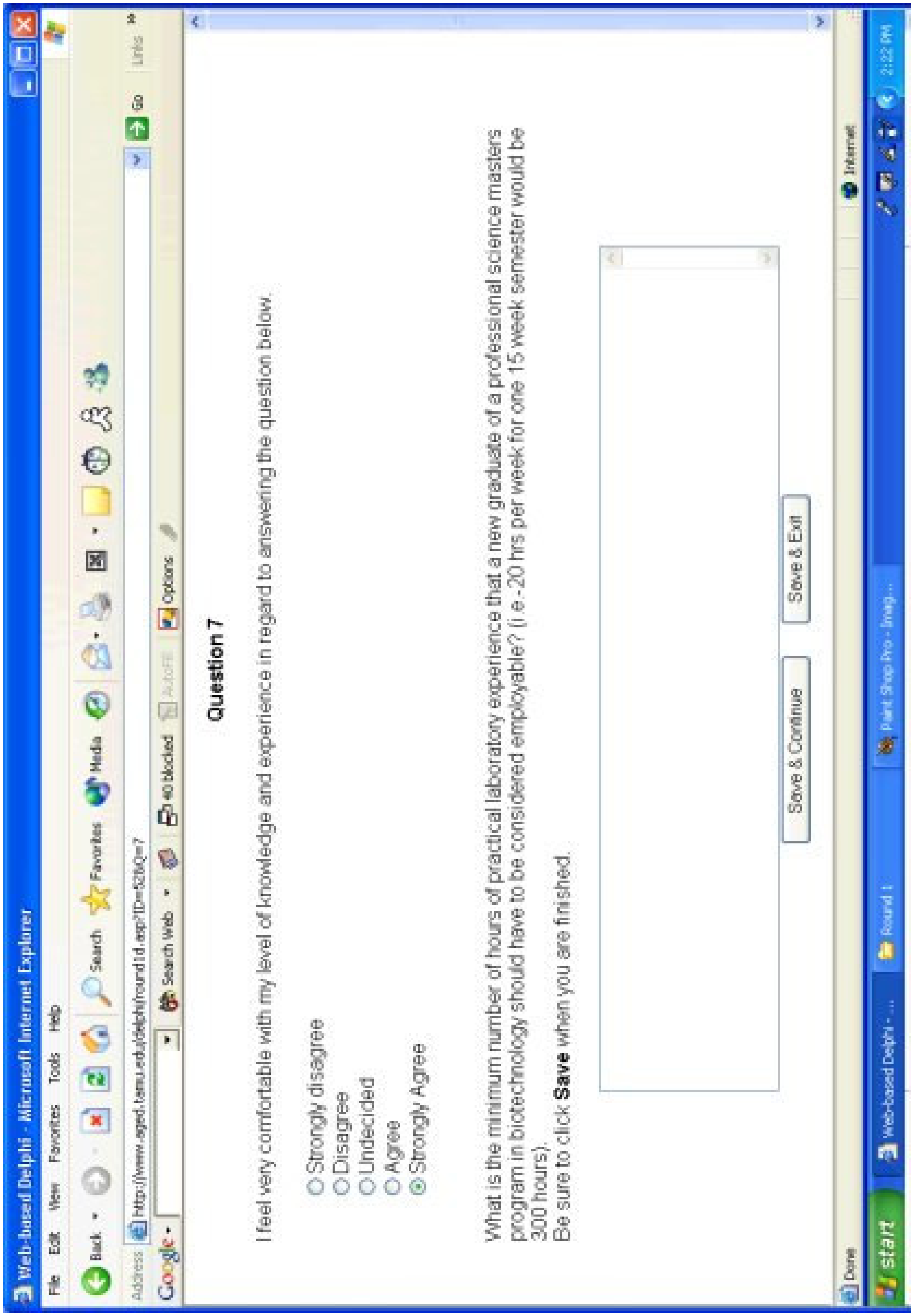
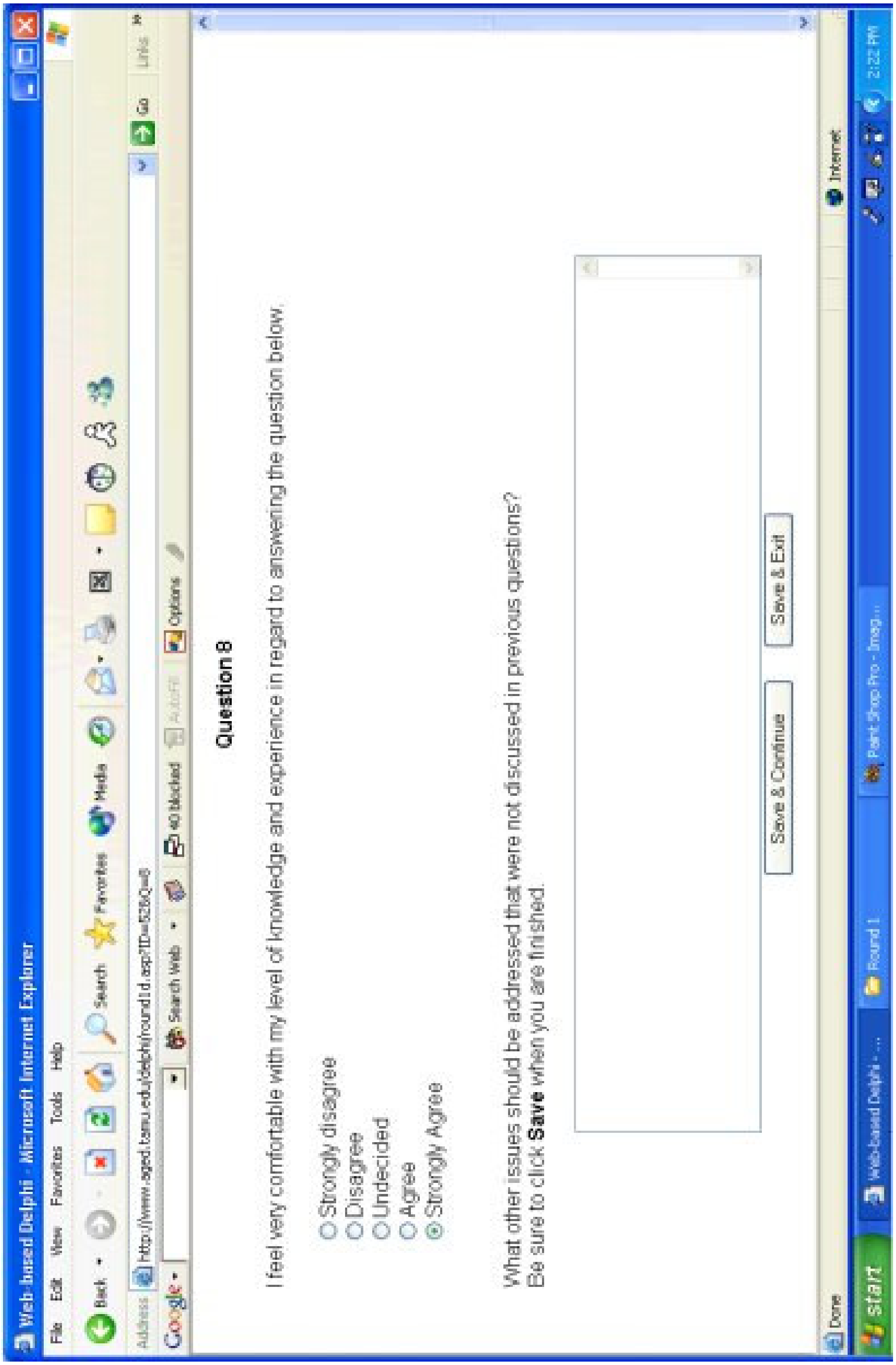

Web-based Delphi - Microsoft Internet Explorer
Question 6
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
What roles are appropriate for an industry advisory committee for a professional science masters program in biotechnology?
Be sure to click Save when you are finished.
Save & Continue
Save & Exit


Web-based Delphi - Microsoft Internet Explorer
Question 7
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
What is the minimum number of hours of practical laboratory experience that a new graduate of a professional science masters program in biotechnology should have to be considered employable? (i.e.-20 hrs per week for one 15 week semester would be 300 hours).
Be sure to click Save when you are finished.
Save & Continue
Save & Exit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Go Links
Search Web 40 blocked AutoFill Options
Question 8
I feel very comfortable with my level of knowledge and experience in regard to answering the question below.
Strongly disagree
Disagree
Undecided
Agree
Strongly Agree
What other issues should be addressed that were not discussed in previous questions?
Be sure to click Save when you are finished.
Save & Continue
Save & Exit
Done
Internet
start
Web-based Delphi - ...
Round 1
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APPENDIX B

EMAILS SENT TO PROSPECTIVE PANELISTS

EMAIL TO EXECUTIVE COMMITTEE OF PROFESSIONAL PROGRAM IN BIOTECHNOLOGY REQUESTING REFERRALS

I am conducting a Delphi study to develop a model for a professional science master's program combining biotechnology and business. The specific objectives of the study are (1) to identify and clarify critical core components that should be included in the program, (2) to identify differences in priorities of industry and academic professionals for a program of this nature, and (3) to evaluate the Web as a mechanism for conducting Delphi research.

This study could provide valuable data to inform course and program development for this new type of Master's degree program. Decision-makers at education institutions rely heavily on published information when redirecting resources in support of these programs for science students. Studies like this one provide that information.

Today, I am asking for your assistance in identifying other people who could contribute to this process. Your participation is strictly voluntary and will be greatly appreciated. In order to identify the very best people for this Delphi panel, please recommend at least two other people, here at TAMU or nationally, that you think would have the necessary expertise to participate in this process. Again, your contributions will remain strictly confidential.

Thank you for your consideration of this request.

Sincerely,

EMAIL TO PANEL REQUESTING

THEIR PARTICIPATION AND REFERRALS

I am conducting a Delphi study to develop a model for a professional science master's program combining biotechnology and business. The specific objectives of the study are (1) to identify and clarify critical core components that should be included in the program, (2) to identify differences in priorities of industry and academic professionals fro a program of this nature, and (3) to evaluate the Web as a mechanism for conducting Delphi research.

This study could provide valuable data to inform course and program development for this new type of master's degree program. Decision-makers at education institutions rely heavily on published information when redirecting resources in support of these programs for science students. This is an opportunity for you to influence those decisions.

Knowing the demands made on your time already, we have designed the study so that it would be more convenient for you. It will be available on-line, and does not have to be completed all at one time. You may answer as many questions online as you have time for, exit, then return later to continue anytime you find a minute.

Delphi studies, unlike surveys, provide participants with more than one opportunity to engage with the topic. Your initial responses allow us to refine our questions, clarify issues, and expose new issues that we, as a Delphi panel, need to examine. This process normally takes between 2 and four "rounds." Each of these "rounds" will be available online 7-24 for approximately 2 weeks. The entire process will be completed in approximately 8 weeks.

Through my professional contact with you, I have identified you as a person who would bring valuable expertise to this Delphi panel. The panel will consist of approximately 20 individuals identified for their expertise in biotechnology research, business, or education.

Today, I am asking for your assistance with two tasks. First, I would like for you to serve on this Delphi Panel. Secondly, I would like your help in identifying other people who could contribute to this process. You may choose to do both, either, or neither, but in any case please respond to this email informing me of your choice.

Your participation is strictly voluntary and will be greatly appreciated. Your identity will be confidential and you may withdraw from the study at any time. There is no personal risk involved. When all panelists have been confirmed, I will email the URL of the study's website to the panelists. All panelists will have the option of participating via the web or through more traditional, paper and US Postal Mail, methods.

Please consider participating in this study. Whether or not you decide to participate, please help identify the very best people for this Delphi panel by recommending at least three other people that you think would have the necessary expertise to participate in this process. Again, your contributions will remain strictly confidential.

Thank you for your consideration of this request. I look forward to your response.

Sincerely,

EMAIL TO NOMINEES OF PANEL

I am conducting a Delphi study to develop a model for a professional science master's program combining biotechnology and business. The specific objectives of the study are (1) to identify and clarify critical core components that should be included in the program, (2) to identify differences in priorities of industry and academic professionals fro a program of this nature, and (3) to evaluate the Web as a mechanism for conducting Delphi research.

You have been identified by your peers as a person who could bring considerable expertise to this study. The panel will consist of approximately 20 individuals identified for their expertise in biotechnology research, business, or education.

This study could provide valuable data to inform course and program development for this new type of master's degree program. Decision-makers at education institutions rely heavily on published information when redirecting resources in support of these programs for science students. This is an opportunity for you to influence those decisions.

Knowing the demands made on your time already, we have designed the study so that it would be more convenient for you. It will be available on-line, and does not have to be completed all at one time. You may answer as many questions online as you have time for, exit, then return later to continue anytime you find a minute.

Delphi studies, unlike surveys, provide participants with more than one opportunity to engage with the topic. Your initial responses allow us to refine our questions, clarify issues, and expose new issues that we, as a Delphi panel, need to examine. This process normally takes between 2 and four "rounds." Each of these "rounds" will be available online 7-24 for approximately 2 weeks. The entire process will be completed in approximately 8 weeks.

Your participation is strictly voluntary and will be greatly appreciated. Your identity will be confidential and you may withdraw from the study at any time. There is no personal risk involved. When all panelists have been confirmed, I will email the URL of the study's website to the panelists. All panelists will have the option of participating via the web or through more traditional, paper and US Postal Mail, methods.

Please consider participating in this study. Again, your contributions will remain strictly confidential.

Thank you for your consideration of this request. I look forward to your response.

Sincerely,

APPENDIX C

FOLLOW UP EMAIL TO PANELISTS AFTER ROUND 1

April 11, 2003

In response to different questions throughout the study, five people suggested that programs should offer two or more tracks for students. Before we go on to Round 2, we need to clarify the issue of offering different tracks for students because it will determine how questions are structured for Round 2. The different responses regarding tracks are listed below. Please read them and respond to this email and tell us if you think a professional master's program should offer two or more tracks or should it concentrate on one set of skills for all students. The responses regarding tracks are listed below:

Response 1:
"For the third option it might be possible to have two separate tracks in a professional program, one for the technical or research oriented person and one for the more general management of lab management person."

Response 2:
"The biotechnology field is vast (as alluded to in the last question). I would say that several categories of knowledge and skills would be appropriate, with specific geared to the industry and level the student aspires to."

Response 3:
"You might also consider a Prof M.S. with various tracks, some of which might have a wet-bench component…e.g., emphasis in proteomics."

Response 4:
"There can be no ONE program to meet the needs of all students however, a program that started with "all aspects of industry" and then branched off to several specialty areas would be ideal. Specialty areas should include not only laboratory functions but also drug discovery, product development, preclinical, human factors, clinical, regulatory, and medical writing areas. Most students may be initially attracted to one aspect of a program only to find out later they are more interested in some other aspect. The needs of the local, regional and national workforce are such students should be exposed to all job functions in order to fill all the gaps. "

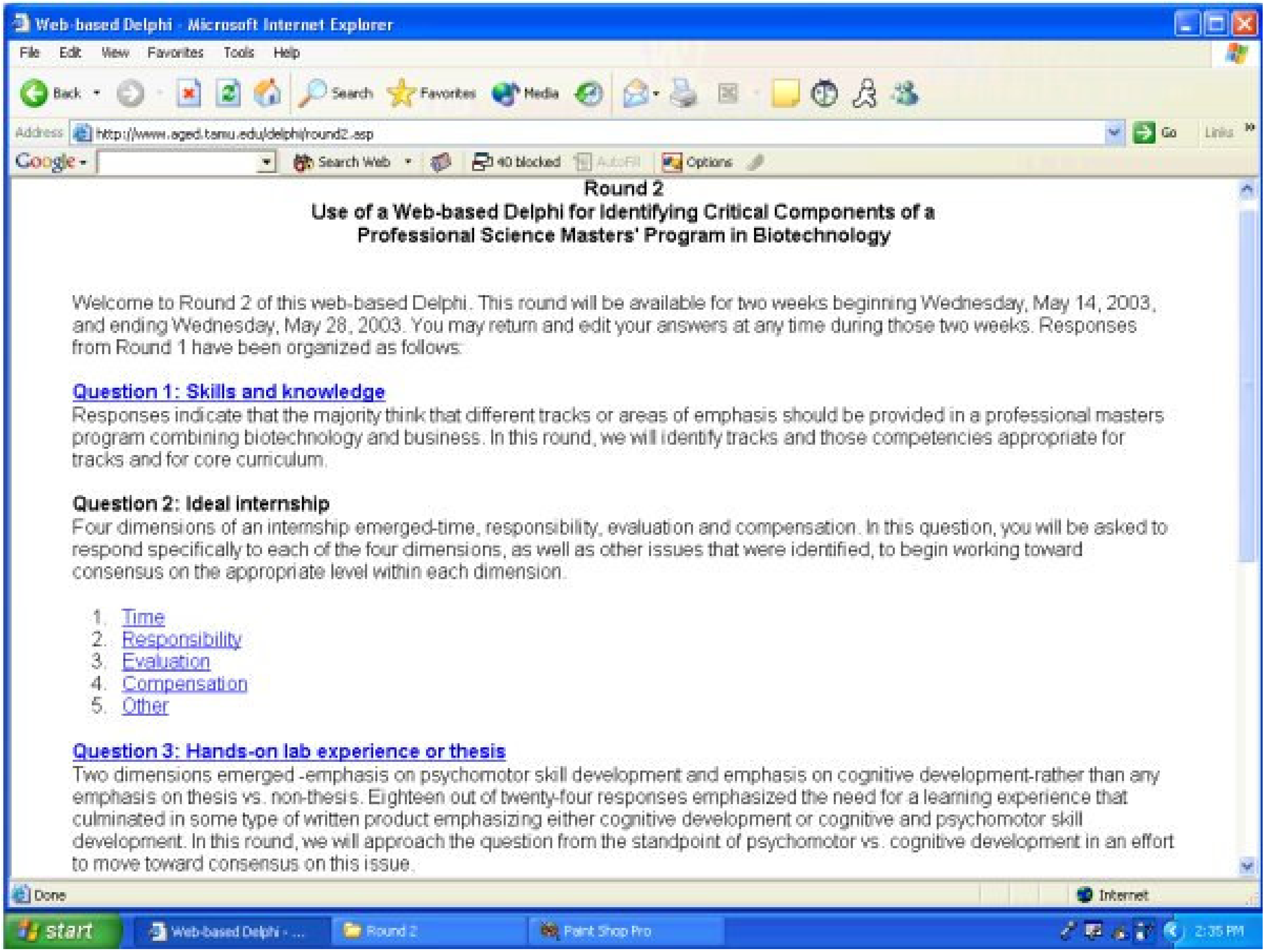
Response 5:
A separate presentation of analytical methods would have great value, however these disciplines can be very diverse and specialized. To suggest that a single graduating master's professional would need to be somewhat proficient in all techniques is ambitious. If the approach could be targeted to a particular

discipline, that may have merit and present options to the student. Examples follow:

1. QC methods, classical biotechnology:
    a. HPLC
    b. SDS-PAGE Electrophoresis and 2D gels
    c. Southern/Northern blotting
    d. Western blotting
    e. Polymerase Chain Reaction (PCR)
    f. Protein analysis (BCA/Lowery)
    g. Endotoxin analysis
2. QC methods, Cellular Therapies:
    a. Flow Cytometry
    b. Cell Counting-hemacytometer
    c. Trypan blue cell evaluation
    d. ELISA
    e. LAL
    f. Coulter-cell counter
3. Manufacturing production:
    a. Classical fermentation-prokaryotes, fungi
    b. Roller Bottle cell expansion
    c. Stirred Tank production (eukaryotic cells)
    d. Hollow fiber continuous feed systems
    e. Fluidized beds
    f. Classical chromatography
        i. Size exclusion
        ii. Ion exchange
        iii. Affinity
        iv. Etc
    g. Filtration
        i. End point
        ii. UF
        iii. DF

APPENDIX D

ROUND 2 INSTRUMENT



Round 2
Use of a Web-based Delphi for Identifying Critical Components of a Professional Science Masters' Program in Biotechnology

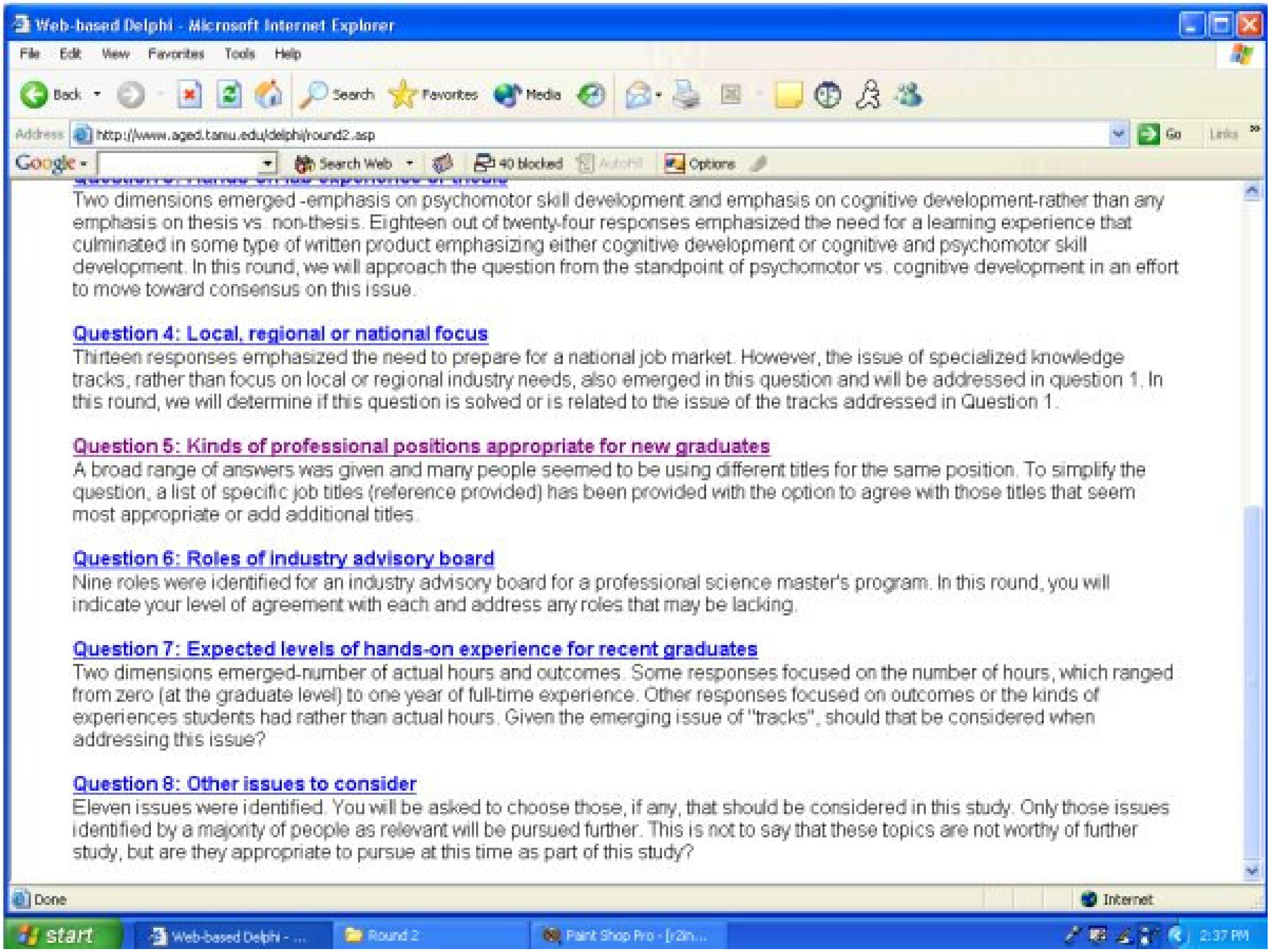
Welcome to Round 2 of this web-based Delphi. This round will be available for two weeks beginning Wednesday, May 14, 2003, and ending Wednesday, May 28, 2003. You may return and edit your answers at any time during those two weeks. Responses from Round 1 have been organized as follows:

Question 1: Skills and knowledge
Responses indicate that the majority think that different tracks or areas of emphasis should be provided in a professional masters program combining biotechnology and business. In this round, we will identify tracks and those competencies appropriate for tracks and for core curriculum.

Question 2: Ideal internship
Four dimensions of an internship emerged-time, responsibility, evaluation and compensation. In this question, you will be asked to respond specifically to each of the four dimensions, as well as other issues that were identified, to begin working toward consensus on the appropriate level within each dimension.

1. Time
2. Responsibility
3. Evaluation
4. Compensation
5. Other

Question 3: Hands-on lab experience or thesis
Two dimensions emerged -emphasis on psychomotor skill development and emphasis on cognitive development-rather than any emphasis on thesis vs. non-thesis. Eighteen out of twenty-four responses emphasized the need for a learning experience that culminated in some type of written product emphasizing either cognitive development or cognitive and psychomotor skill development. In this round, we will approach the question from the standpoint of psychomotor vs. cognitive development in an effort to move toward consensus on this issue.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Two dimensions emerged -emphasis on psychomotor skill development and emphasis on cognitive development-rather than any emphasis on thesis vs. non-thesis. Eighteen out of twenty-four responses emphasized the need for a learning experience that culminated in some type of written product emphasizing either cognitive development or cognitive and psychomotor skill development. In this round, we will approach the question from the standpoint of psychomotor vs. cognitive development in an effort to move toward consensus on this issue.
Question 4: Local, regional or national focus
Thirteen responses emphasized the need to prepare for a national job market. However, the issue of specialized knowledge tracks, rather than focus on local or regional industry needs, also emerged in this question and will be addressed in question 1. In this round, we will determine if this question is solved or is related to the issue of the tracks addressed in Question 1.
Question 5: Kinds of professional positions appropriate for new graduates
A broad range of answers was given and many people seemed to be using different titles for the same position. To simplify the question, a list of specific job titles (reference provided) has been provided with the option to agree with those titles that seem most appropriate or add additional titles.
Question 6: Roles of industry advisory board
Nine roles were identified for an industry advisory board for a professional science master's program. In this round, you will indicate your level of agreement with each and address any roles that may be lacking.
Question 7: Expected levels of hands-on experience for recent graduates
Two dimensions emerged-number of actual hours and outcomes. Some responses focused on the number of hours, which ranged from zero (at the graduate level) to one year of full-time experience. Other responses focused on outcomes or the kinds of experiences students had rather than actual hours. Given the emerging issue of "tracks", should that be considered when addressing this issue?
Question 8: Other issues to consider
Eleven issues were identified. You will be asked to choose those, if any, that should be considered in this study. Only those issues identified by a majority of people as relevant will be pursued further. This is not to say that these topics are not worthy of further study, but are they appropriate to pursue at this time as part of this study?
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Round 2
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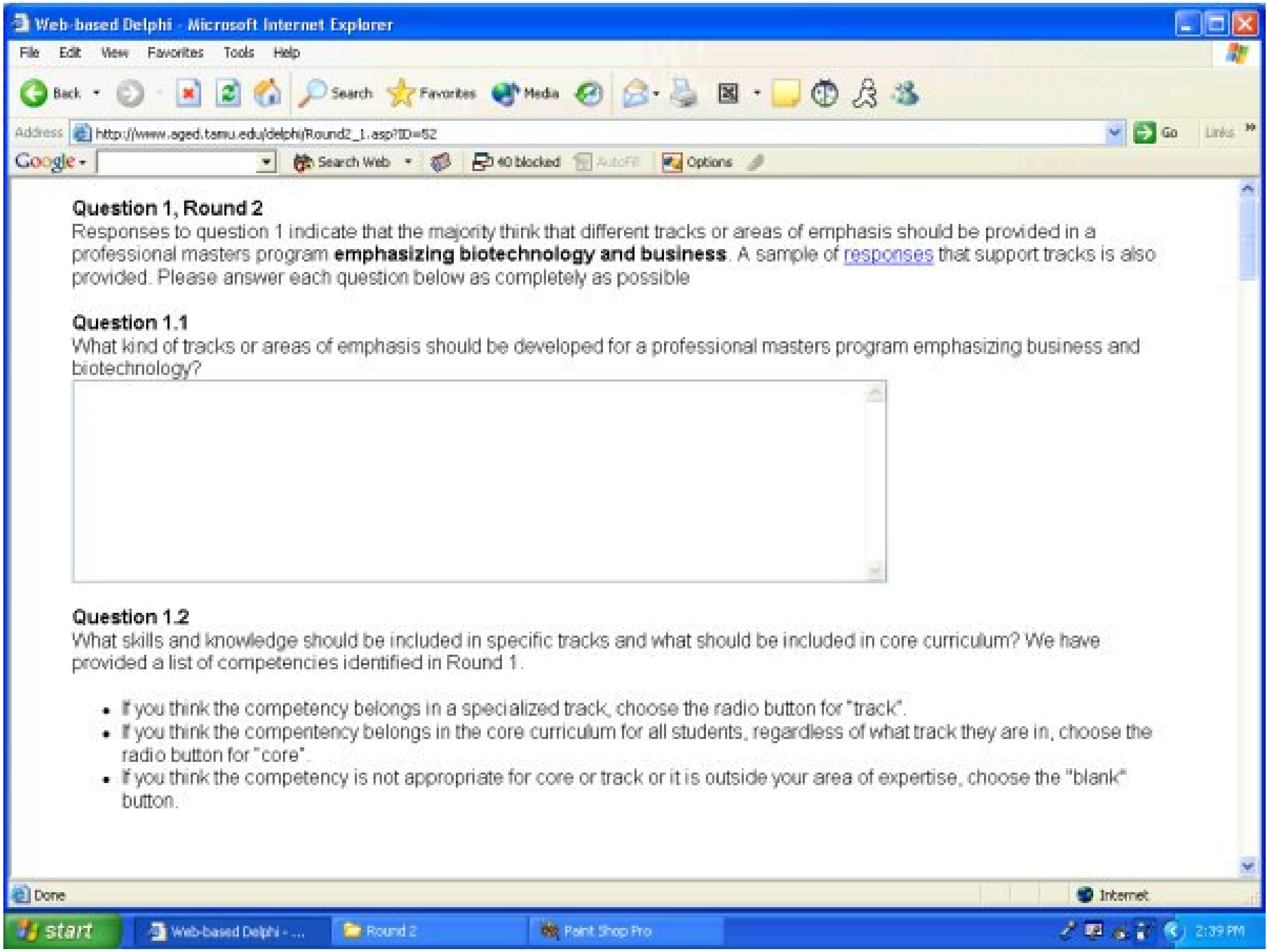
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Question 1, Round 2
Responses to question 1 indicate that the majority think that different tracks or areas of emphasis should be provided in a professional masters program **emphasizing biotechnology and business**. A sample of responses that support tracks is also provided. Please answer each question below as completely as possible
Question 1.1
What kind of tracks or areas of emphasis should be developed for a professional masters program emphasizing business and biotechnology?
Question 1.2
What skills and knowledge should be included in specific tracks and what should be included in core curriculum? We have provided a list of competencies identified in Round 1.
• If you think the competency belongs in a specialized track, choose the radio button for "track".
• If you think the compentency belongs in the core curriculum for all students, regardless of what track they are in, choose the radio button for "core".
• If you think the competency is not appropriate for core or track or it is outside your area of expertise, choose the "blank" button.
Done
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Round 2
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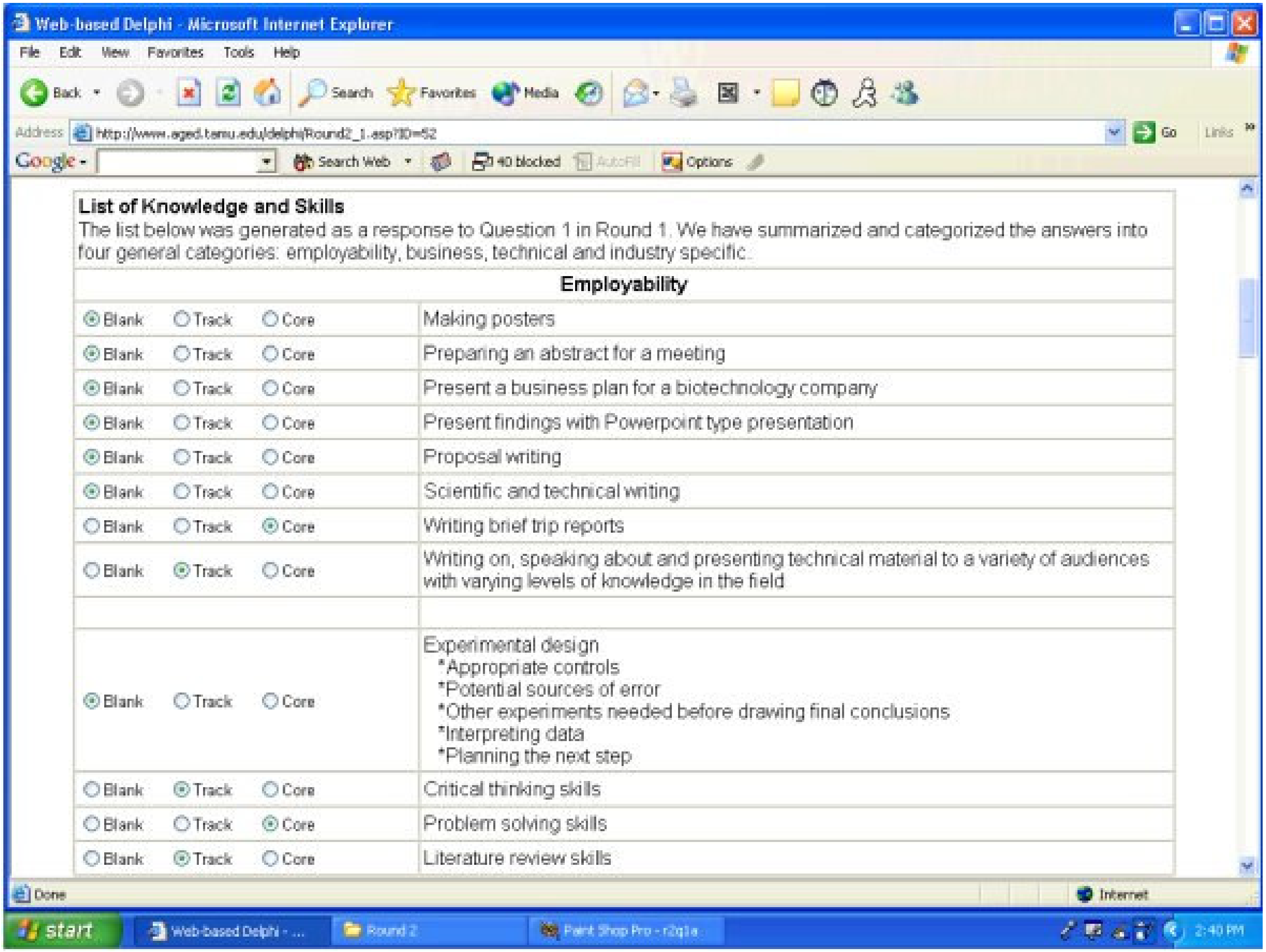
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List of Knowledge and Skills
The list below was generated as a response to Question 1 in Round 1. We have summarized and categorized the answers into four general categories: employability, business, technical and industry specific.
Employability
Blank Track Core Making posters
Blank Track Core Preparing an abstract for a meeting
Blank Track Core Present a business plan for a biotechnology company
Blank Track Core Present findings with Powerpoint type presentation
Blank Track Core Proposal writing
Blank Track Core Scientific and technical writing
Blank Track Core Writing brief trip reports
Blank Track Core Writing on, speaking about and presenting technical material to a variety of audiences with varying levels of knowledge in the field
Blank Track Core Experimental design
*Appropriate controls
*Potential sources of error
*Other experiments needed before drawing final conclusions
*Interpreting data
*Planning the next step
Blank Track Core Critical thinking skills
Blank Track Core Problem solving skills
Blank Track Core Literature review skills
Done
Internet
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Round 2
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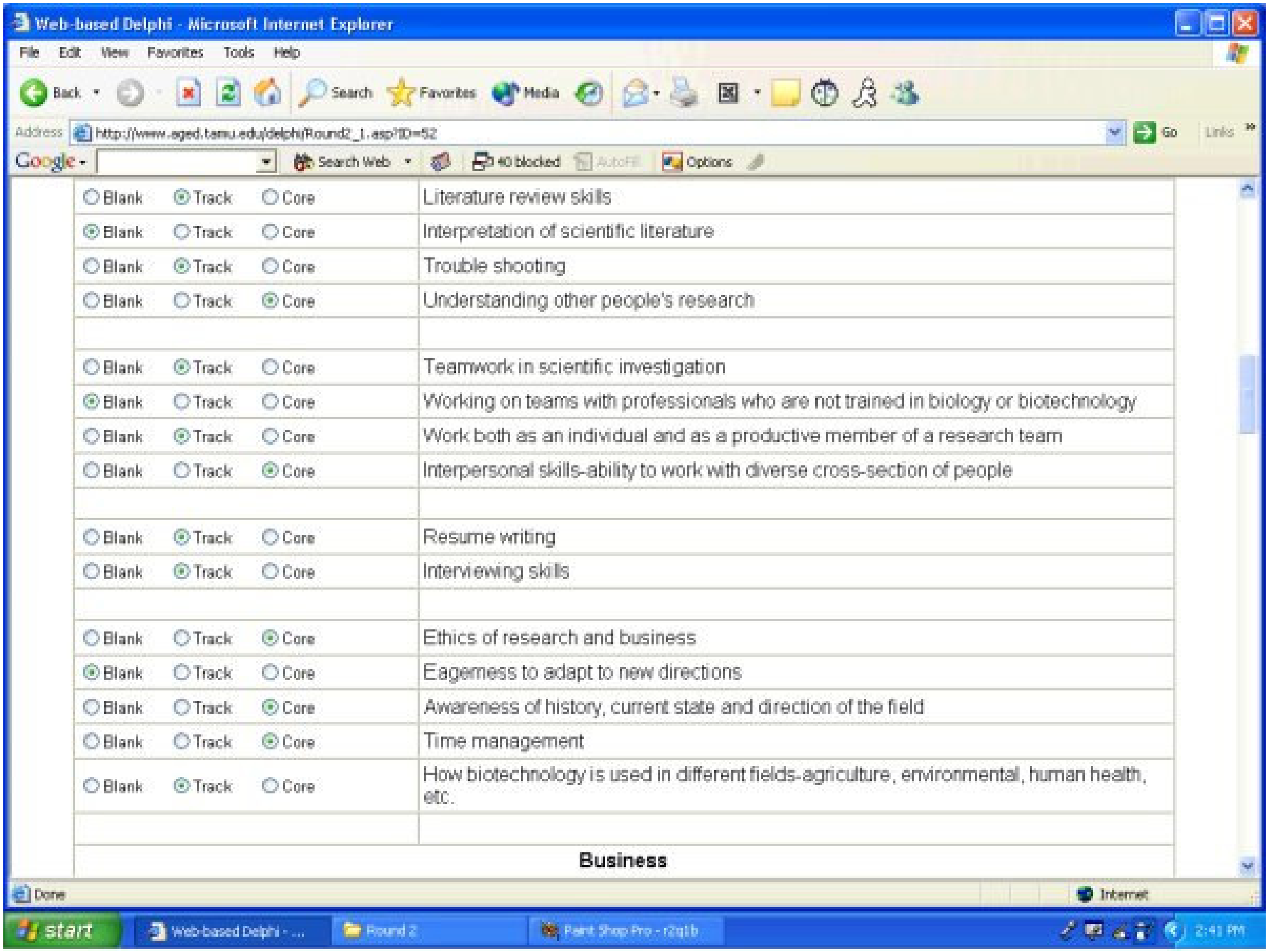
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Go Links
Google Search Web 40 blocked AutoFill Options
Blank Track Core Literature review skills
Blank Track Core Interpretation of scientific literature
Blank Track Core Trouble shooting
Blank Track Core Understanding other people's research
Blank Track Core Teamwork in scientific investigation
Blank Track Core Working on teams with professionals who are not trained in biology or biotechnology
Blank Track Core Work both as an individual and as a productive member of a research team
Blank Track Core Interpersonal skills-ability to work with diverse cross-section of people
Blank Track Core Resume writing
Blank Track Core Interviewing skills
Blank Track Core Ethics of research and business
Blank Track Core Eagerness to adapt to new directions
Blank Track Core Awareness of history, current state and direction of the field
Blank Track Core Time management
Blank Track Core How biotechnology is used in different fields-agriculture, environmental, human health, etc.
Business
Done
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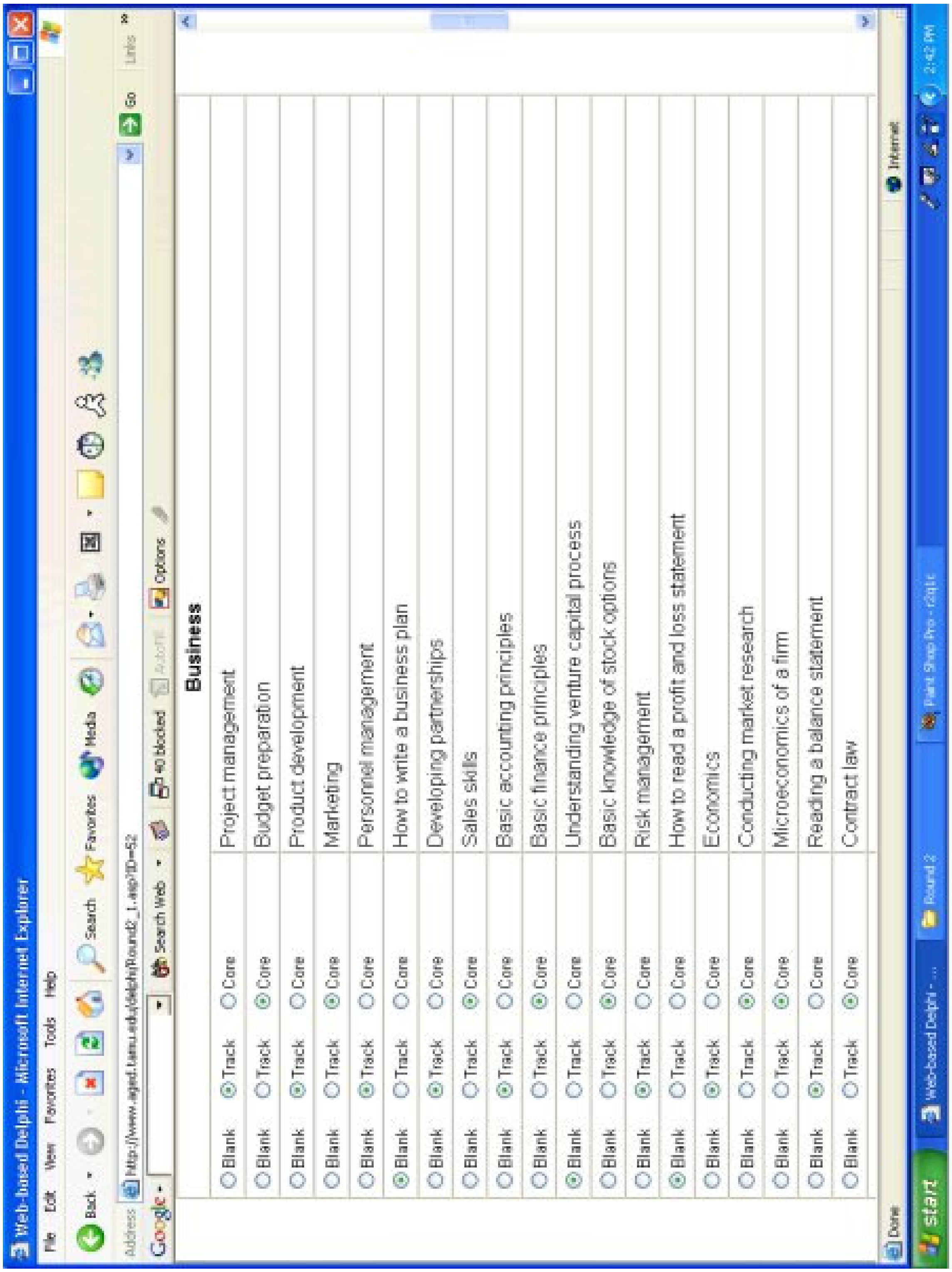
Web-based Delphi - Microsoft Internet Explorer
Business
Project management
Budget preparation
Product development
Marketing
Personnel management
How to write a business plan
Developing partnerships
Sales skills
Basic accounting principles
Basic finance principles
Understanding venture capital process
Basic knowledge of stock options
Risk management
How to read a profit and loss statement
Economics
Conducting market research
Microeconomics of a firm
Reading a balance statement
Contract law
Blank
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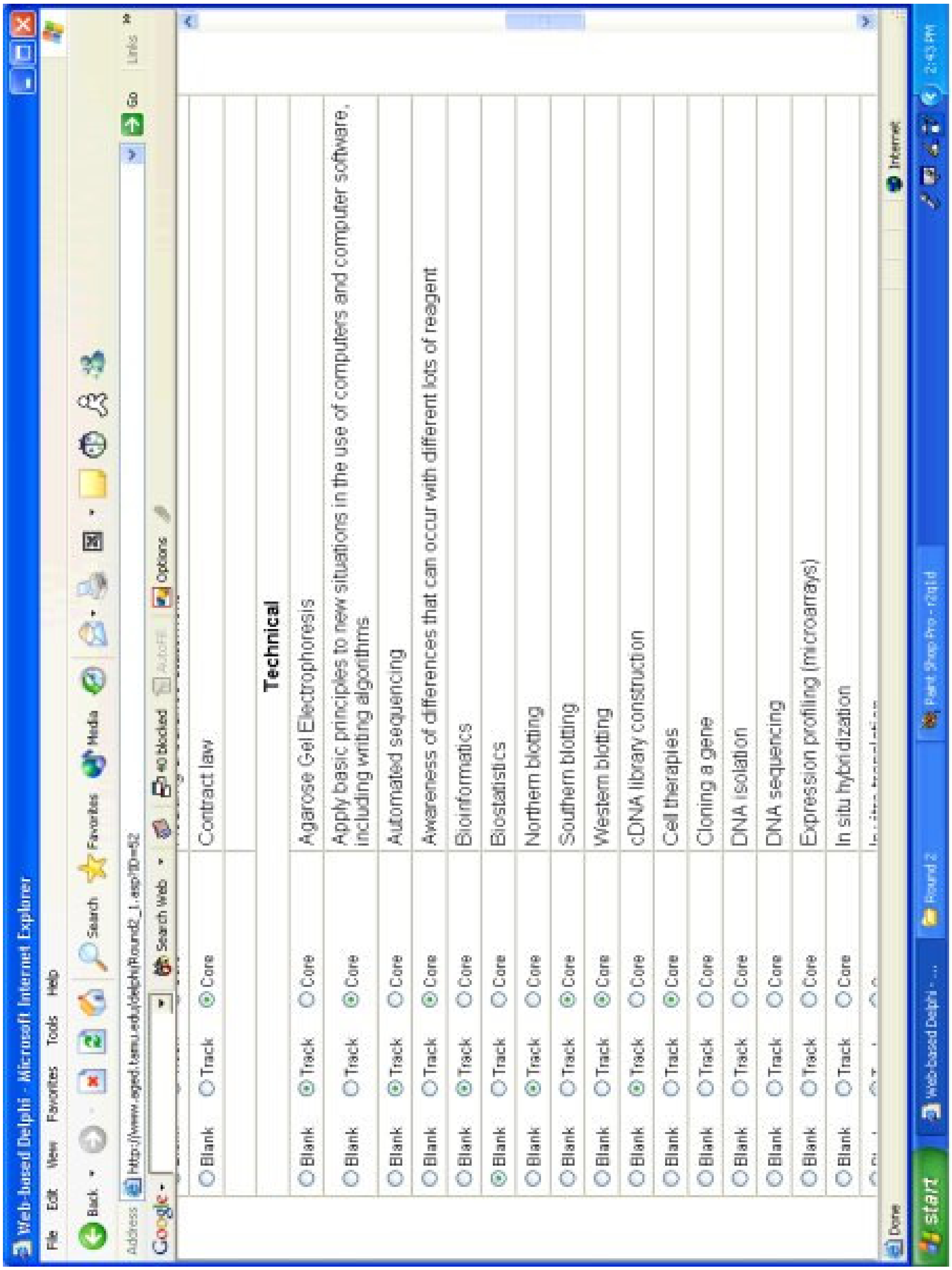
Core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Blank Track Core Contract law
Technical
Blank Track Core Agarose Gel Electrophoresis
Blank Track Core Apply basic principles to new situations in the use of computers and computer software, including writing algorithms
Blank Track Core Automated sequencing
Blank Track Core Awareness of differences that can occur with different lots of reagent
Blank Track Core Bioinformatics
Blank Track Core Biostatistics
Blank Track Core Northern blotting
Blank Track Core Southern blotting
Blank Track Core Western blotting
Blank Track Core cDNA library construction
Blank Track Core Cell therapies
Blank Track Core Cloning a gene
Blank Track Core DNA isolation
Blank Track Core DNA sequencing
Blank Track Core Expression profiling (microarrays)
Blank Track Core In situ hybridization
Done
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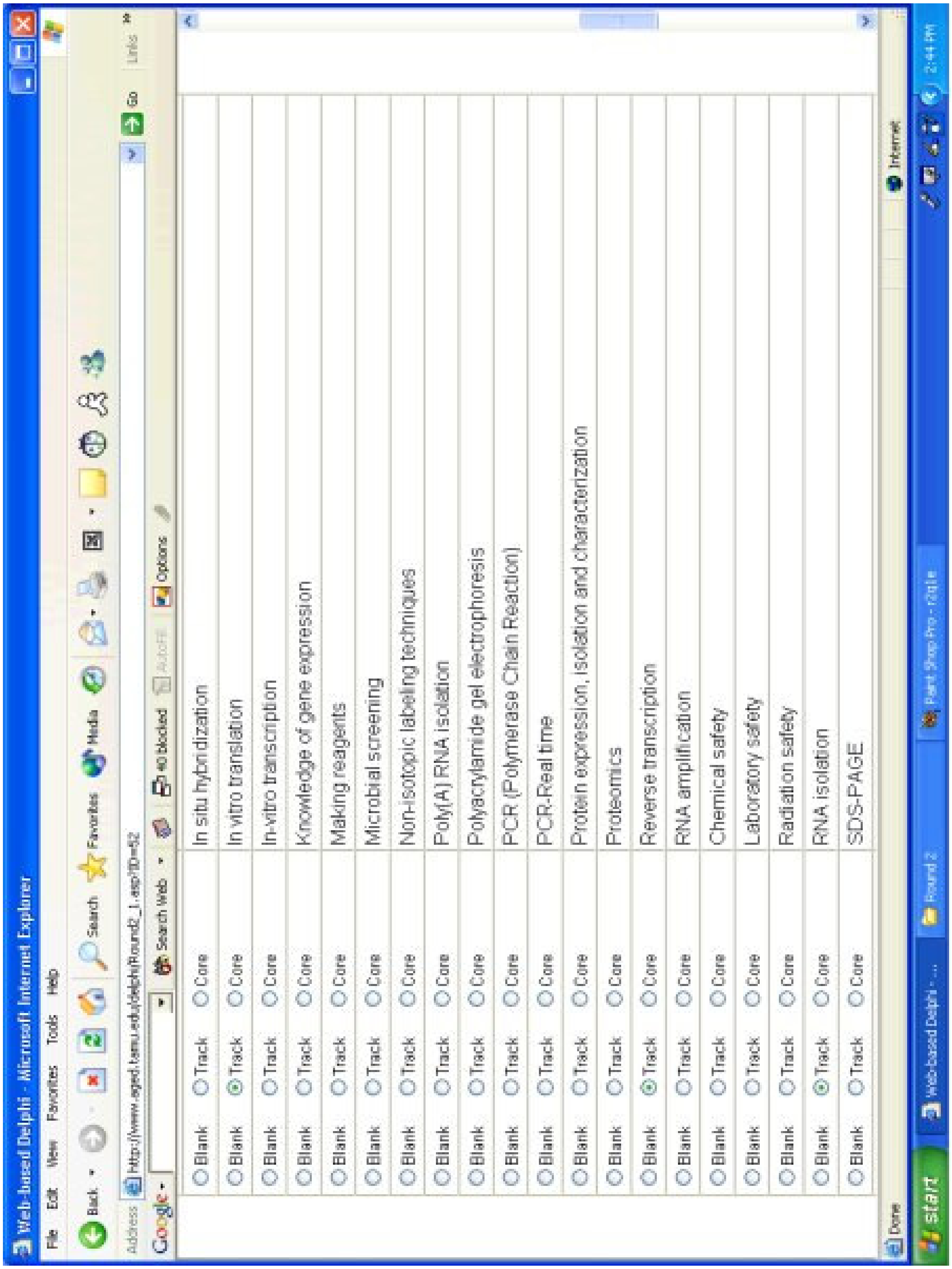
Round 2
Paint Shop Pro - r2q1d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Blank Track Core In situ hybridization
Blank Track Core In vitro translation
Blank Track Core In-vitro transcription
Blank Track Core Knowledge of gene expression
Blank Track Core Making reagents
Blank Track Core Microbial screening
Blank Track Core Non-isotopic labeling techniques
Blank Track Core Poly(A) RNA isolation
Blank Track Core Polyacrylamide gel electrophoresis
Blank Track Core PCR (Polymerase Chain Reaction)
Blank Track Core PCR-Real time
Blank Track Core Protein expression, isolation and characterization
Blank Track Core Proteomics
Blank Track Core Reverse transcription
Blank Track Core RNA amplification
Blank Track Core Chemical safety
Blank Track Core Laboratory safety
Blank Track Core Radiation safety
Blank Track Core RNA isolation
Blank Track Core SDS-PAGE
Done
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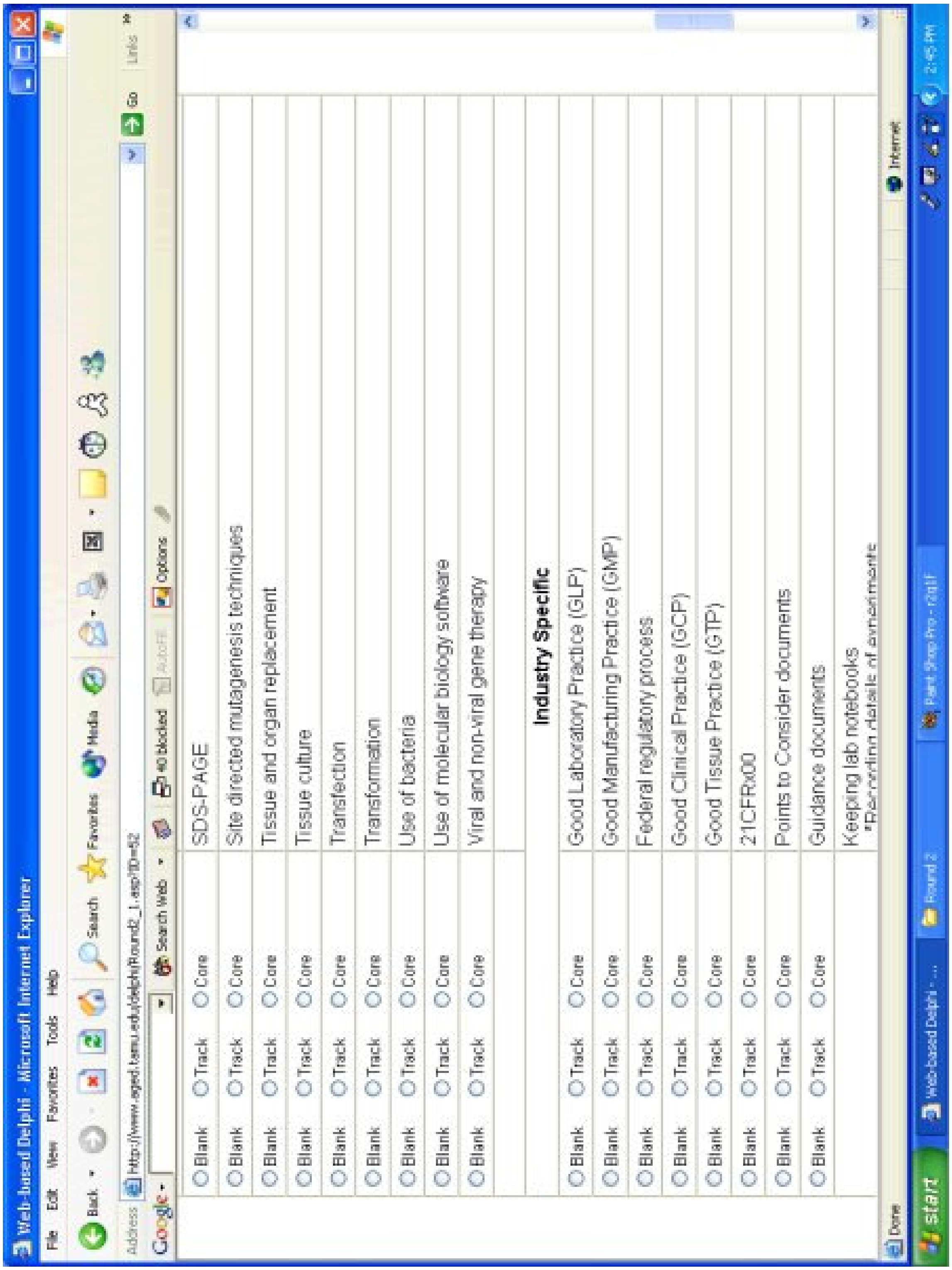
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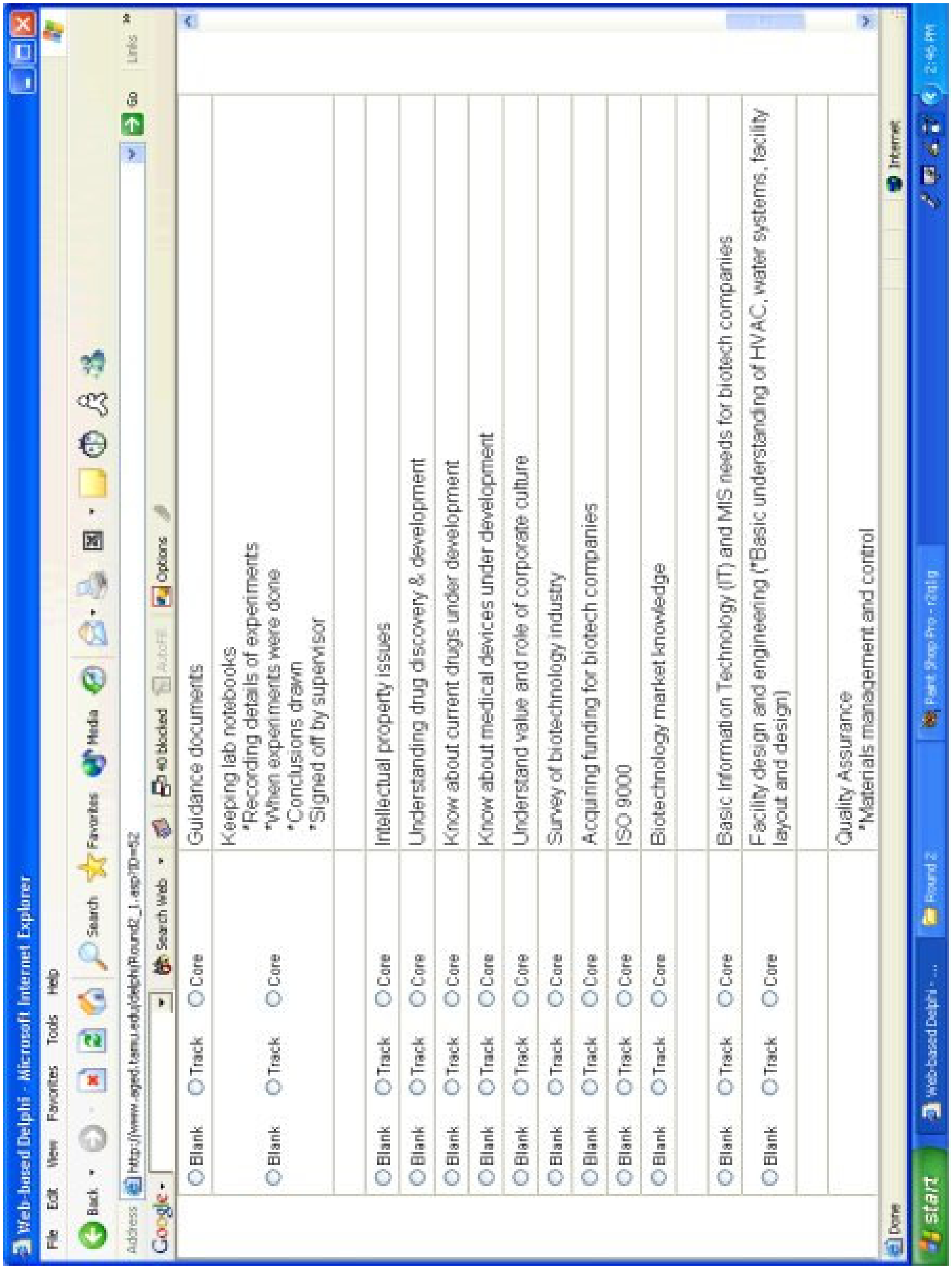
Blank Track Core SDS-PAGE
Blank Track Core Site directed mutagenesis techniques
Blank Track Core Tissue and organ replacement
Blank Track Core Tissue culture
Blank Track Core Transfection
Blank Track Core Transformation
Blank Track Core Use of bacteria
Blank Track Core Use of molecular biology software
Blank Track Core Viral and non-viral gene therapy
Industry Specific
Blank Track Core Good Laboratory Practice (GLP)
Blank Track Core Good Manufacturing Practice (GMP)
Blank Track Core Federal regulatory process
Blank Track Core Good Clinical Practice (GCP)
Blank Track Core Good Tissue Practice (GTP)
Blank Track Core 21CFRx00
Blank Track Core Points to Consider documents
Blank Track Core Guidance documents
Blank Track Core Keeping lab notebooks
Done
Internet
start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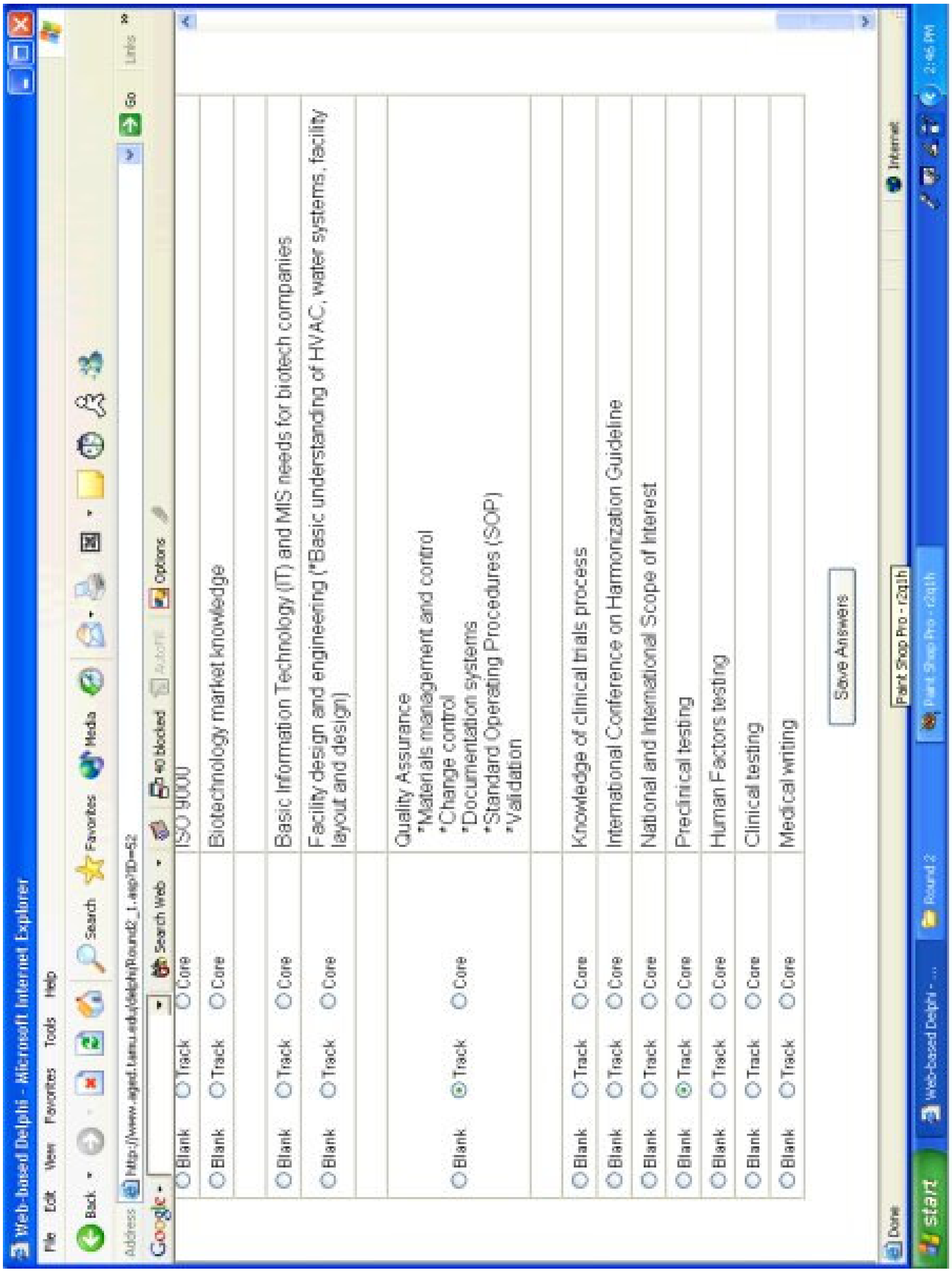
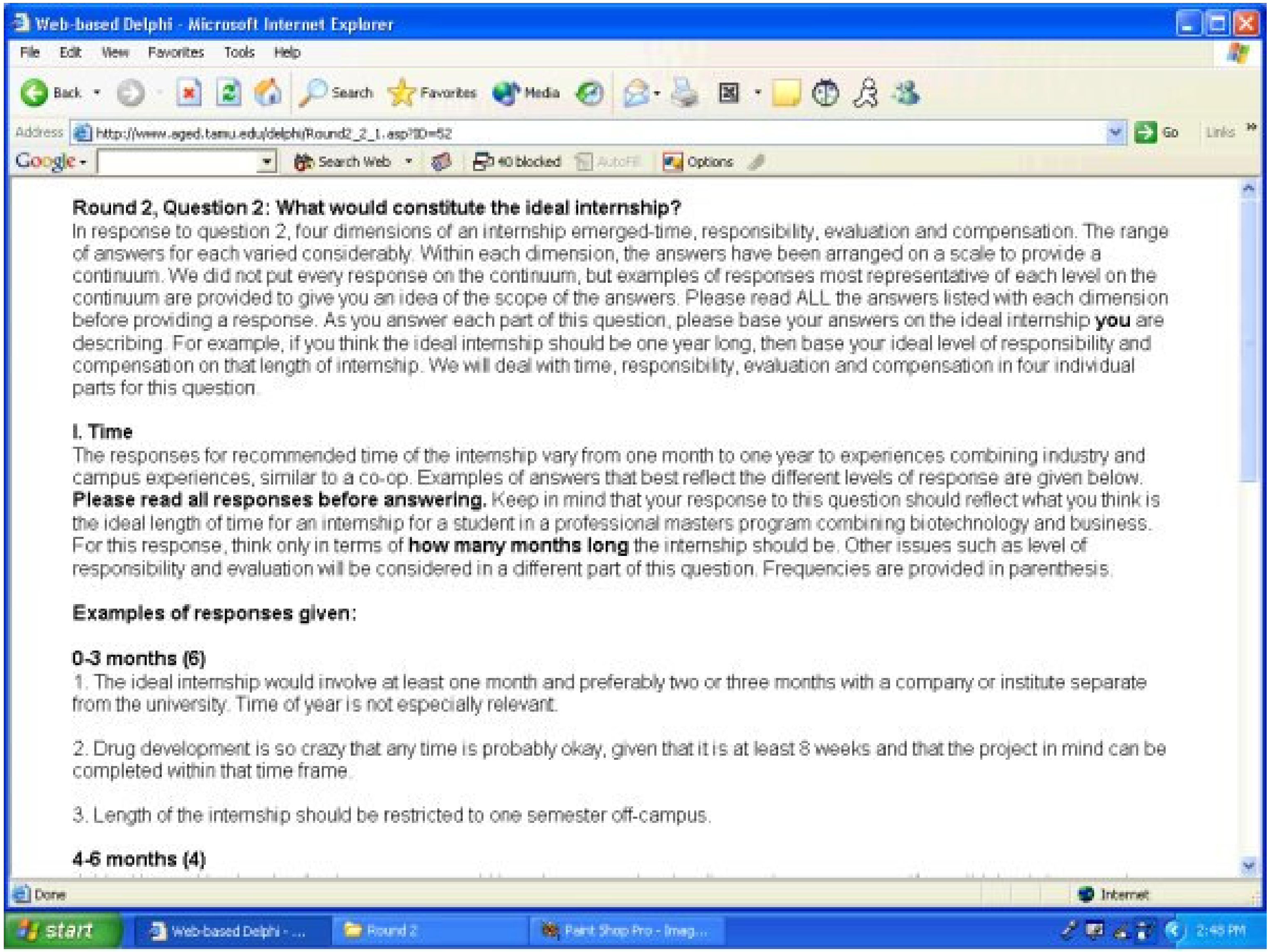
Core
Guidance documents
Keeping lab notebooks
*Recording details of experiments
*When experiments were done
*Conclusions drawn
*Signed off by supervisor
Intellectual property issues
Understanding drug discovery & development
Know about current drugs under development
Know about medical devices under development
Understand value and role of corporate culture
Survey of biotechnology industry
Acquiring funding for biotech companies
ISO 9000
Biotechnology market knowledge
Basic Information Technology (IT) and MIS needs for biotech companies
Facility design and engineering (*Basic understanding of HVAC, water systems, facility layout and design)
Quality Assurance
*Materials management and control


Web-based Delphi - Microsoft Internet Explorer
ISO 9000
Biotechnology market knowledge
Basic Information Technology (IT) and MIS needs for biotech companies
Facility design and engineering (*Basic understanding of HVAC, water systems, facility layout and design)
Quality Assurance
*Materials management and control
*Change control
*Documentation systems
*Standard Operating Procedures (SOP)
*Validation
Knowledge of clinical trials process
International Conference on Harmonization Guideline
National and International Scope of Interest
Preclinical testing
Human Factors testing
Clinical testing
Medical writing
Blank
Track
Core
Save Answers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Round 2, Question 2: What would constitute the ideal internship?
In response to question 2, four dimensions of an internship emerged-time, responsibility, evaluation and compensation. The range of answers for each varied considerably. Within each dimension, the answers have been arranged on a scale to provide a continuum. We did not put every response on the continuum, but examples of responses most representative of each level on the continuum are provided to give you an idea of the scope of the answers. Please read ALL the answers listed with each dimension before providing a response. As you answer each part of this question, please base your answers on the ideal internship you are describing. For example, if you think the ideal internship should be one year long, then base your ideal level of responsibility and compensation on that length of internship. We will deal with time, responsibility, evaluation and compensation in four individual parts for this question.
I. Time
The responses for recommended time of the internship vary from one month to one year to experiences combining industry and campus experiences, similar to a co-op. Examples of answers that best reflect the different levels of response are given below. Please read all responses before answering. Keep in mind that your response to this question should reflect what you think is the ideal length of time for an internship for a student in a professional masters program combining biotechnology and business. For this response, think only in terms of how many months long the internship should be. Other issues such as level of responsibility and evaluation will be considered in a different part of this question. Frequencies are provided in parenthesis.
Examples of responses given:
0-3 months (6)
1. The ideal internship would involve at least one month and preferably two or three months with a company or institute separate from the university. Time of year is not especially relevant.
2. Drug development is so crazy that any time is probably okay, given that it is at least 8 weeks and that the project in mind can be completed within that time frame.
3. Length of the internship should be restricted to one semester off-campus.
4-6 months (4)
Done
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4-6 months (4)
4. Ideal internship situation for the company would be a long-term situation (longer than a semester if possible) only because it takes time to train someone and it often isn't worth the time it takes to train an intern because they are with a company such a short time.

5. The internship should be very short (8 weeks) or fairly long (4-6 months). The short one keeps the time commitment from the company short to limit resource commitment but allows the student to learn some interesting things. The longer term allows the person to be adequately trained to so that he/she may actually contribute to the work. Time of year is irrelevant from the company's point of view.

Longer than 6 months (8)
6. A one year internship that is full time in the summer and preceded by part time work to set up the project and part time work afterwards to finish the project and write up the results.

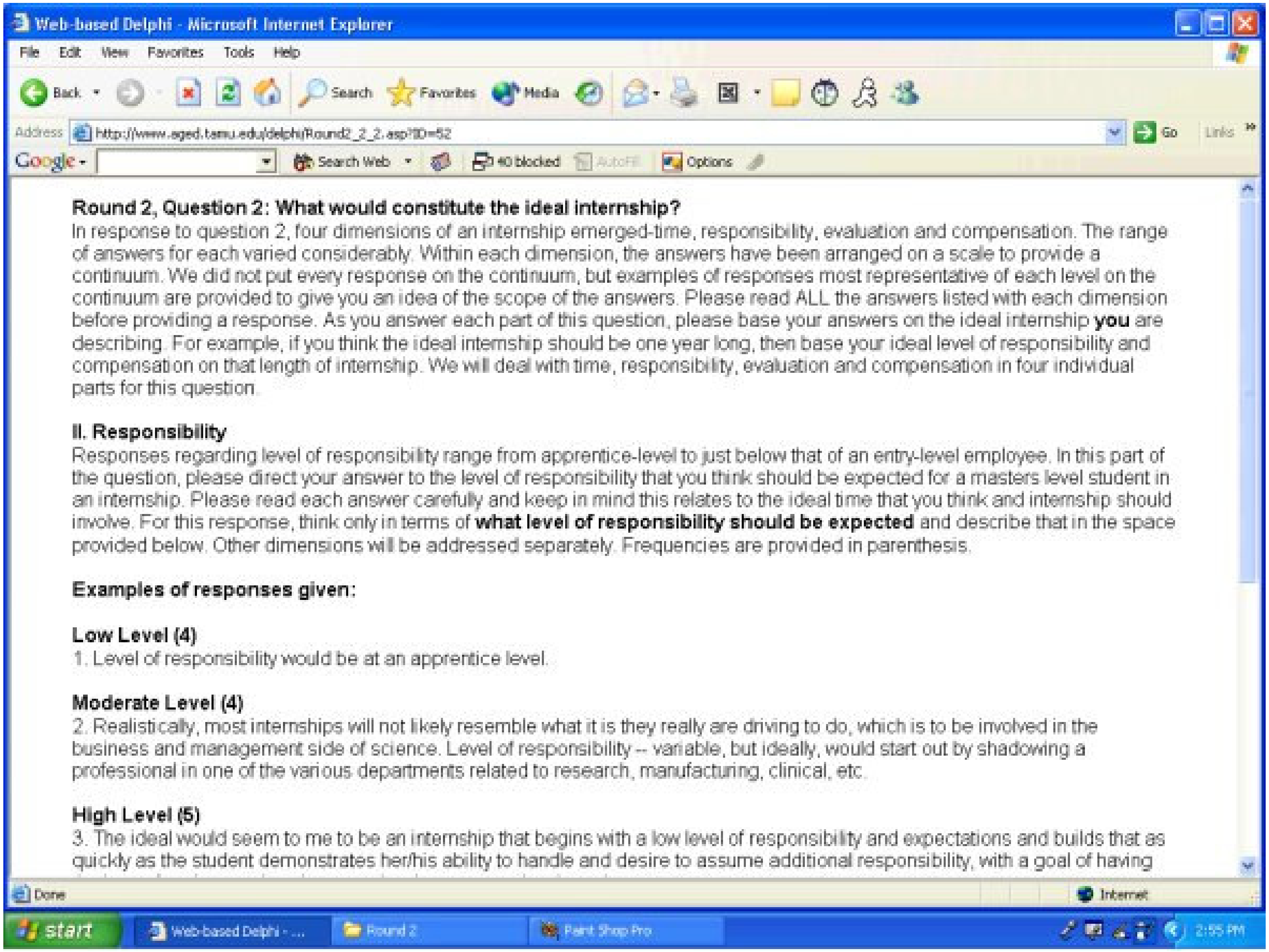
7. A rotating internship which is broken up by 1 semester of study and allows the student to return 2-3 times to the same company is ideal: example: summer- intern; fall- class; spring- intern; summer-class; fall - intern; spring-class. The reason being that this allows a student to grow and develop in level of responsibility each time they return to the company. Ideally each time they came back they would begin a new project or work in a different area of the company.

8. Two levels of internship 1. Short-term (maybe one summer term) early in program with more administrative responsibilities basically to familiarize intern with aspects of working in a corporate environment. Shorter commitment would work well for both employee and employer in cases where this is a mismatch. If intern makes it through the short-term internship, could be considered for long-term in the same field. 2. Long-term (maybe whole fall or spring semester) with higher level, functional responsibilities. This would further expose students to the corporate environment and development of their work ethic and functional skills. At the end of this, intern should be able to work at an entry level job at most biotech companies.

9. One Year Assistant to VP Business Development of a Biotech Company.

10. 3 months, 6 months, one year, doesn't matter unless the end of the internship doesn't release the student for employment (we would like the option to hire immediately following the internship).

Save Answers



Round 2, Question 2: What would constitute the ideal internship?

In response to question 2, four dimensions of an internship emerged-time, responsibility, evaluation and compensation. The range of answers for each varied considerably. Within each dimension, the answers have been arranged on a scale to provide a continuum. We did not put every response on the continuum, but examples of responses most representative of each level on the continuum are provided to give you an idea of the scope of the answers. Please read ALL the answers listed with each dimension before providing a response. As you answer each part of this question, please base your answers on the ideal internship **you** are describing. For example, if you think the ideal internship should be one year long, then base your ideal level of responsibility and compensation on that length of internship. We will deal with time, responsibility, evaluation and compensation in four individual parts for this question.

II. Responsibility

Responses regarding level of responsibility range from apprentice-level to just below that of an entry-level employee. In this part of the question, please direct your answer to the level of responsibility that you think should be expected for a masters level student in an internship. Please read each answer carefully and keep in mind this relates to the ideal time that you think and internship should involve. For this response, think only in terms of **what level of responsibility should be expected** and describe that in the space provided below. Other dimensions will be addressed separately. Frequencies are provided in parenthesis.

Examples of responses given:

Low Level (4)

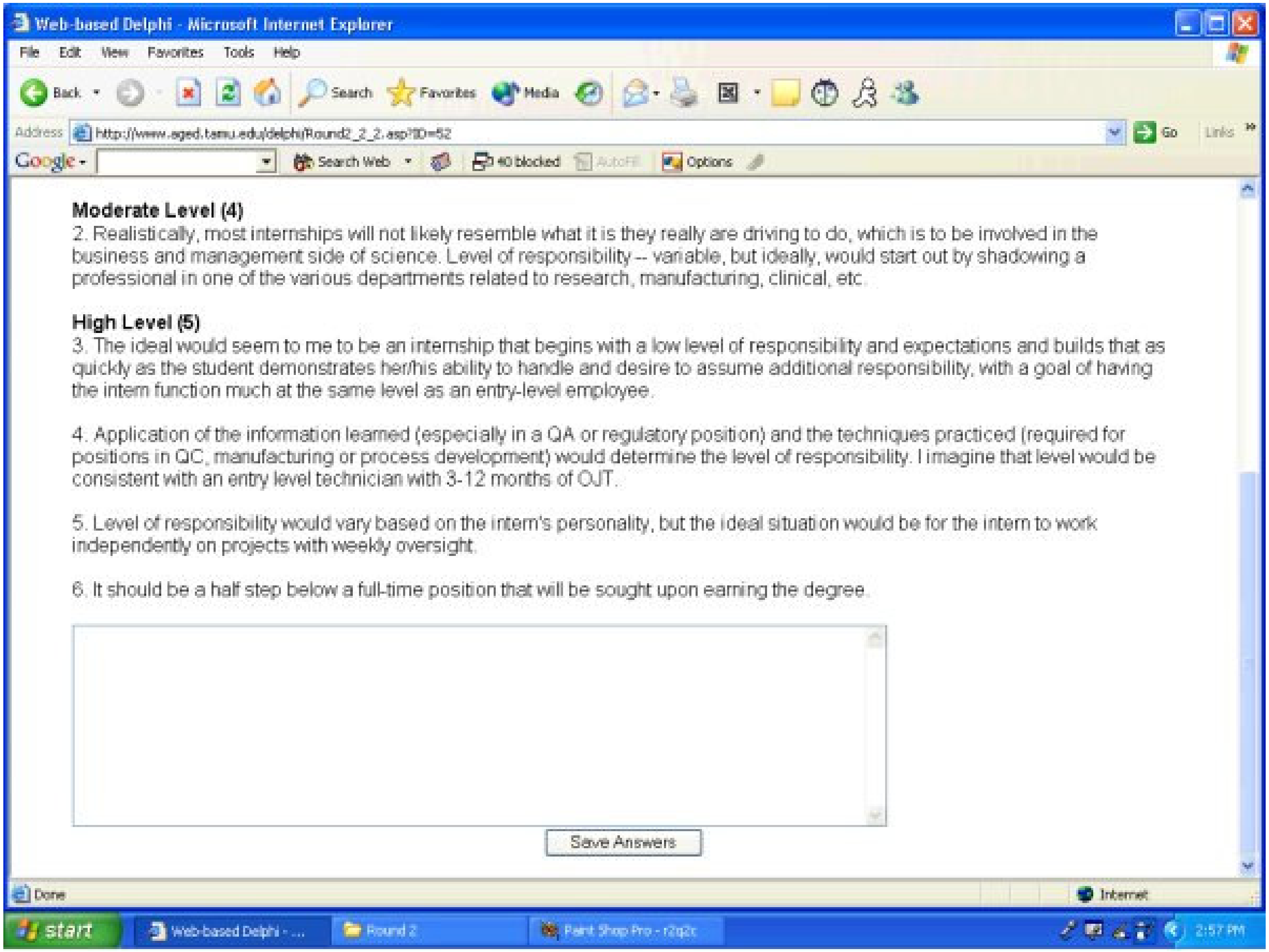
1. Level of responsibility would be at an apprentice level.

Moderate Level (4)

2. Realistically, most internships will not likely resemble what it is they really are driving to do, which is to be involved in the business and management side of science. Level of responsibility -- variable, but ideally, would start out by shadowing a professional in one of the various departments related to research, manufacturing, clinical, etc.

High Level (5)

3. The ideal would seem to me to be an internship that begins with a low level of responsibility and expectations and builds that as quickly as the student demonstrates her/his ability to handle and desire to assume additional responsibility, with a goal of having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Moderate Level (4)
2. Realistically, most internships will not likely resemble what it is they really are driving to do, which is to be involved in the business and management side of science. Level of responsibility -- variable, but ideally, would start out by shadowing a professional in one of the various departments related to research, manufacturing, clinical, etc.
High Level (5)
3. The ideal would seem to me to be an internship that begins with a low level of responsibility and expectations and builds that as quickly as the student demonstrates her/his ability to handle and desire to assume additional responsibility, with a goal of having the intern function much at the same level as an entry-level employee.
4. Application of the information learned (especially in a QA or regulatory position) and the techniques practiced (required for positions in QC, manufacturing or process development) would determine the level of responsibility. I imagine that level would be consistent with an entry level technician with 3-12 months of OJT.
5. Level of responsibility would vary based on the intern's personality, but the ideal situation would be for the intern to work independently on projects with weekly oversight.
6. It should be a half step below a full-time position that will be sought upon earning the degree.
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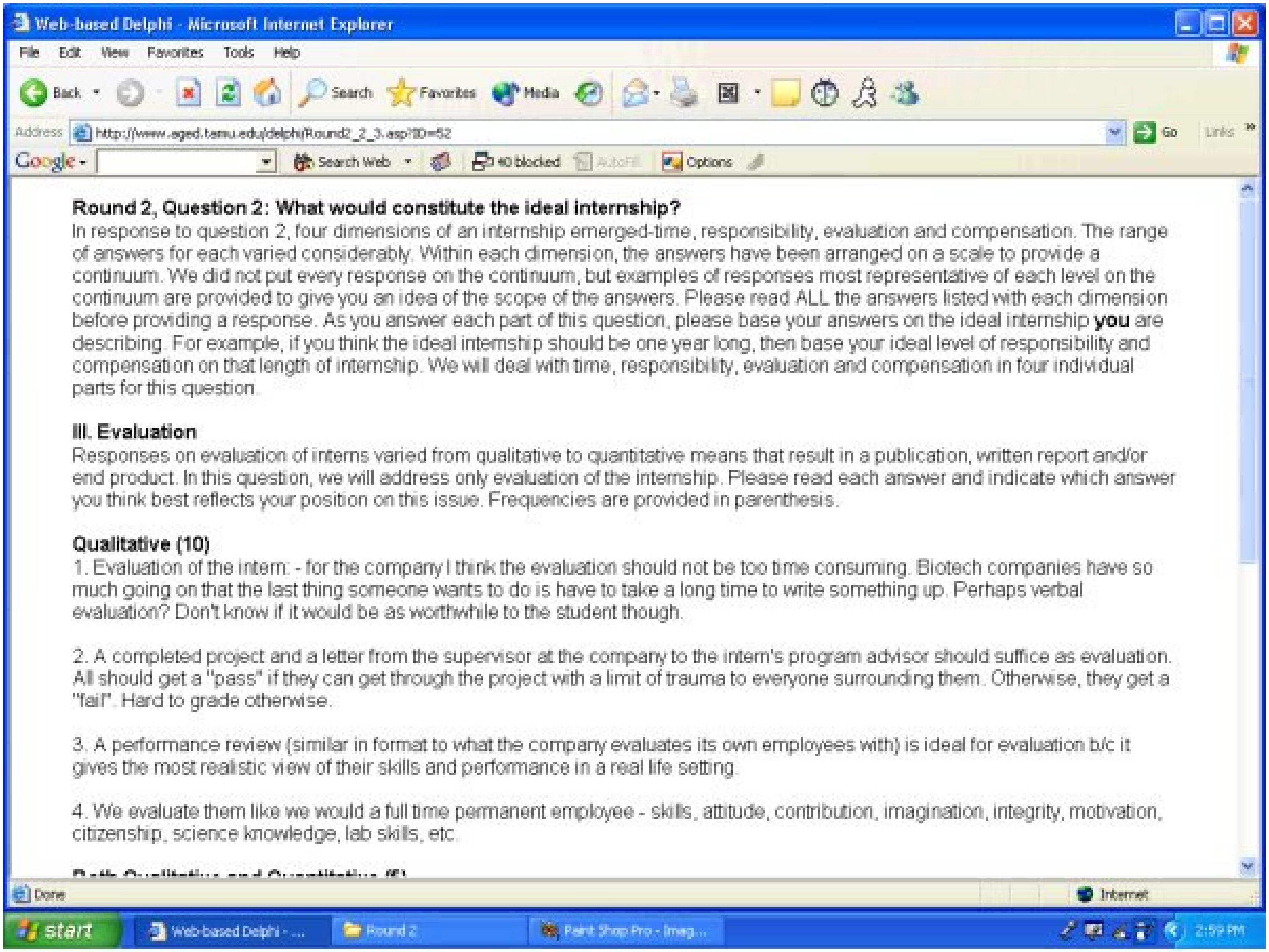

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Round 2, Question 2: What would constitute the ideal internship?

In response to question 2, four dimensions of an internship emerged-time, responsibility, evaluation and compensation. The range of answers for each varied considerably. Within each dimension, the answers have been arranged on a scale to provide a continuum. We did not put every response on the continuum, but examples of responses most representative of each level on the continuum are provided to give you an idea of the scope of the answers. Please read ALL the answers listed with each dimension before providing a response. As you answer each part of this question, please base your answers on the ideal internship **you** are describing. For example, if you think the ideal internship should be one year long, then base your ideal level of responsibility and compensation on that length of internship. We will deal with time, responsibility, evaluation and compensation in four individual parts for this question.

III. Evaluation

Responses on evaluation of interns varied from qualitative to quantitative means that result in a publication, written report and/or end product. In this question, we will address only evaluation of the internship. Please read each answer and indicate which answer you think best reflects your position on this issue. Frequencies are provided in parenthesis.

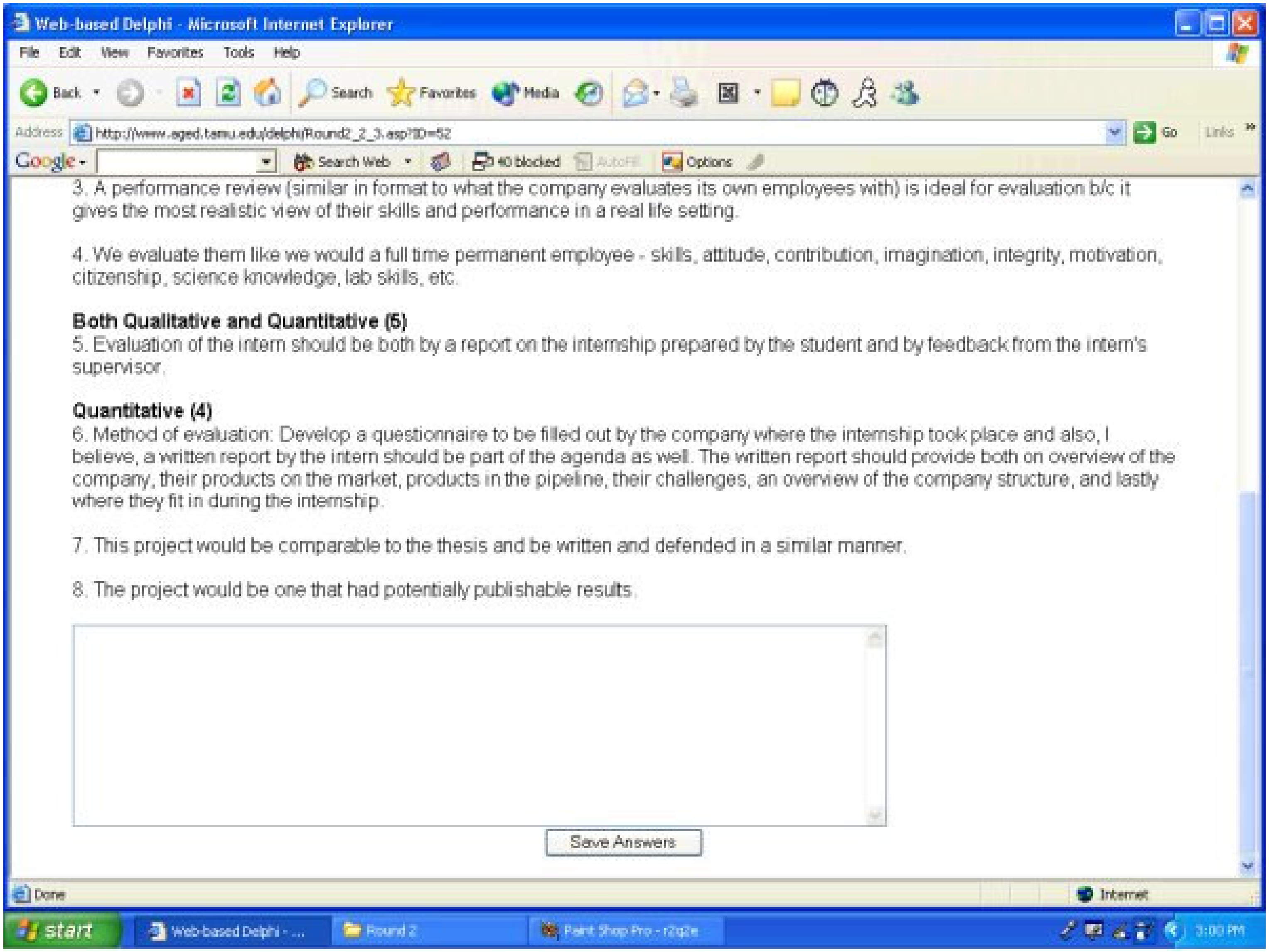
Qualitative (10)

1. Evaluation of the intern: - for the company I think the evaluation should not be too time consuming. Biotech companies have so much going on that the last thing someone wants to do is have to take a long time to write something up. Perhaps verbal evaluation? Don't know if it would be as worthwhile to the student though.

2. A completed project and a letter from the supervisor at the company to the intern's program advisor should suffice as evaluation. All should get a "pass" if they can get through the project with a limit of trauma to everyone surrounding them. Otherwise, they get a "fail". Hard to grade otherwise.

3. A performance review (similar in format to what the company evaluates its own employees with) is ideal for evaluation b/c it gives the most realistic view of their skills and performance in a real life setting.

4. We evaluate them like we would a full time permanent employee - skills, attitude, contribution, imagination, integrity, motivation, citizenship, science knowledge, lab skills, etc.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3. A performance review (similar in format to what the company evaluates its own employees with) is ideal for evaluation b/c it gives the most realistic view of their skills and performance in a real life setting.
4. We evaluate them like we would a full time permanent employee - skills, attitude, contribution, imagination, integrity, motivation, citizenship, science knowledge, lab skills, etc.
Both Qualitative and Quantitative (5)
5. Evaluation of the intern should be both by a report on the internship prepared by the student and by feedback from the intern's supervisor.
Quantitative (4)
6. Method of evaluation: Develop a questionnaire to be filled out by the company where the internship took place and also, I believe, a written report by the intern should be part of the agenda as well. The written report should provide both on overview of the company, their products on the market, products in the pipeline, their challenges, an overview of the company structure, and lastly where they fit in during the internship.
7. This project would be comparable to the thesis and be written and defended in a similar manner.
8. The project would be one that had potentially publishable results.
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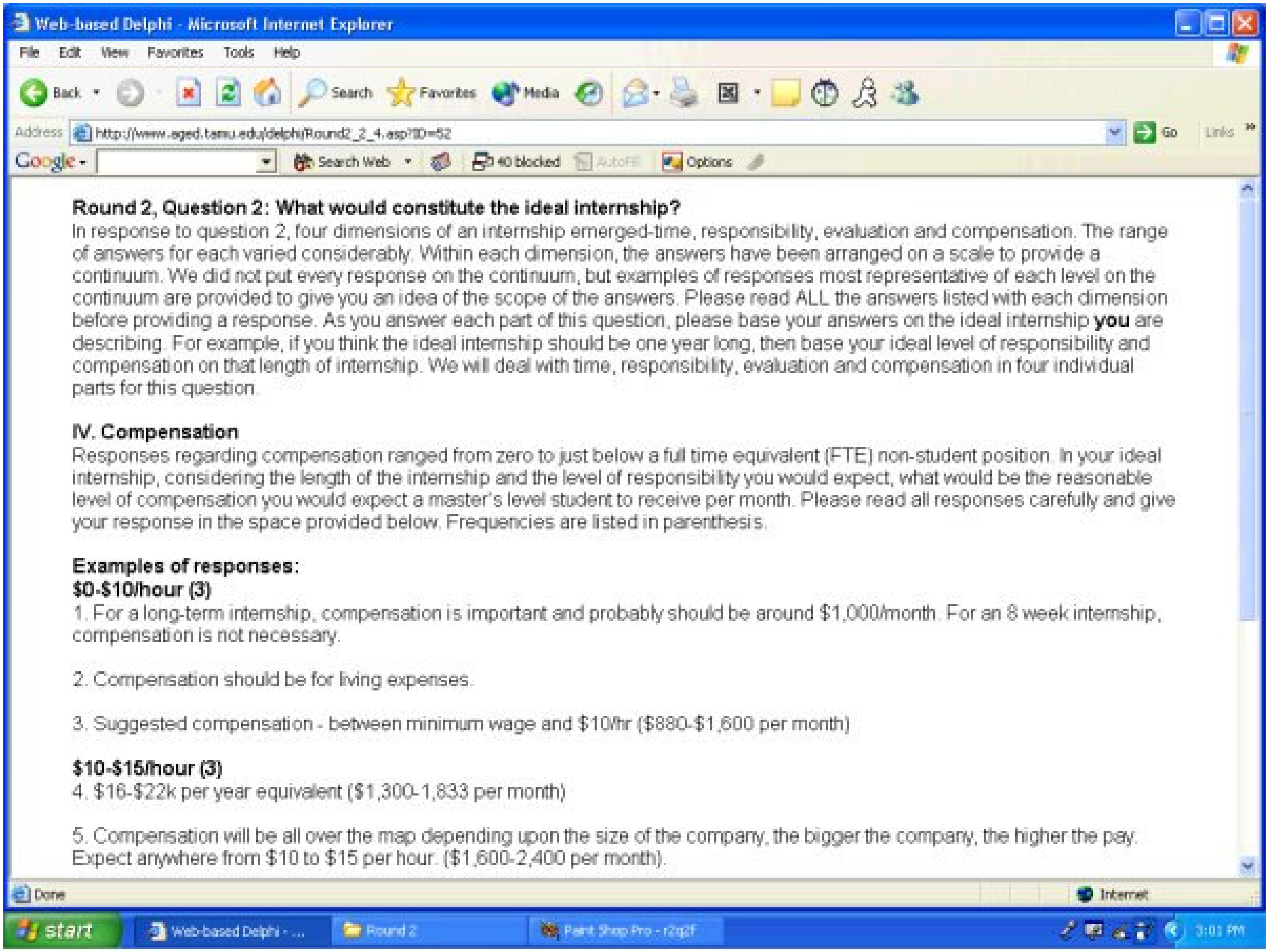

Round 2, Question 2: What would constitute the ideal internship?

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IV. Compensation

Responses regarding compensation ranged from zero to just below a full time equivalent (FTE) non-student position. In your ideal internship, considering the length of the internship and the level of responsibility you would expect, what would be the reasonable level of compensation you would expect a master's level student to receive per month. Please read all responses carefully and give your response in the space provided below. Frequencies are listed in parenthesis.

Examples of responses:

$0-$10/hour (3)

1. For a long-term internship, compensation is important and probably should be around $1,000/month. For an 8 week internship, compensation is not necessary.

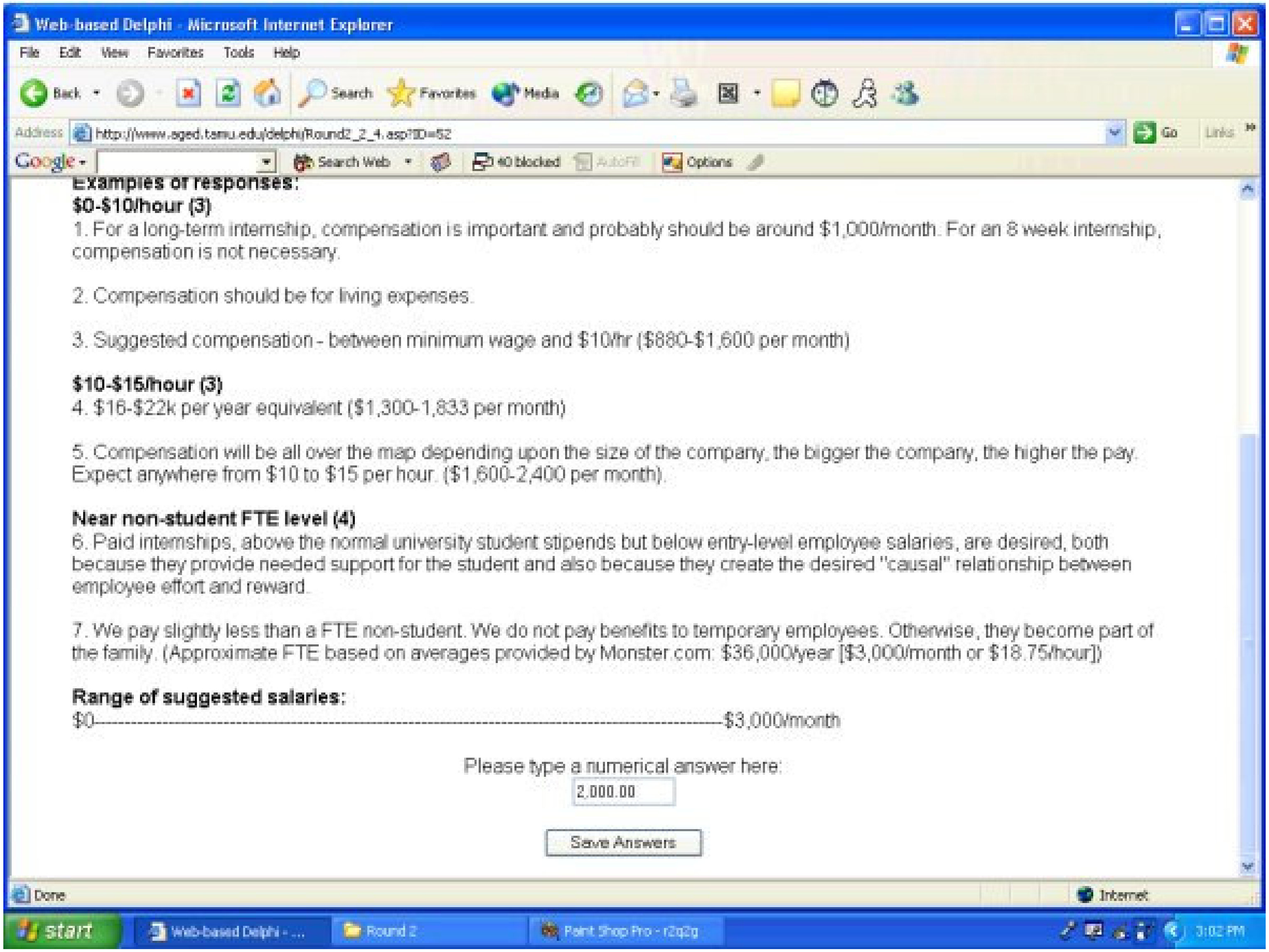
2. Compensation should be for living expenses.

3. Suggested compensation - between minimum wage and $10/hr ($880-$1,600 per month)

$10-$15/hour (3)

4. $16-$22k per year equivalent ($1,300-1,833 per month)

5. Compensation will be all over the map depending upon the size of the company, the bigger the company, the higher the pay. Expect anywhere from $10 to $15 per hour. ($1,600-2,400 per month).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Examples of responses:
$0-$10/hour (3)
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2. Compensation should be for living expenses.
3. Suggested compensation - between minimum wage and $10/hr ($880-$1,600 per month)
$10-$15/hour (3)
4. $16-$22k per year equivalent ($1,300-1,833 per month)
5. Compensation will be all over the map depending upon the size of the company, the bigger the company, the higher the pay. Expect anywhere from $10 to $15 per hour. ($1,600-2,400 per month).
Near non-student FTE level (4)
6. Paid internships, above the normal university student stipends but below entry-level employee salaries, are desired, both because they provide needed support for the student and also because they create the desired "causal" relationship between employee effort and reward.
7. We pay slightly less than a FTE non-student. We do not pay benefits to temporary employees. Otherwise, they become part of the family. (Approximate FTE based on averages provided by Monster.com: $36,000/year [$3,000/month or $18.75/hour])
Range of suggested salaries:
$0--$3,000/month
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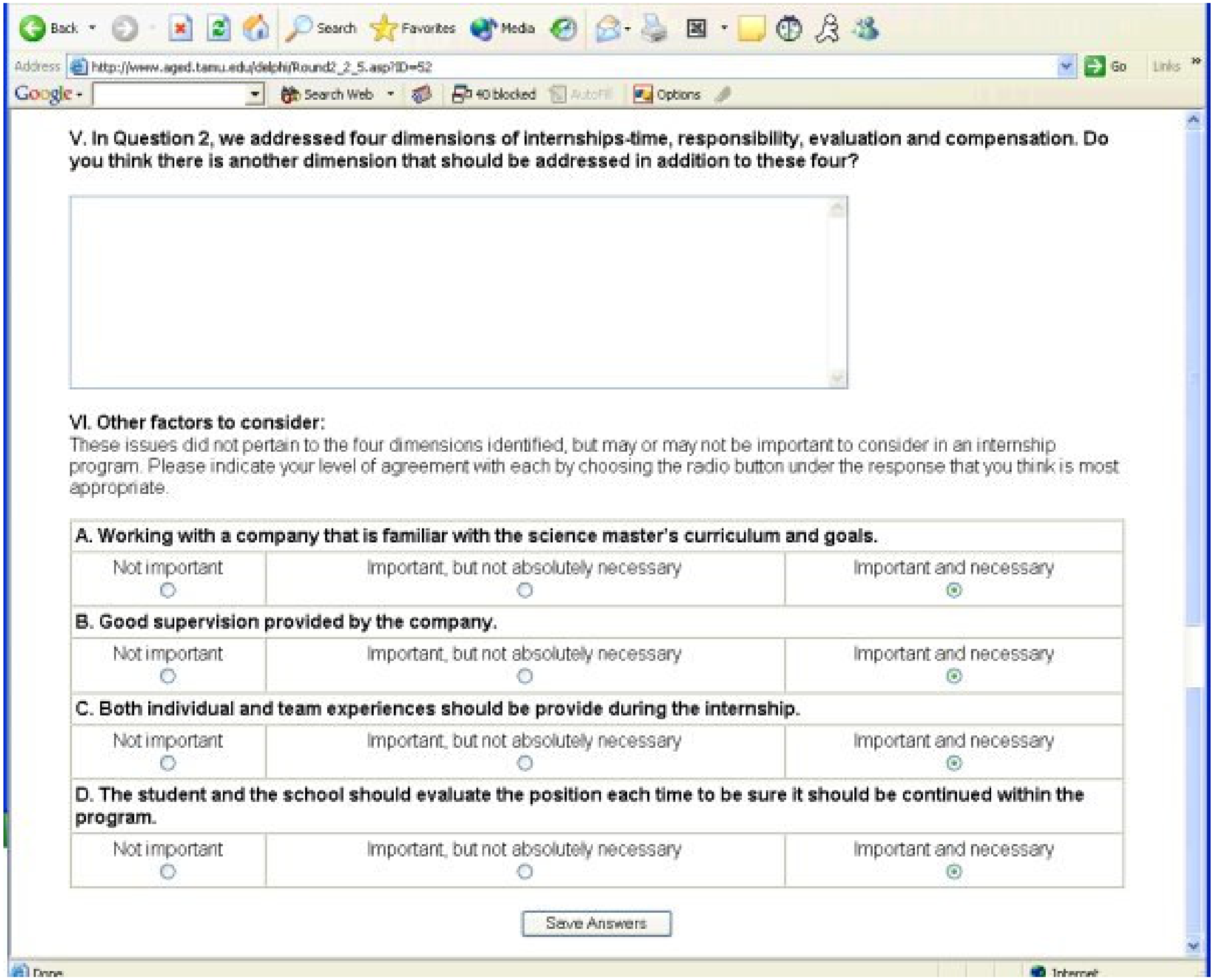
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V. In Question 2, we addressed four dimensions of internships-time, responsibility, evaluation and compensation. Do you think there is another dimension that should be addressed in addition to these four?

VI. Other factors to consider:
These issues did not pertain to the four dimensions identified, but may or may not be important to consider in an internship program. Please indicate your level of agreement with each by choosing the radio button under the response that you think is most appropriate.

A. Working with a company that is familiar with the science master's curriculum and goals.		
Not important	Important, but not absolutely necessary	Important and necessary
B. Good supervision provided by the company.		
Not important	Important, but not absolutely necessary	Important and necessary
C. Both individual and team experiences should be provide during the internship.		
Not important	Important, but not absolutely necessary	Important and necessary
D. The student and the school should evaluate the position each time to be sure it should be continued within the program.		
Not important	Important, but not absolutely necessary	Important and necessary

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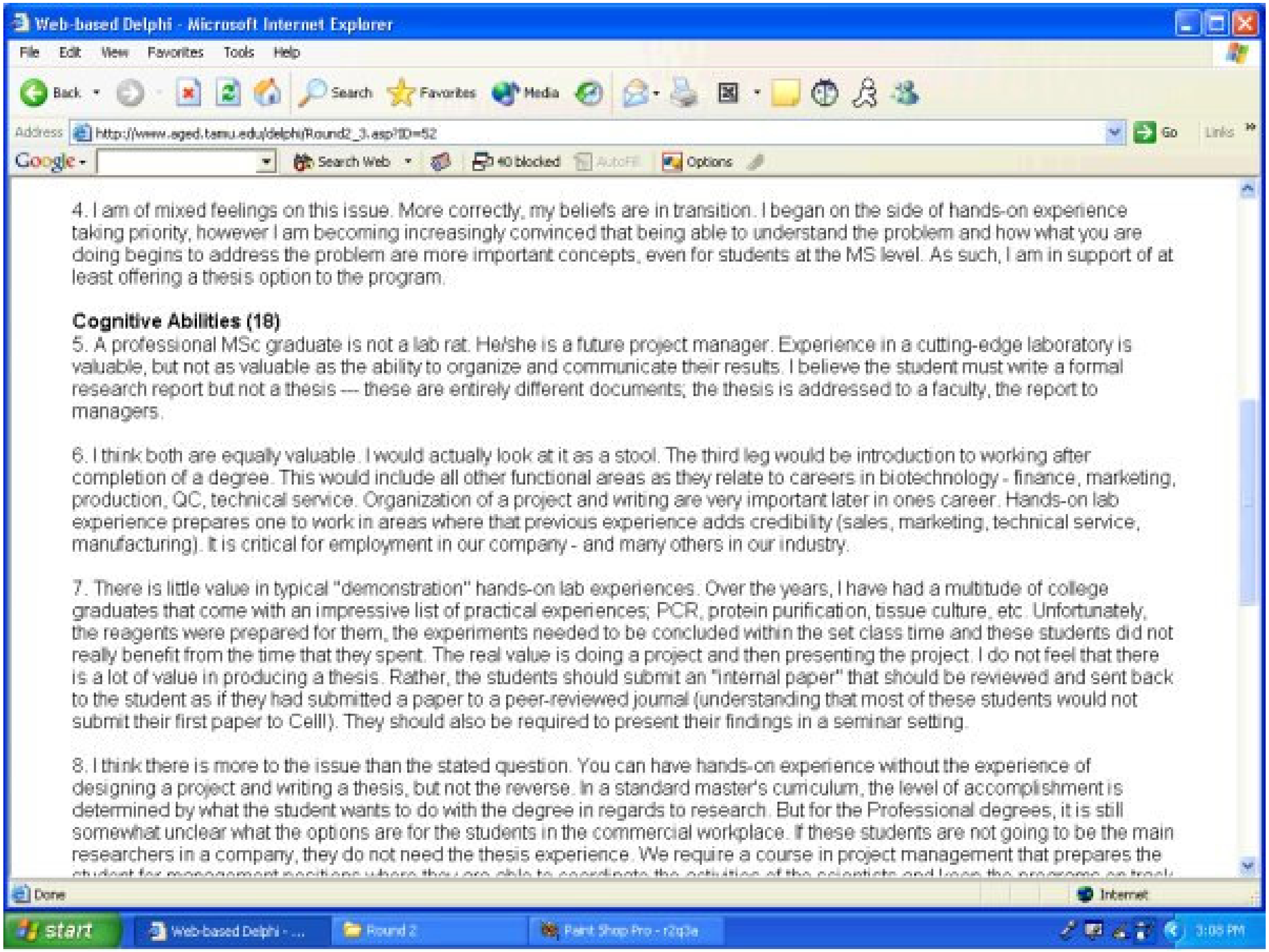


4. I am of mixed feelings on this issue. More correctly, my beliefs are in transition. I began on the side of hands-on experience taking priority, however I am becoming increasingly convinced that being able to understand the problem and how what you are doing begins to address the problem are more important concepts, even for students at the MS level. As such, I am in support of at least offering a thesis option to the program.

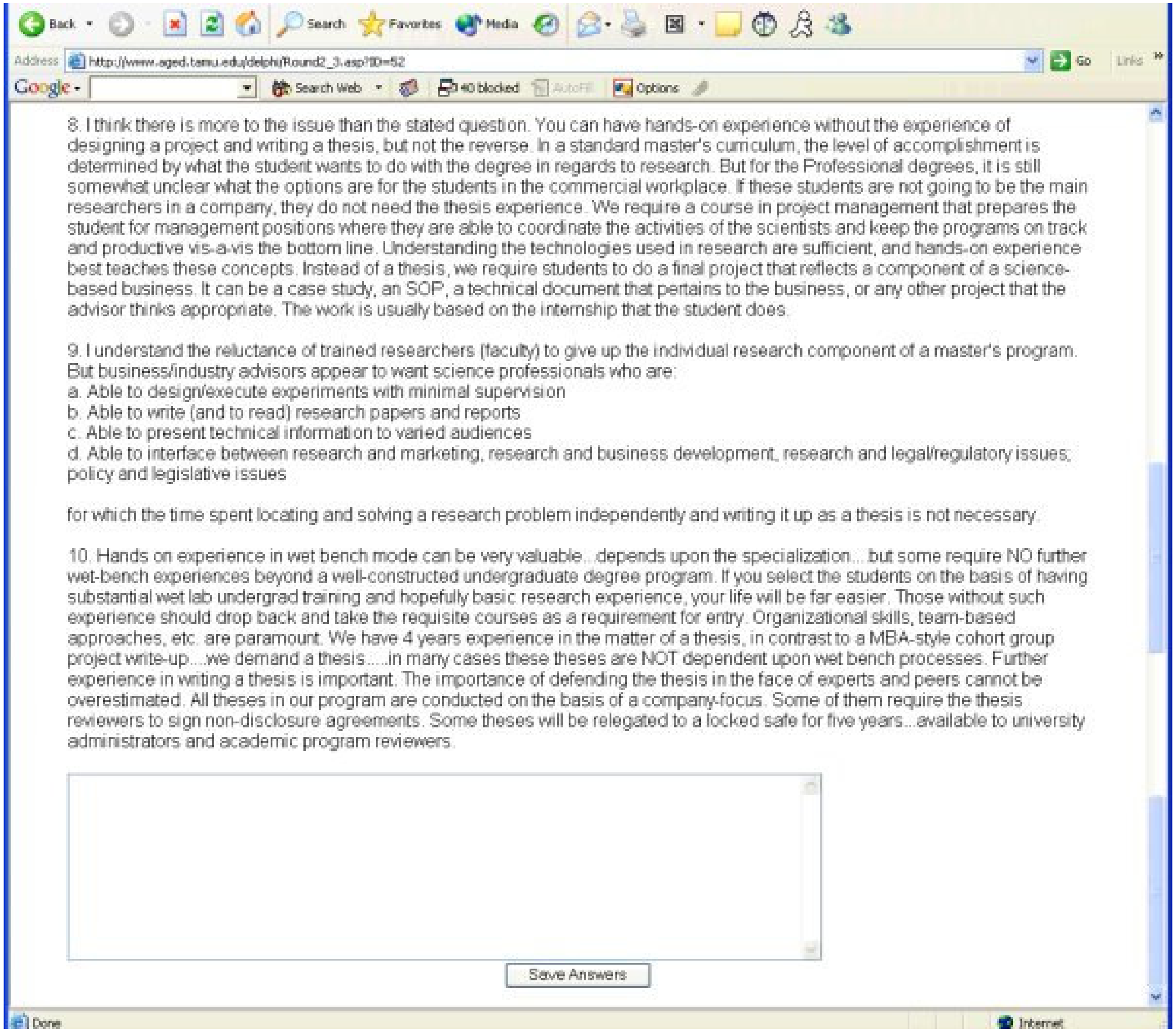
Cognitive Abilities (18)

5. A professional MSc graduate is not a lab rat. He/she is a future project manager. Experience in a cutting-edge laboratory is valuable, but not as valuable as the ability to organize and communicate their results. I believe the student must write a formal research report but not a thesis --- these are entirely different documents; the thesis is addressed to a faculty, the report to managers.

6. I think both are equally valuable. I would actually look at it as a stool. The third leg would be introduction to working after completion of a degree. This would include all other functional areas as they relate to careers in biotechnology - finance, marketing, production, QC, technical service. Organization of a project and writing are very important later in ones career. Hands-on lab experience prepares one to work in areas where that previous experience adds credibility (sales, marketing, technical service, manufacturing). It is critical for employment in our company - and many others in our industry.

7. There is little value in typical "demonstration" hands-on lab experiences. Over the years, I have had a multitude of college graduates that come with an impressive list of practical experiences; PCR, protein purification, tissue culture, etc. Unfortunately, the reagents were prepared for them, the experiments needed to be concluded within the set class time and these students did not really benefit from the time that they spent. The real value is doing a project and then presenting the project. I do not feel that there is a lot of value in producing a thesis. Rather, the students should submit an "internal paper" that should be reviewed and sent back to the student as if they had submitted a paper to a peer-reviewed journal (understanding that most of these students would not submit their first paper to Celll). They should also be required to present their findings in a seminar setting.

8. I think there is more to the issue than the stated question. You can have hands-on experience without the experience of designing a project and writing a thesis, but not the reverse. In a standard master's curriculum, the level of accomplishment is determined by what the student wants to do with the degree in regards to research. But for the Professional degrees, it is still somewhat unclear what the options are for the students in the commercial workplace. If these students are not going to be the main researchers in a company, they do not need the thesis experience. We require a course in project management that prepares the



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8. I think there is more to the issue than the stated question. You can have hands-on experience without the experience of designing a project and writing a thesis, but not the reverse. In a standard master's curriculum, the level of accomplishment is determined by what the student wants to do with the degree in regards to research. But for the Professional degrees, it is still somewhat unclear what the options are for the students in the commercial workplace. If these students are not going to be the main researchers in a company, they do not need the thesis experience. We require a course in project management that prepares the student for management positions where they are able to coordinate the activities of the scientists and keep the programs on track and productive vis-a-vis the bottom line. Understanding the technologies used in research are sufficient, and hands-on experience best teaches these concepts. Instead of a thesis, we require students to do a final project that reflects a component of a science-based business. It can be a case study, an SOP, a technical document that pertains to the business, or any other project that the advisor thinks appropriate. The work is usually based on the internship that the student does.

9. I understand the reluctance of trained researchers (faculty) to give up the individual research component of a master's program. But business/industry advisors appear to want science professionals who are:
a. Able to design/execute experiments with minimal supervision
b. Able to write (and to read) research papers and reports
c. Able to present technical information to varied audiences
d. Able to interface between research and marketing, research and business development, research and legal/regulatory issues; policy and legislative issues

for which the time spent locating and solving a research problem independently and writing it up as a thesis is not necessary.

10. Hands on experience in wet bench mode can be very valuable...depends upon the specialization....but some require NO further wet-bench experiences beyond a well-constructed undergraduate degree program. If you select the students on the basis of having substantial wet lab undergrad training and hopefully basic research experience, your life will be far easier. Those without such experience should drop back and take the requisite courses as a requirement for entry. Organizational skills, team-based approaches, etc. are paramount. We have 4 years experience in the matter of a thesis, in contrast to a MBA-style cohort group project write-up....we demand a thesis.....in many cases these theses are NOT dependent upon wet bench processes. Further experience in writing a thesis is important. The importance of defending the thesis in the face of experts and peers cannot be overestimated. All theses in our program are conducted on the basis of a company-focus. Some of them require the thesis reviewers to sign non-disclosure agreements. Some theses will be relegated to a locked safe for five years...available to university administrators and academic program reviewers.

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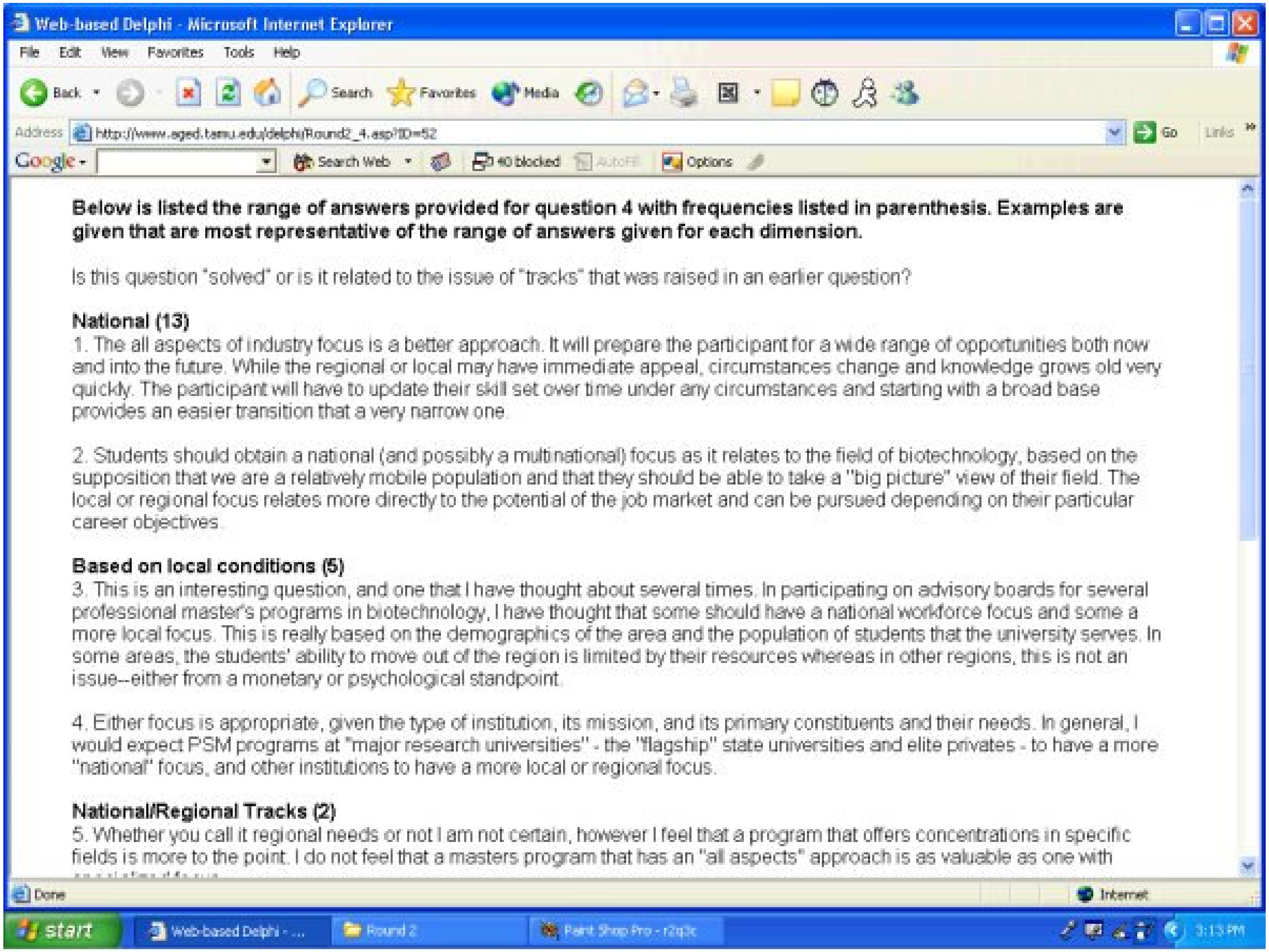


Below is listed the range of answers provided for question 4 with frequencies listed in parenthesis. Examples are given that are most representative of the range of answers given for each dimension.

Is this question "solved" or is it related to the issue of "tracks" that was raised in an earlier question?

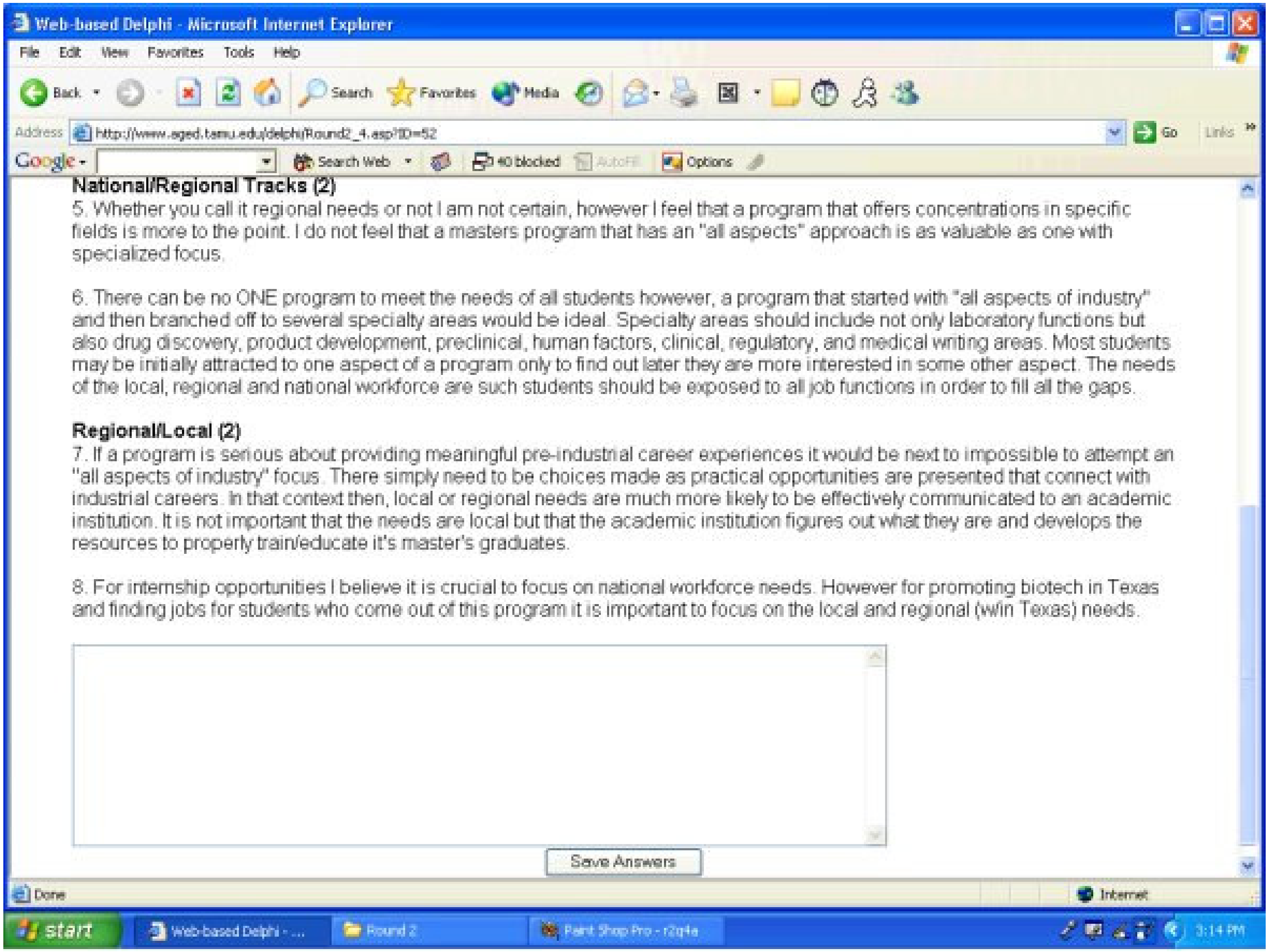
National (13)
1. The all aspects of industry focus is a better approach. It will prepare the participant for a wide range of opportunities both now and into the future. While the regional or local may have immediate appeal, circumstances change and knowledge grows old very quickly. The participant will have to update their skill set over time under any circumstances and starting with a broad base provides an easier transition that a very narrow one.

2. Students should obtain a national (and possibly a multinational) focus as it relates to the field of biotechnology, based on the supposition that we are a relatively mobile population and that they should be able to take a "big picture" view of their field. The local or regional focus relates more directly to the potential of the job market and can be pursued depending on their particular career objectives.

Based on local conditions (5)
3. This is an interesting question, and one that I have thought about several times. In participating on advisory boards for several professional master's programs in biotechnology, I have thought that some should have a national workforce focus and some a more local focus. This is really based on the demographics of the area and the population of students that the university serves. In some areas, the students' ability to move out of the region is limited by their resources whereas in other regions, this is not an issue--either from a monetary or psychological standpoint.

4. Either focus is appropriate, given the type of institution, its mission, and its primary constituents and their needs. In general, I would expect PSM programs at "major research universities" - the "flagship" state universities and elite privates - to have a more "national" focus, and other institutions to have a more local or regional focus.

National/Regional Tracks (2)
5. Whether you call it regional needs or not I am not certain, however I feel that a program that offers concentrations in specific fields is more to the point. I do not feel that a masters program that has an "all aspects" approach is as valuable as one with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National/Regional Tracks (2)
5. Whether you call it regional needs or not I am not certain, however I feel that a program that offers concentrations in specific fields is more to the point. I do not feel that a masters program that has an "all aspects" approach is as valuable as one with specialized focus.
6. There can be no ONE program to meet the needs of all students however, a program that started with "all aspects of industry" and then branched off to several specialty areas would be ideal. Specialty areas should include not only laboratory functions but also drug discovery, product development, preclinical, human factors, clinical, regulatory, and medical writing areas. Most students may be initially attracted to one aspect of a program only to find out later they are more interested in some other aspect. The needs of the local, regional and national workforce are such students should be exposed to all job functions in order to fill all the gaps.
Regional/Local (2)
7. If a program is serious about providing meaningful pre-industrial career experiences it would be next to impossible to attempt an "all aspects of industry" focus. There simply need to be choices made as practical opportunities are presented that connect with industrial careers. In that context then, local or regional needs are much more likely to be effectively communicated to an academic institution. It is not important that the needs are local but that the academic institution figures out what they are and develops the resources to properly train/educate it's master's graduates.
8. For internship opportunities I believe it is crucial to focus on national workforce needs. However for promoting biotech in Texas and finding jobs for students who come out of this program it is important to focus on the local and regional (w/in Texas) needs.
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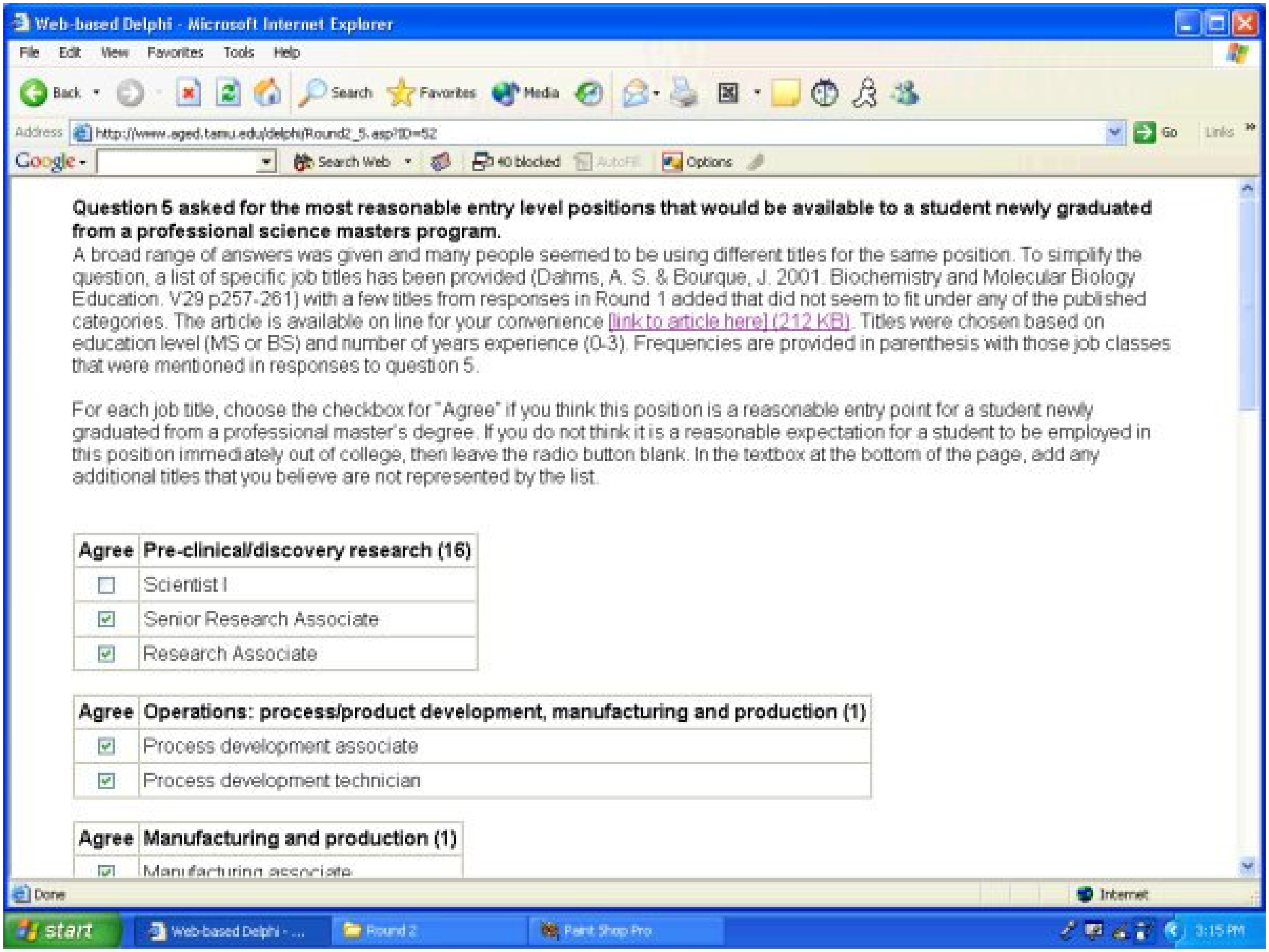

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Question 5 asked for the most reasonable entry level positions that would be available to a student newly graduated from a professional science masters program.

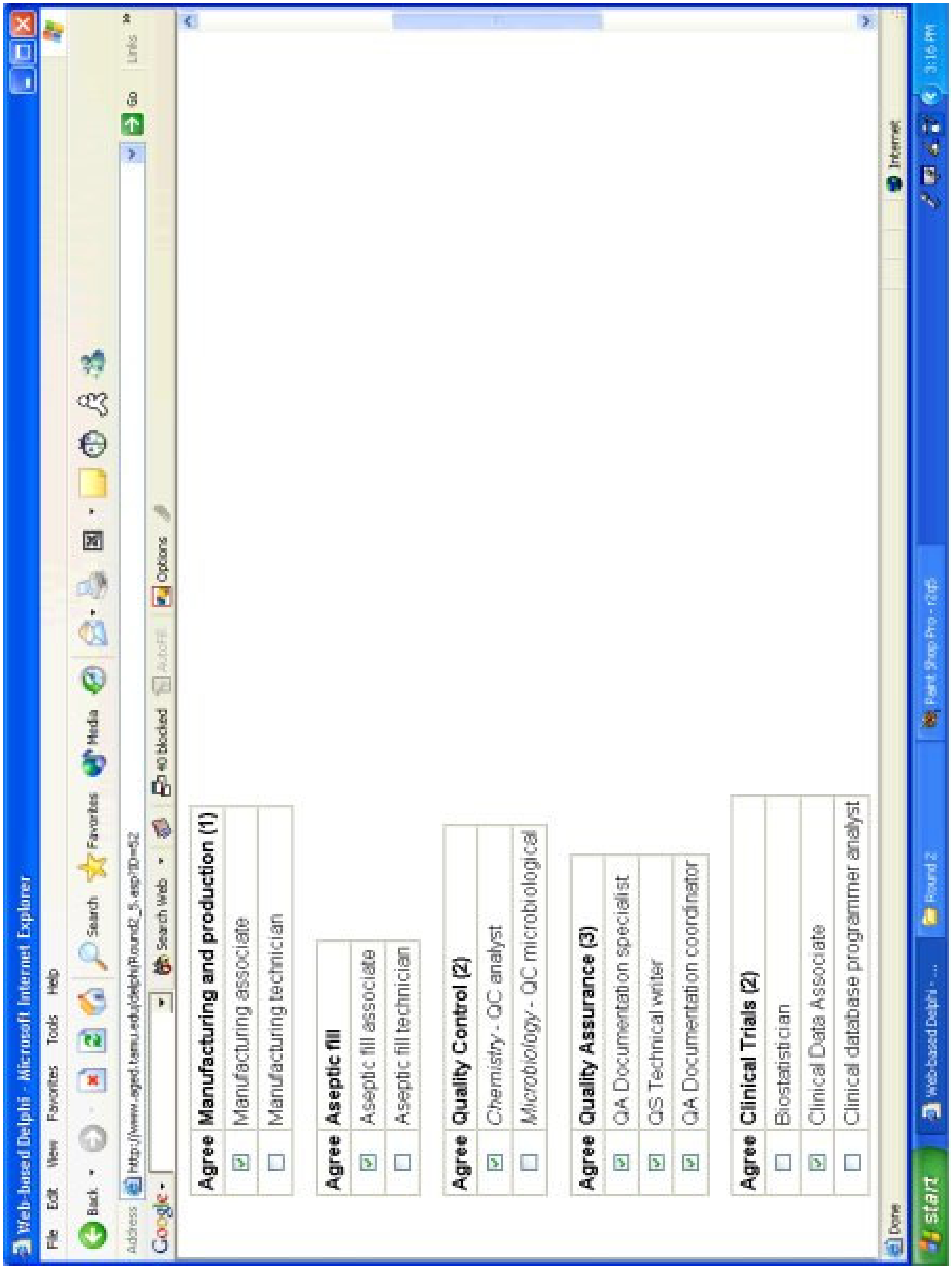
A broad range of answers was given and many people seemed to be using different titles for the same position. To simplify the question, a list of specific job titles has been provided (Dahms, A. S. & Bourque, J. 2001. Biochemistry and Molecular Biology Education. V29 p257-261) with a few titles from responses in Round 1 added that did not seem to fit under any of the published categories. The article is available on line for your convenience [link to article here] (212 KB). Titles were chosen based on education level (MS or BS) and number of years experience (0-3). Frequencies are provided in parenthesis with those job classes that were mentioned in responses to question 5.

For each job title, choose the checkbox for "Agree" if you think this position is a reasonable entry point for a student newly graduated from a professional master's degree. If you do not think it is a reasonable expectation for a student to be employed in this position immediately out of college, then leave the radio button blank. In the textbox at the bottom of the page, add any additional titles that you believe are not represented by the list.

Agree	Pre-clinical/discovery research (16)
☐	Scientist I
☑	Senior Research Associate
☑	Research Associate

Agree	Operations: process/product development, manufacturing and production (1)
☑	Process development associate
☑	Process development technician

Agree	Manufacturing and production (1)
☑	Manufacturing associate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Agree Manufacturing and production (1)
Manufacturing associate
Manufacturing technician
Agree Aseptic fill
Aseptic fill associate
Aseptic fill technician
Agree Quality Control (2)
Chemistry - QC analyst
Microbiology - QC microbiological
Agree Quality Assurance (3)
QA Documentation specialist
QS Technical writer
QA Documentation coordinator
Agree Clinical Trials (2)
Biostatistician
Clinical Data Associate
Clinical database programmer analyst
Done
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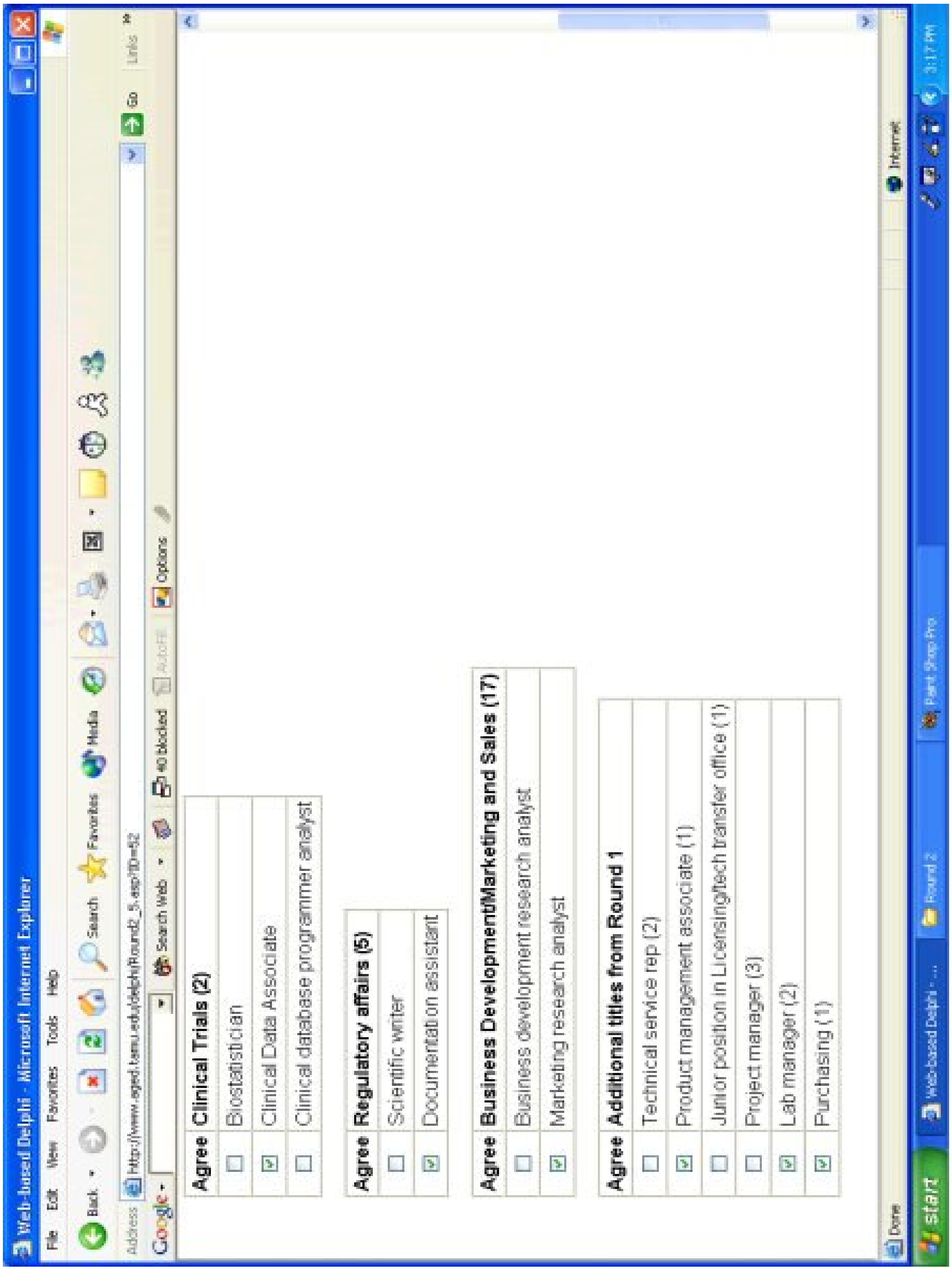

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Agree Clinical Trials (2)
Biostatistician
Clinical Data Associate
Clinical database programmer analyst
Agree Regulatory affairs (5)
Scientific writer
Documentation assistant
Agree Business Development/Marketing and Sales (17)
Business development research analyst
Marketing research analyst
Agree Additional titles from Round 1
Technical service rep (2)
Product management associate (1)
Junior position in Licensing/tech transfer office (1)
Project manager (3)
Lab manager (2)
Purchasing (1)
Done
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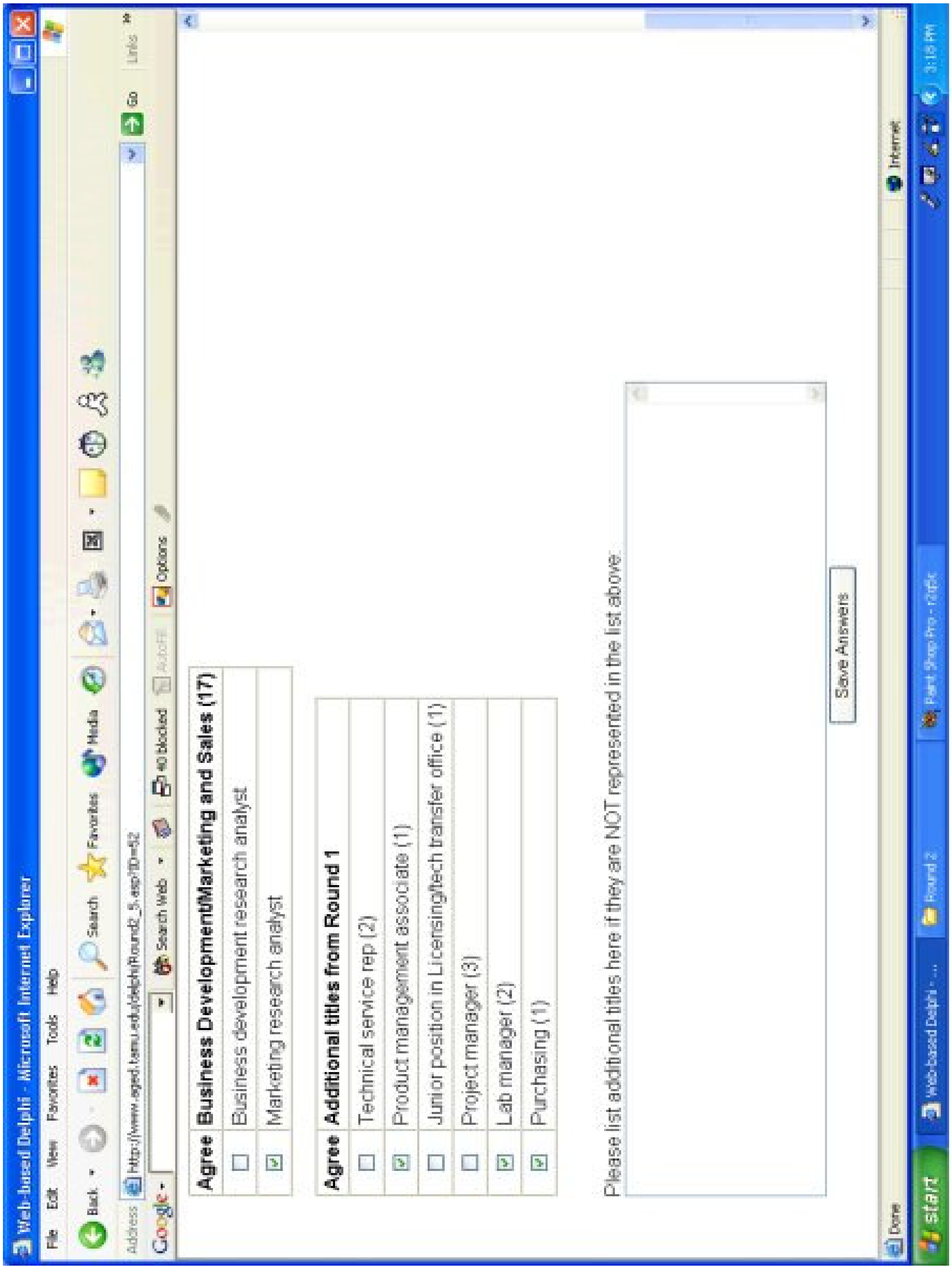
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Agree Business Development/Marketing and Sales (17)
Business development research analyst
Marketing research analyst
Agree Additional titles from Round 1
Technical service rep (2)
Product management associate (1)
Junior position in Licensing/tech transfer office (1)
Project manager (3)
Lab manager (2)
Purchasing (1)
Please list additional titles here if they are NOT represented in the list above.
Save Answers


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Question 6
Below are nine roles identified for an industry advisory board for a professional science master's program. Frequencies are indicated in parentheses. In the text box below, please add any role you think may not be adequately represented by this list. If you think this list is complete as is, please answer so in the space provided. Please indicate your level of agreement with each role that has been identified by choosing the appropriate checkbox.
Needs Assessment and curriculum review (16)
Agree strongly
Agree
No opinion
Disagree
Disagree strongly
Internship development (9)
Identifying issues and trends in industry (5)
Establishing university/industry ties (2)
Suggest or provide seminars, team projects, case studies, etc. that are typical of industry to supplement faculty teaching (8)
Student job placement (6)
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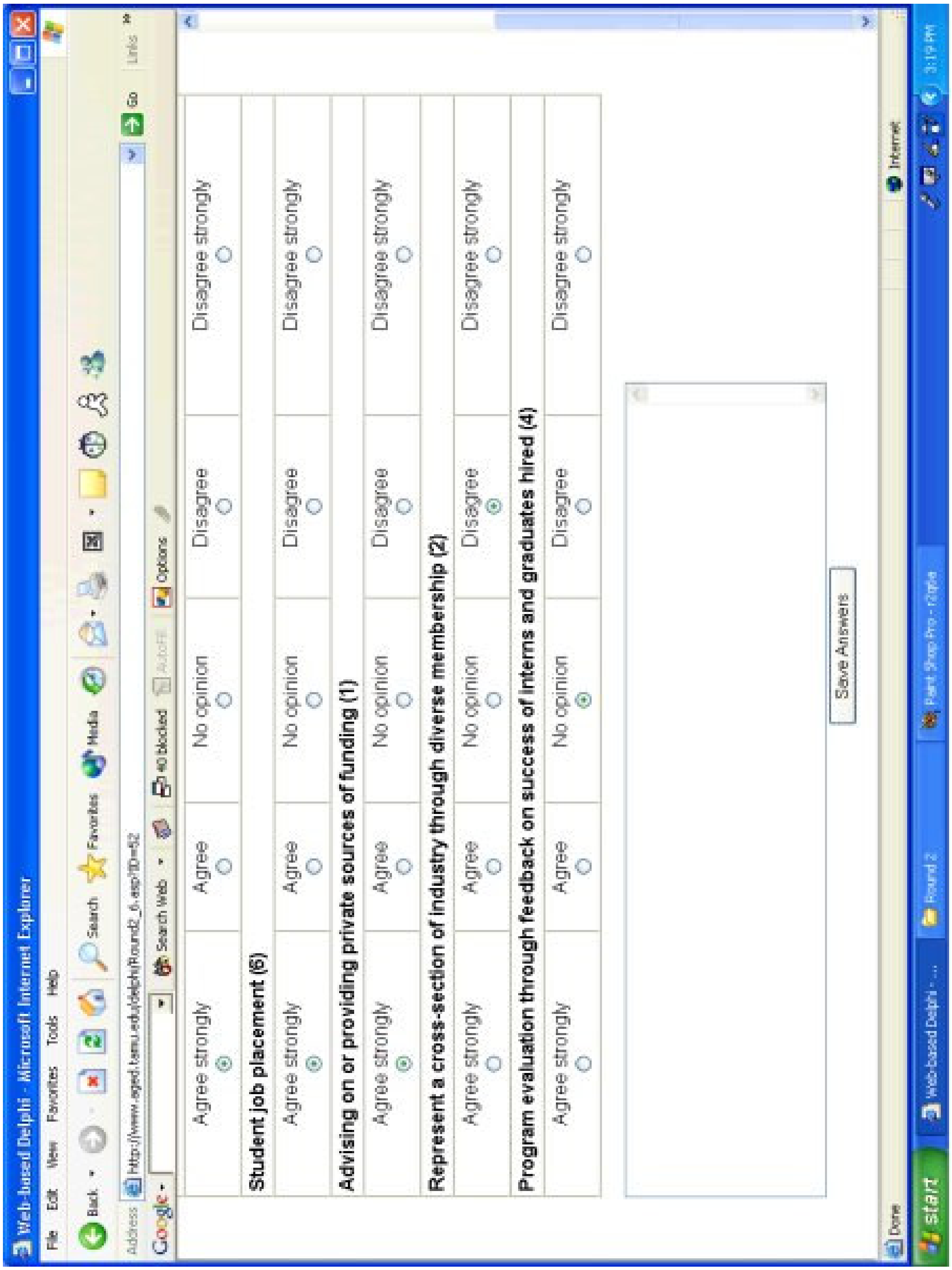
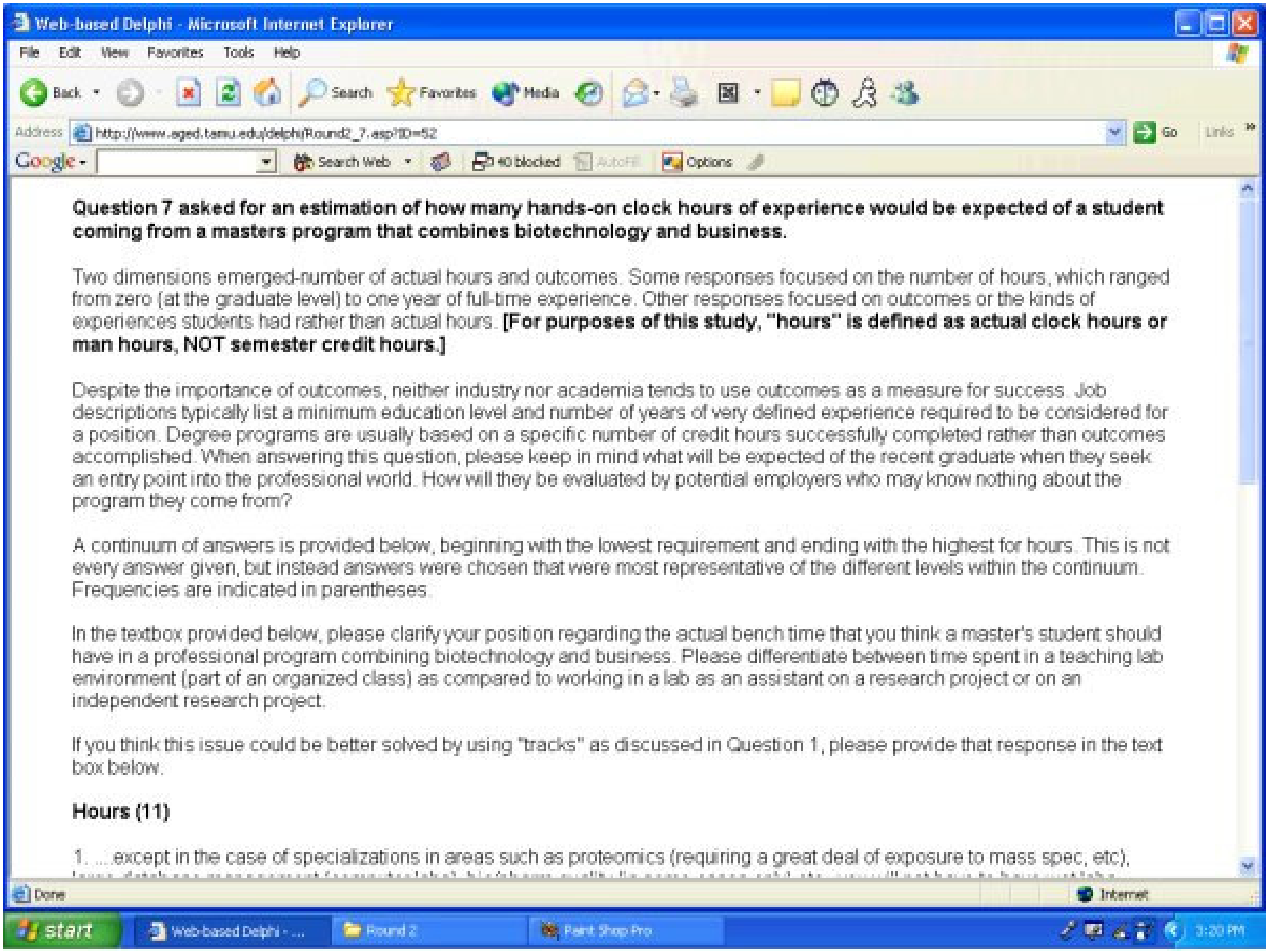

Web-based Delphi - Microsoft Internet Explorer
Agree strongly
Agree
No opinion
Disagree
Disagree strongly
Student job placement (6)
Advising on or providing private sources of funding (1)
Represent a cross-section of industry through diverse membership (2)
Program evaluation through feedback on success of interns and graduates hired (4)
Save Answers



Question 7 asked for an estimation of how many hands-on clock hours of experience would be expected of a student coming from a masters program that combines biotechnology and business.

Two dimensions emerged-number of actual hours and outcomes. Some responses focused on the number of hours, which ranged from zero (at the graduate level) to one year of full-time experience. Other responses focused on outcomes or the kinds of experiences students had rather than actual hours. **[For purposes of this study, "hours" is defined as actual clock hours or man hours, NOT semester credit hours.]**

Despite the importance of outcomes, neither industry nor academia tends to use outcomes as a measure for success. Job descriptions typically list a minimum education level and number of years of very defined experience required to be considered for a position. Degree programs are usually based on a specific number of credit hours successfully completed rather than outcomes accomplished. When answering this question, please keep in mind what will be expected of the recent graduate when they seek an entry point into the professional world. How will they be evaluated by potential employers who may know nothing about the program they come from?

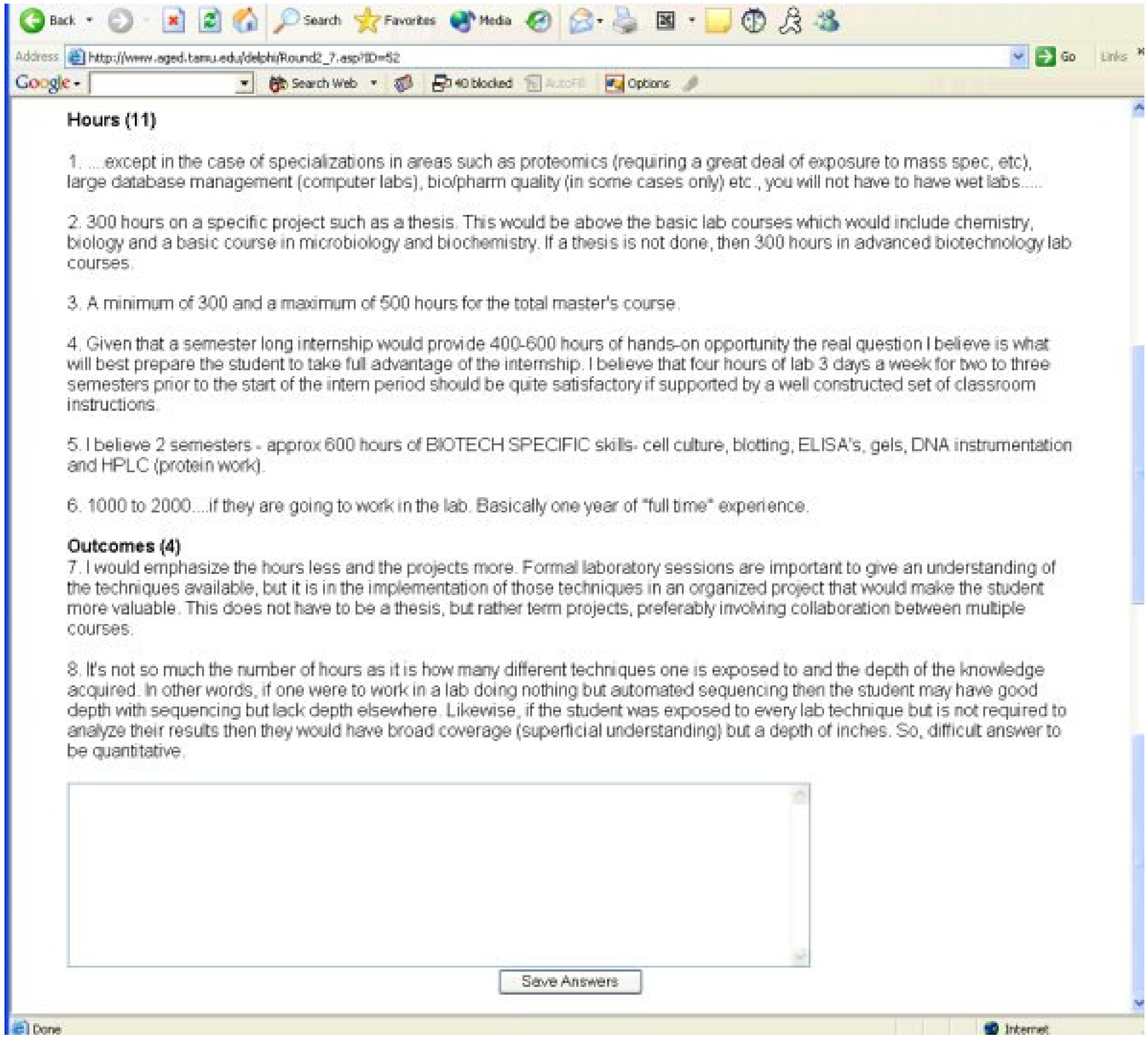
A continuum of answers is provided below, beginning with the lowest requirement and ending with the highest for hours. This is not every answer given, but instead answers were chosen that were most representative of the different levels within the continuum. Frequencies are indicated in parentheses.

In the textbox provided below, please clarify your position regarding the actual bench time that you think a master's student should have in a professional program combining biotechnology and business. Please differentiate between time spent in a teaching lab environment (part of an organized class) as compared to working in a lab as an assistant on a research project or on an independent research project.

If you think this issue could be better solved by using "tracks" as discussed in Question 1, please provide that response in the text box below.

Hours (11)

1. ....except in the case of specializations in areas such as proteomics (requiring a great deal of exposure to mass spec, etc),



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Hours (11)

1. ....except in the case of specializations in areas such as proteomics (requiring a great deal of exposure to mass spec, etc), large database management (computer labs), bio/pharm quality (in some cases only) etc., you will not have to have wet labs.....

2. 300 hours on a specific project such as a thesis. This would be above the basic lab courses which would include chemistry, biology and a basic course in microbiology and biochemistry. If a thesis is not done, then 300 hours in advanced biotechnology lab courses.

3. A minimum of 300 and a maximum of 500 hours for the total master's course.

4. Given that a semester long internship would provide 400-600 hours of hands-on opportunity the real question I believe is what will best prepare the student to take full advantage of the internship. I believe that four hours of lab 3 days a week for two to three semesters prior to the start of the intern period should be quite satisfactory if supported by a well constructed set of classroom instructions.

5. I believe 2 semesters - approx 600 hours of BIOTECH SPECIFIC skills- cell culture, blotting, ELISA's, gels, DNA instrumentation and HPLC (protein work).

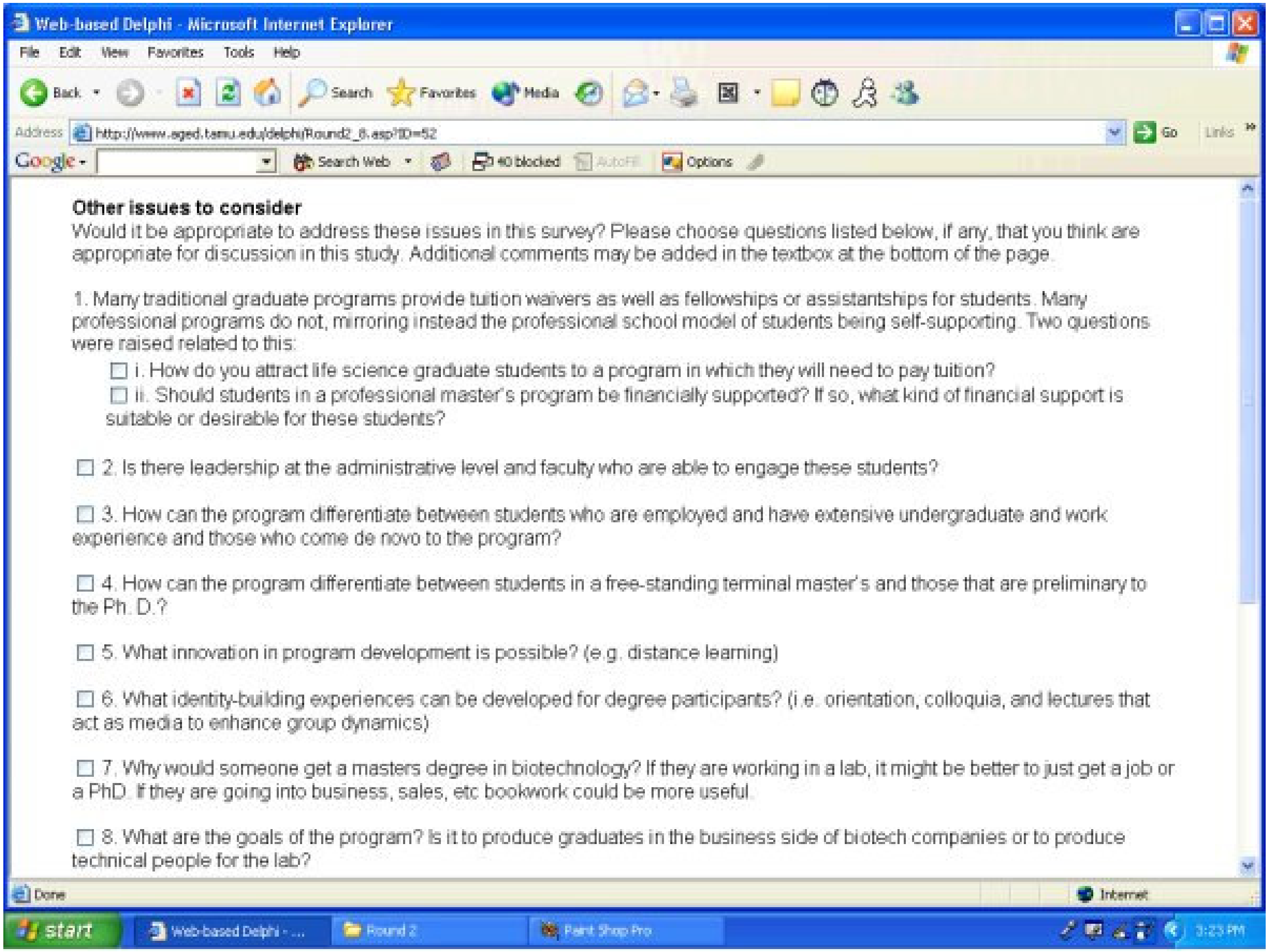
6. 1000 to 2000....if they are going to work in the lab. Basically one year of "full time" experience.

Outcomes (4)

7. I would emphasize the hours less and the projects more. Formal laboratory sessions are important to give an understanding of the techniques available, but it is in the implementation of those techniques in an organized project that would make the student more valuable. This does not have to be a thesis, but rather term projects, preferably involving collaboration between multiple courses.

8. It's not so much the number of hours as it is how many different techniques one is exposed to and the depth of the knowledge acquired. In other words, if one were to work in a lab doing nothing but automated sequencing then the student may have good depth with sequencing but lack depth elsewhere. Likewise, if the student was exposed to every lab technique but is not required to analyze their results then they would have broad coverage (superficial understanding) but a depth of inches. So, difficult answer to be quantitative.

Save Answers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Other issues to consider
Would it be appropriate to address these issues in this survey? Please choose questions listed below, if any, that you think are appropriate for discussion in this study. Additional comments may be added in the textbox at the bottom of the page.
1. Many traditional graduate programs provide tuition waivers as well as fellowships or assistantships for students. Many professional programs do not, mirroring instead the professional school model of students being self-supporting. Two questions were raised related to this:
☐ i. How do you attract life science graduate students to a program in which they will need to pay tuition?
☐ ii. Should students in a professional master's program be financially supported? If so, what kind of financial support is suitable or desirable for these students?
☐ 2. Is there leadership at the administrative level and faculty who are able to engage these students?
☐ 3. How can the program differentiate between students who are employed and have extensive undergraduate and work experience and those who come de novo to the program?
☐ 4. How can the program differentiate between students in a free-standing terminal master's and those that are preliminary to the Ph. D.?
☐ 5. What innovation in program development is possible? (e.g. distance learning)
☐ 6. What identity-building experiences can be developed for degree participants? (i.e. orientation, colloquia, and lectures that act as media to enhance group dynamics)
☐ 7. Why would someone get a masters degree in biotechnology? If they are working in a lab, it might be better to just get a job or a PhD. If they are going into business, sales, etc bookwork could be more useful.
☐ 8. What are the goals of the program? Is it to produce graduates in the business side of biotech companies or to produce technical people for the lab?
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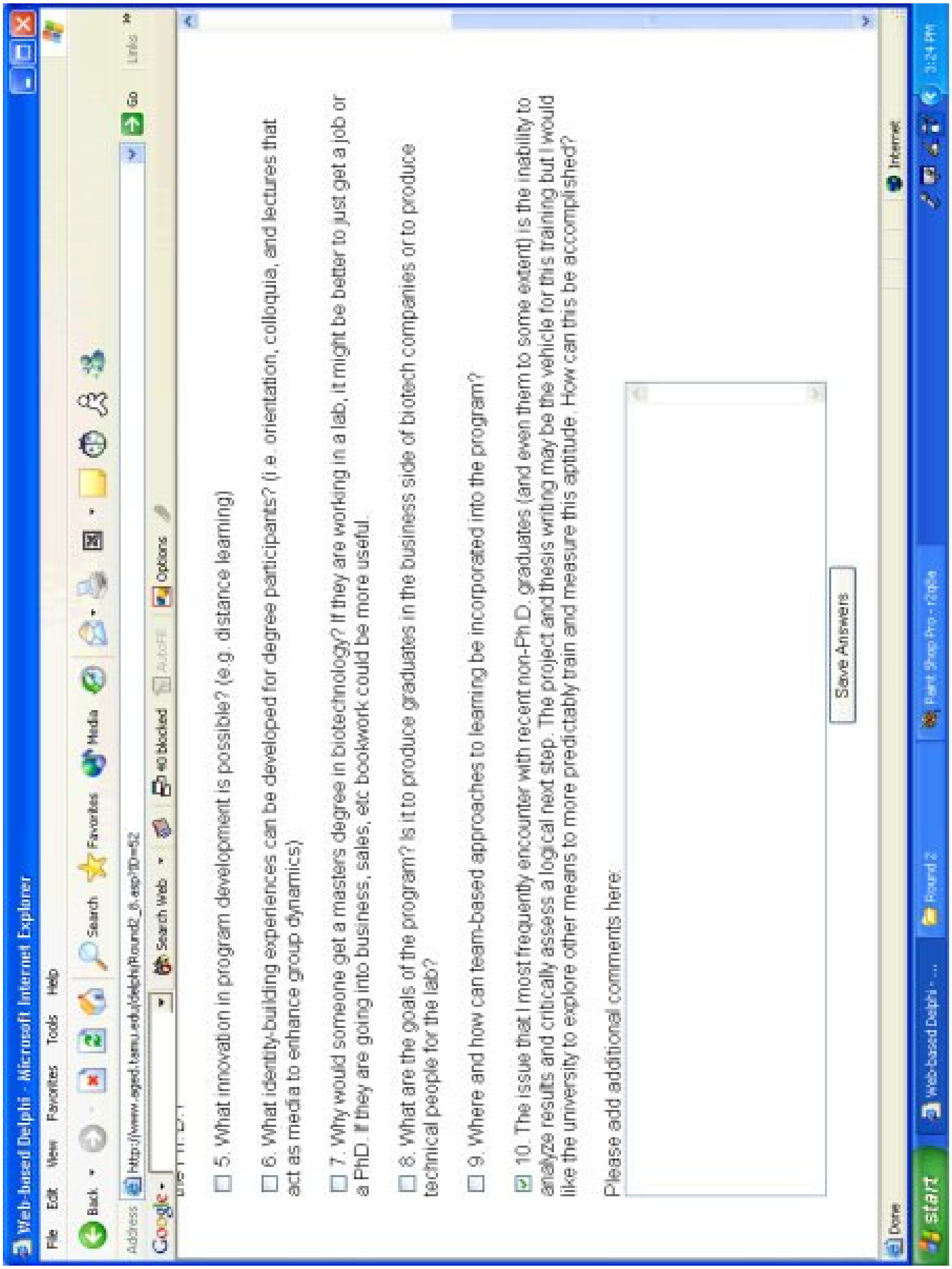
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5. What innovation in program development is possible? (e.g. distance learning)
6. What identity-building experiences can be developed for degree participants? (i.e. orientation, colloquia, and lectures that act as media to enhance group dynamics)
7. Why would someone get a masters degree in biotechnology? If they are working in a lab, it might be better to just get a job or a PhD. If they are going into business, sales, etc. bookwork could be more useful.
8. What are the goals of the program? Is it to produce graduates in the business side of biotech companies or to produce technical people for the lab?
9. Where and how can team-based approaches to learning be incorporated into the program?
10. The issue that I most frequently encounter with recent non-Ph.D. graduates (and even them to some extent) is the inability to analyze results and critically assess a logical next step. The project and thesis writing may be the vehicle for this training but I would like the university to explore other means to more predictably train and measure this aptitude. How can this be accomplished?
Please add additional comments here:
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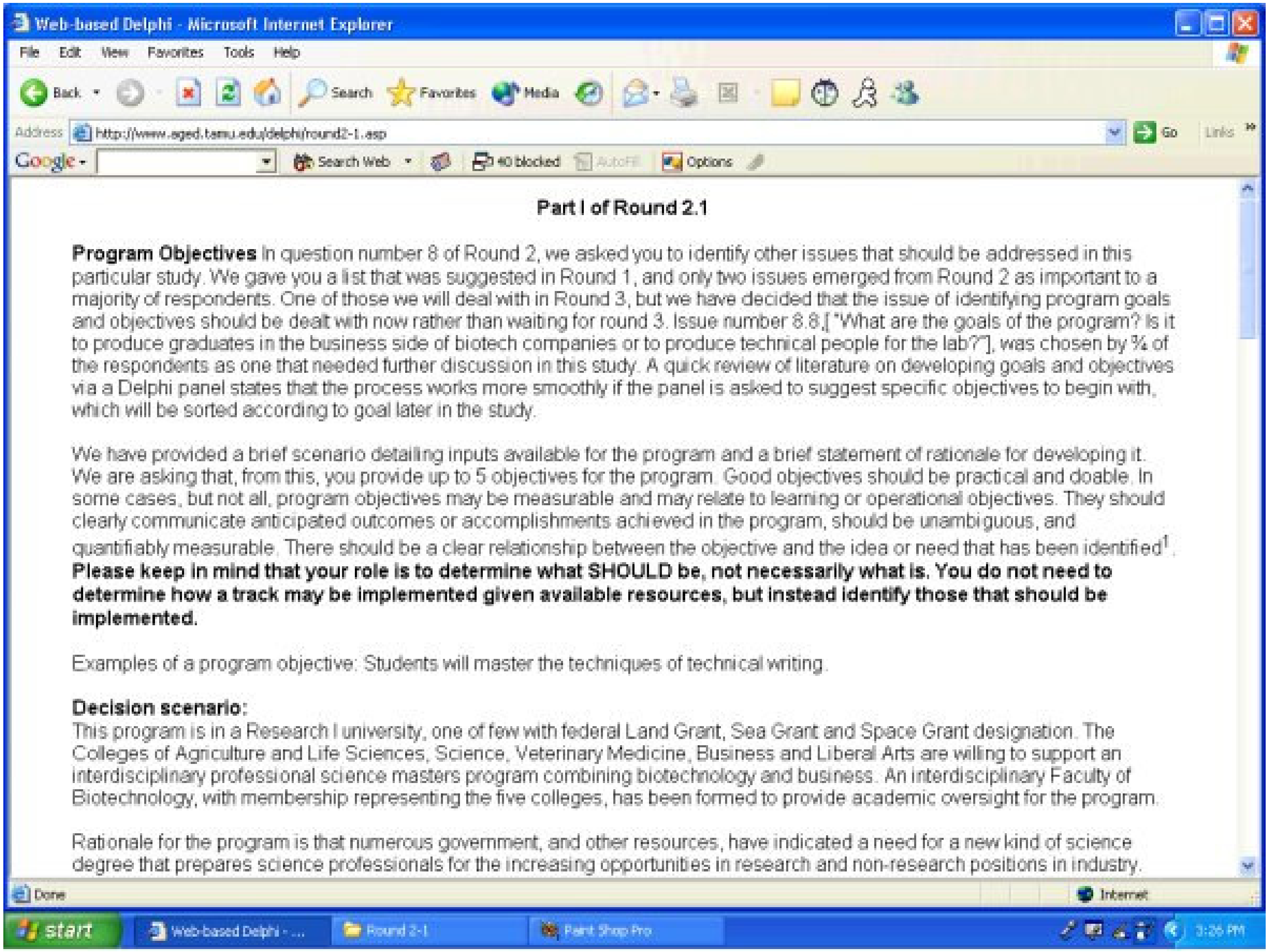
APPENDIX E

ROUND 2.1 INSTRUMENT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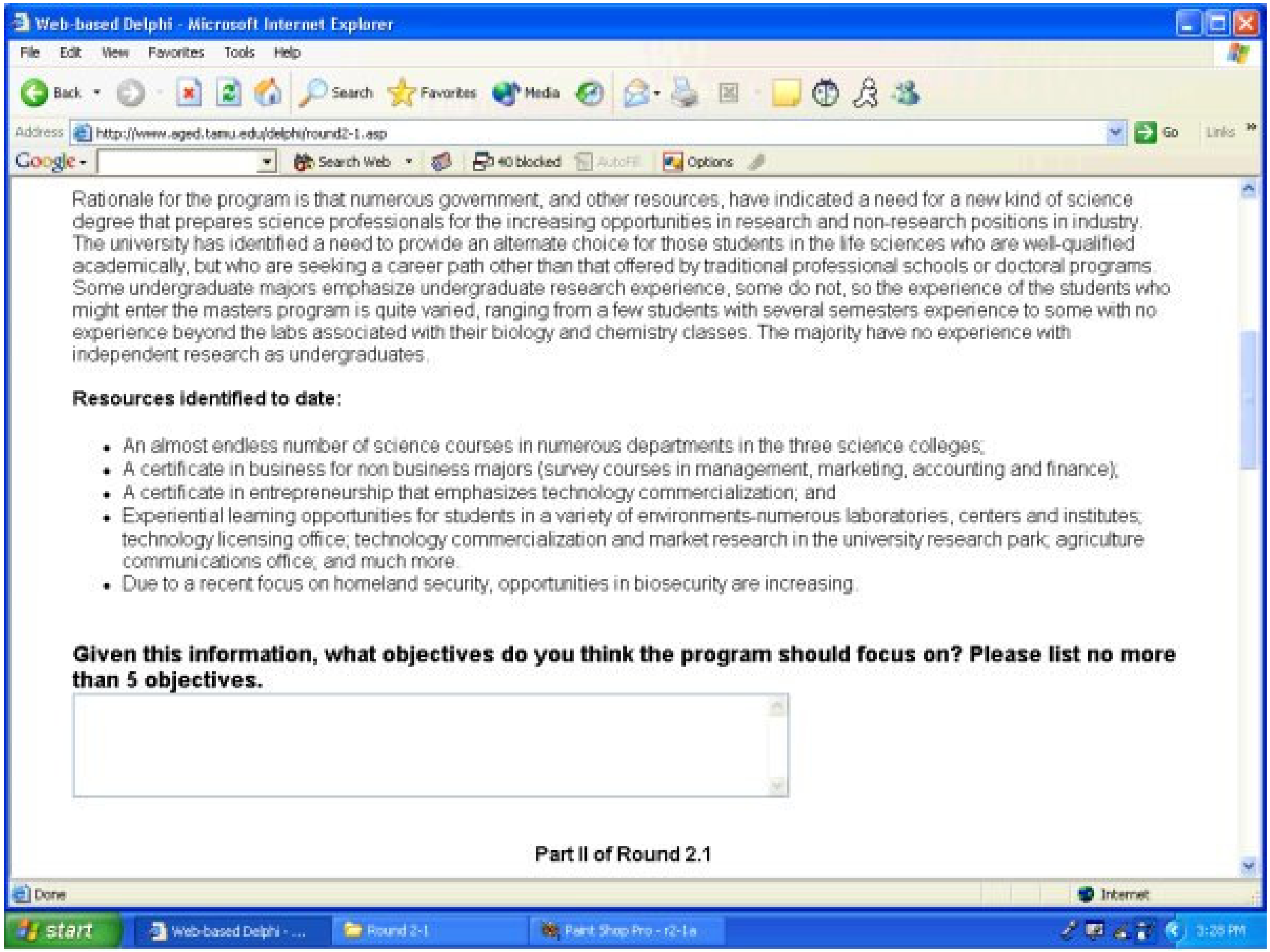
Part I of Round 2.1
Program Objectives In question number 8 of Round 2, we asked you to identify other issues that should be addressed in this particular study. We gave you a list that was suggested in Round 1, and only two issues emerged from Round 2 as important to a majority of respondents. One of those we will deal with in Round 3, but we have decided that the issue of identifying program goals and objectives should be dealt with now rather than waiting for round 3. Issue number 8.8,["What are the goals of the program? Is it to produce graduates in the business side of biotech companies or to produce technical people for the lab?"], was chosen by ¾ of the respondents as one that needed further discussion in this study. A quick review of literature on developing goals and objectives via a Delphi panel states that the process works more smoothly if the panel is asked to suggest specific objectives to begin with, which will be sorted according to goal later in the study.
We have provided a brief scenario detailing inputs available for the program and a brief statement of rationale for developing it. We are asking that, from this, you provide up to 5 objectives for the program. Good objectives should be practical and doable. In some cases, but not all, program objectives may be measurable and may relate to learning or operational objectives. They should clearly communicate anticipated outcomes or accomplishments achieved in the program, should be unambiguous, and quantifiably measurable. There should be a clear relationship between the objective and the idea or need that has been identified[1]. **Please keep in mind that your role is to determine what SHOULD be, not necessarily what is. You do not need to determine how a track may be implemented given available resources, but instead identify those that should be implemented.**
Examples of a program objective: Students will master the techniques of technical writing.
Decision scenario:
This program is in a Research I university, one of few with federal Land Grant, Sea Grant and Space Grant designation. The Colleges of Agriculture and Life Sciences, Science, Veterinary Medicine, Business and Liberal Arts are willing to support an interdisciplinary professional science masters program combining biotechnology and business. An interdisciplinary Faculty of Biotechnology, with membership representing the five colleges, has been formed to provide academic oversight for the program.
Rationale for the program is that numerous government, and other resources, have indicated a need for a new kind of science degree that prepares science professionals for the increasing opportunities in research and non-research positions in industry.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Rationale for the program is that numerous government, and other resources, have indicated a need for a new kind of science degree that prepares science professionals for the increasing opportunities in research and non-research positions in industry. The university has identified a need to provide an alternate choice for those students in the life sciences who are well-qualified academically, but who are seeking a career path other than that offered by traditional professional schools or doctoral programs. Some undergraduate majors emphasize undergraduate research experience, some do not, so the experience of the students who might enter the masters program is quite varied, ranging from a few students with several semesters experience to some with no experience beyond the labs associated with their biology and chemistry classes. The majority have no experience with independent research as undergraduates.
Resources identified to date:
An almost endless number of science courses in numerous departments in the three science colleges;
A certificate in business for non business majors (survey courses in management, marketing, accounting and finance);
A certificate in entrepreneurship that emphasizes technology commercialization; and
Experiential learning opportunities for students in a variety of environments-numerous laboratories, centers and institutes; technology licensing office; technology commercialization and market research in the university research park; agriculture communications office; and much more.
Due to a recent focus on homeland security, opportunities in biosecurity are increasing.
Given this information, what objectives do you think the program should focus on? Please list no more than 5 objectives.
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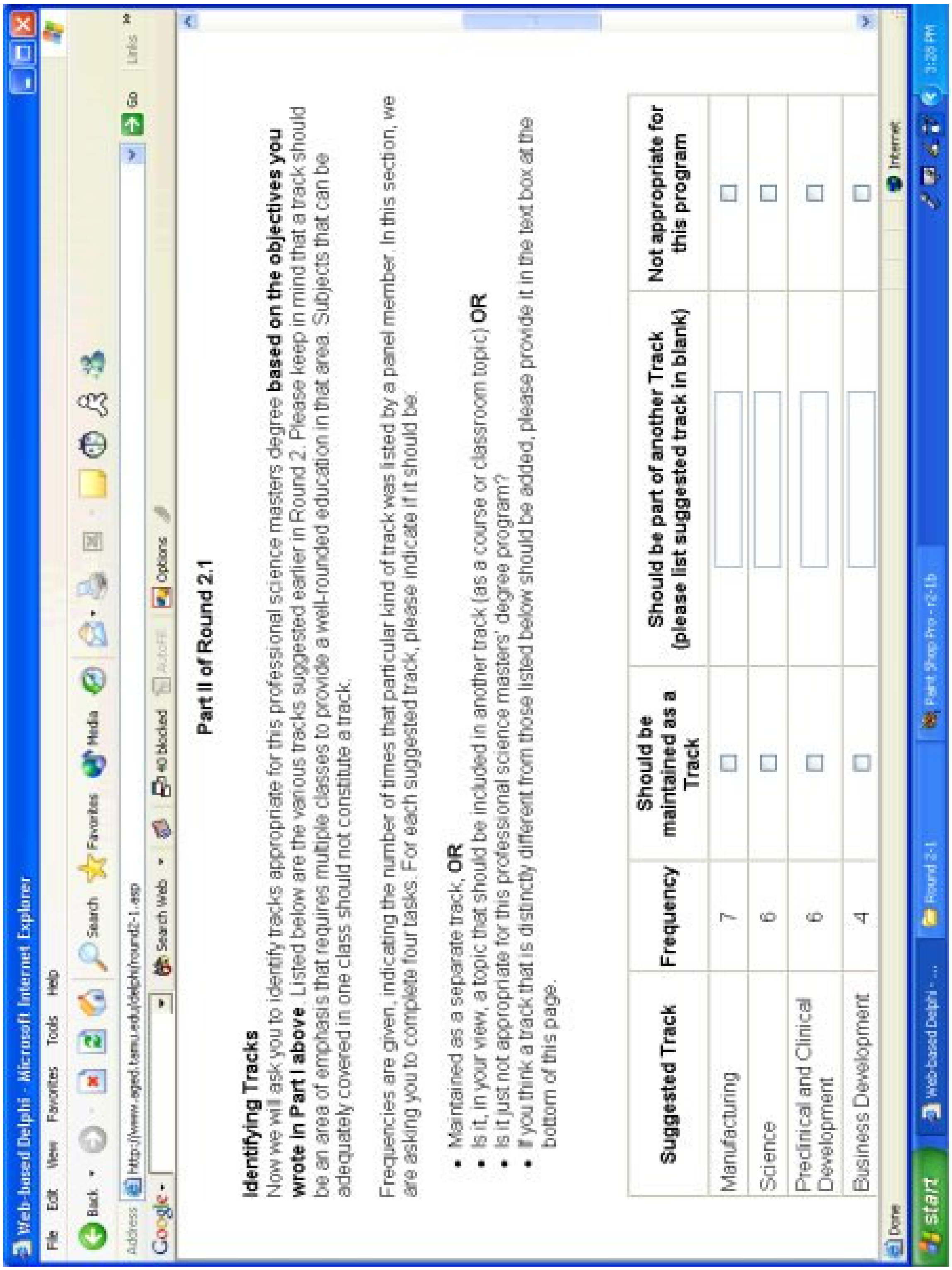
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Part II of Round 2.1

Identifying Tracks

Now we will ask you to identify tracks appropriate for this professional science masters degree **based on the objectives you wrote in Part I above**. Listed below are the various tracks suggested earlier in Round 2. Please keep in mind that a track should be an area of emphasis that requires multiple classes to provide a well-rounded education in that area. Subjects that can be adequately covered in one class should not constitute a track.

Frequencies are given, indicating the number of times that particular kind of track was listed by a panel member. In this section, we are asking you to complete four tasks. For each suggested track, please indicate if it should be:

- Maintained as a separate track, **OR**
- Is it, in your view, a topic that should be included in another track (as a course or classroom topic) **OR**
- Is it just not appropriate for this professional science masters' degree program?
- If you think a track that is distinctly different from those listed below should be added, please provide it in the text box at the bottom of this page.

Suggested Track	Frequency	Should be maintained as a Track	Should be part of another Track (please list suggested track in blank)	Not appropriate for this program
Manufacturing	7	☐		☐
Science	6	☐		☐
Preclinical and Clinical Development	6	☐		☐
Business Development	4	☐		☐


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Business Development 4
Regulatory 4
Drug Discovery 4
Management 4
Marketing 3
Product development 3
Lab Management 3
General Business 2
Quality Assurance 2
Operational Management 1
Intellectual Property 1
Entrepreneurship 1
Pharmacological Economics 1
Bioinformatics 1
Forensics 1
Technology transfer 1
Human factors 1
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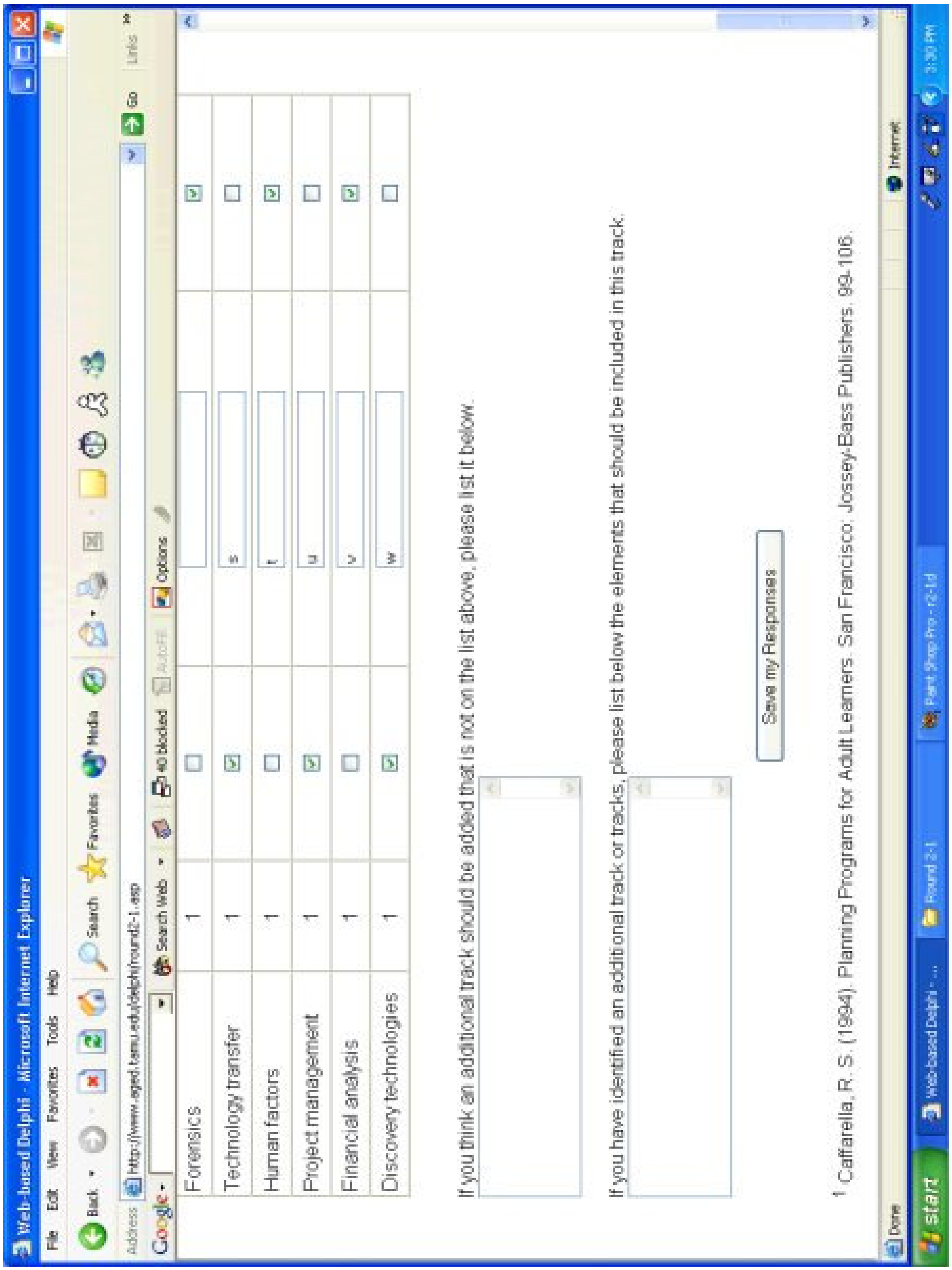
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Forensics 1
Technology transfer 1
Human factors 1
Project management 1
Financial analysis 1
Discovery technologies 1
If you think an additional track should be added that is not on the list above, please list it below.
If you have identified an additional track or tracks, please list below the elements that should be included in this track.
Save my Responses
1 Caffarella, R. S. (1994). Planning Programs for Adult Learners. San Francisco: Jossey-Bass Publishers. 99-106.
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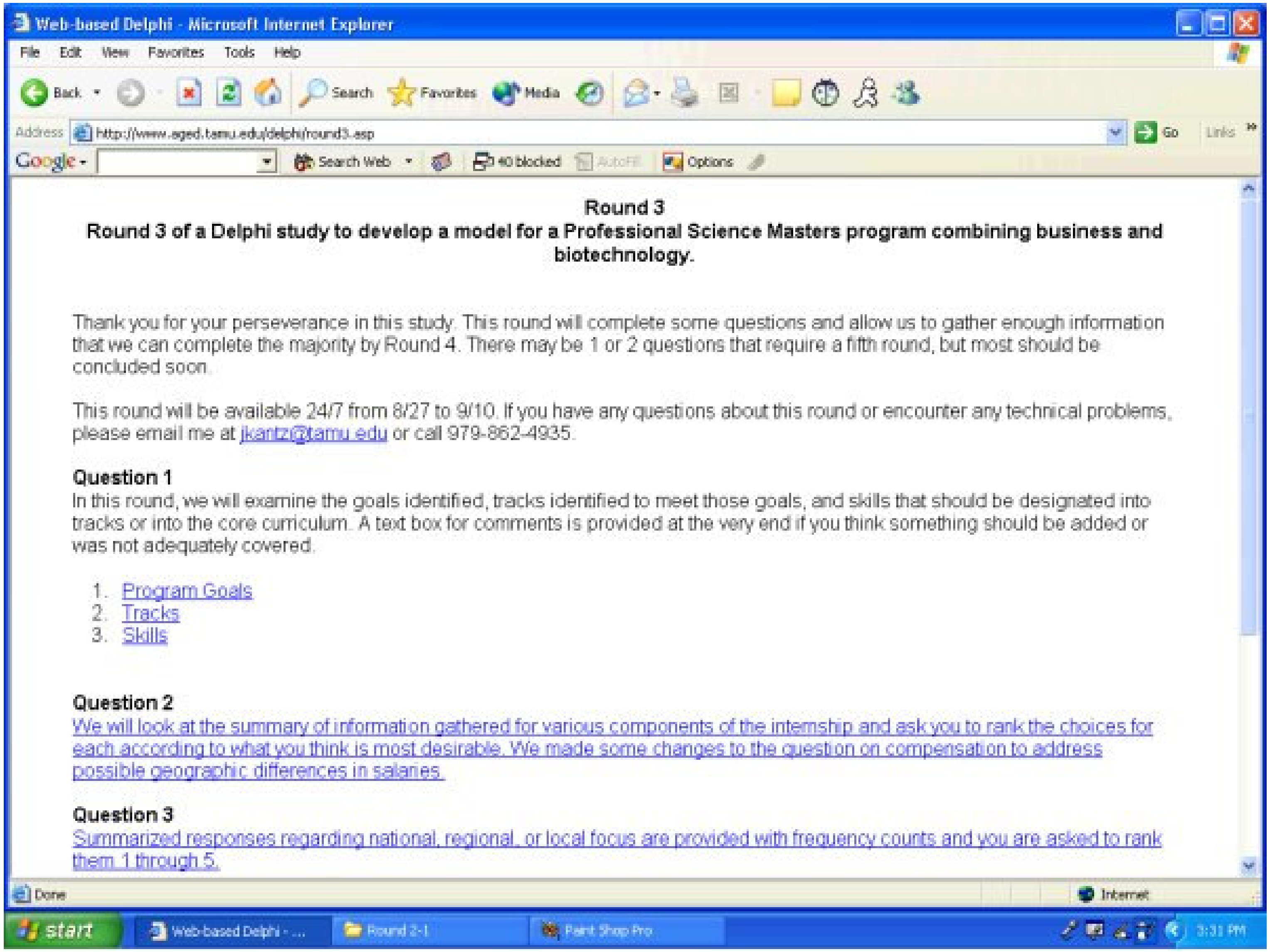
APPENDIX F

ROUND 3 INSTRUMENT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http://www.aged.tamu.edu/delphi/round3.asp
Round 3
Round 3 of a Delphi study to develop a model for a Professional Science Masters program combining business and biotechnology.
Thank you for your perseverance in this study. This round will complete some questions and allow us to gather enough information that we can complete the majority by Round 4. There may be 1 or 2 questions that require a fifth round, but most should be concluded soon.
This round will be available 24/7 from 8/27 to 9/10. If you have any questions about this round or encounter any technical problems, please email me at jkantz@tamu.edu or call 979-862-4935.
Question 1
In this round, we will examine the goals identified, tracks identified to meet those goals, and skills that should be designated into tracks or into the core curriculum. A text box for comments is provided at the very end if you think something should be added or was not adequately covered.
1. Program Goals
2. Tracks
3. Skills
Question 2
We will look at the summary of information gathered for various components of the internship and ask you to rank the choices for each according to what you think is most desirable. We made some changes to the question on compensation to address possible geographic differences in salaries.
Question 3
Summarized responses regarding national, regional, or local focus are provided with frequency counts and you are asked to rank them 1 through 5.
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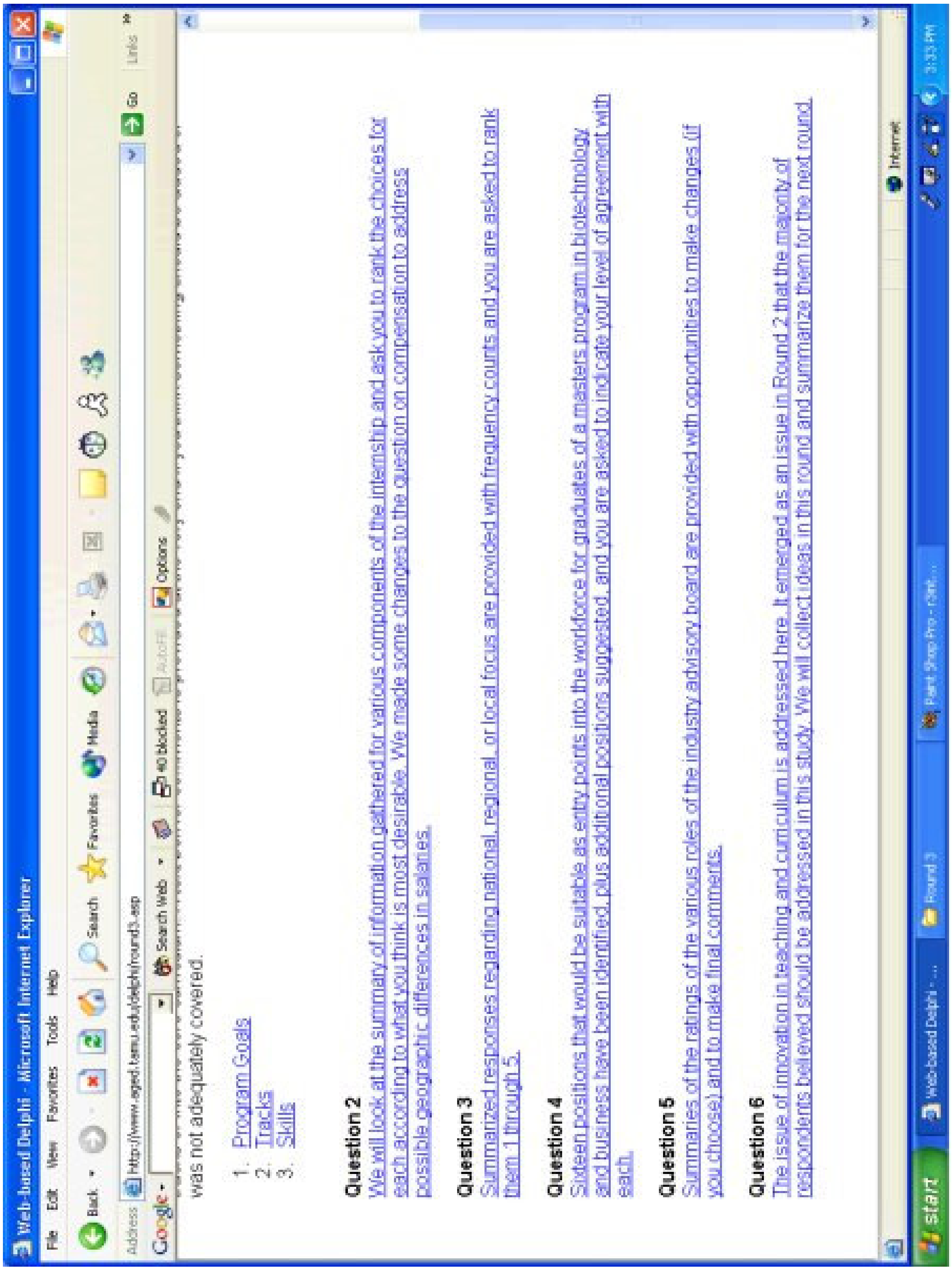
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1. Program Goals
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3. Skills
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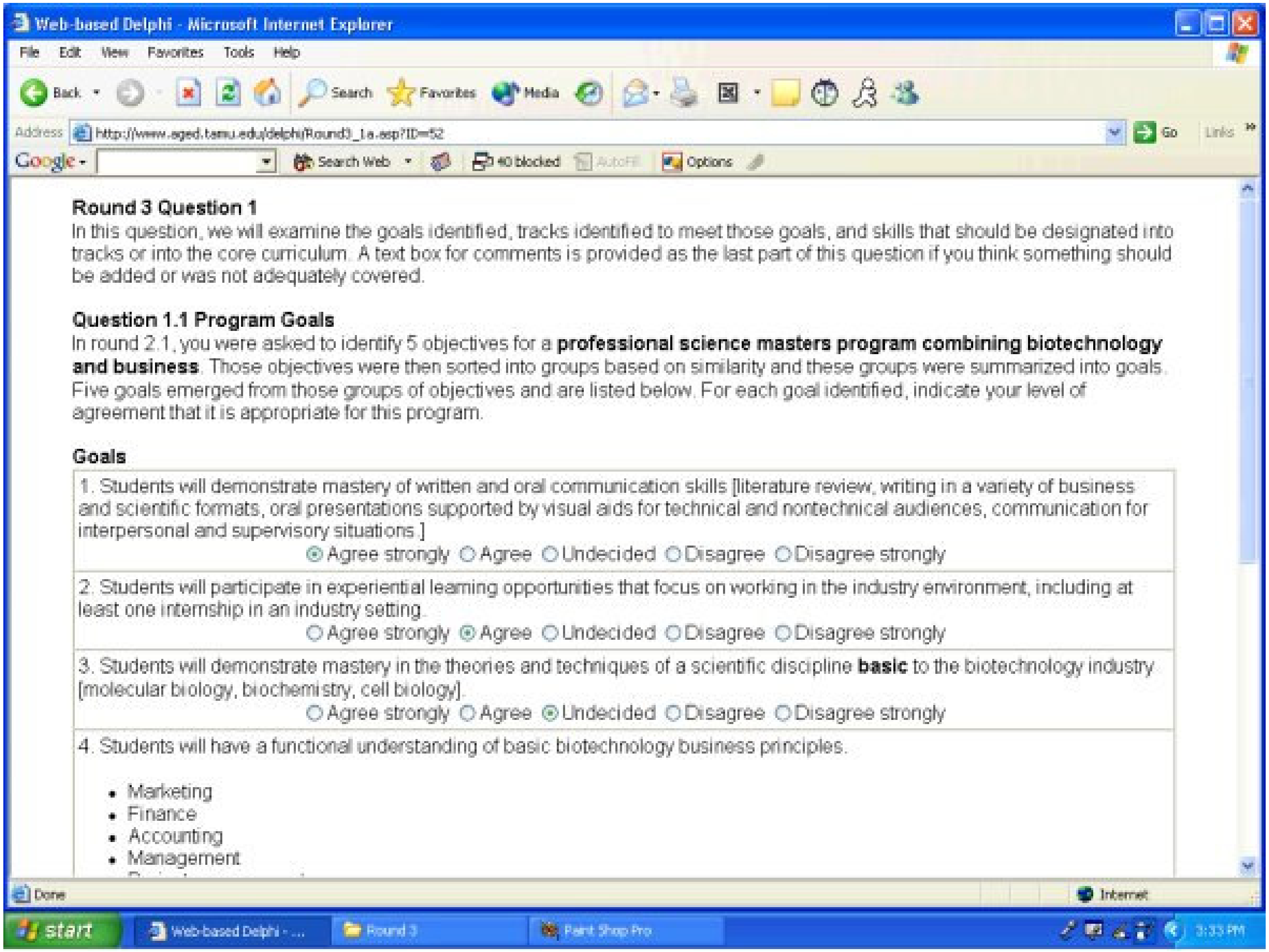
Question 3
Summarized responses regarding national, regional, or local focus are provided with frequency counts and you are asked to rank them 1 through 5.
Question 4
Sixteen positions that would be suitable as entry points into the workforce for graduates of a masters program in biotechnology and business have been identified, plus additional positions suggested, and you are asked to indicate your level of agreement with each.
Question 5
Summaries of the ratings of the various roles of the industry advisory board are provided with opportunities to make changes (if you choose) and to make final comments.
Question 6
The issue of innovation in teaching and curriculum is addressed here. It emerged as an issue in Round 2 that the majority of respondents believed should be addressed in this study. We will collect ideas in this round and summarize them for the next round.



Round 3 Question 1
In this question, we will examine the goals identified, tracks identified to meet those goals, and skills that should be designated into tracks or into the core curriculum. A text box for comments is provided as the last part of this question if you think something should be added or was not adequately covered.

Question 1.1 Program Goals
In round 2.1, you were asked to identify 5 objectives for a **professional science masters program combining biotechnology and business**. Those objectives were then sorted into groups based on similarity and these groups were summarized into goals. Five goals emerged from those groups of objectives and are listed below. For each goal identified, indicate your level of agreement that it is appropriate for this program.

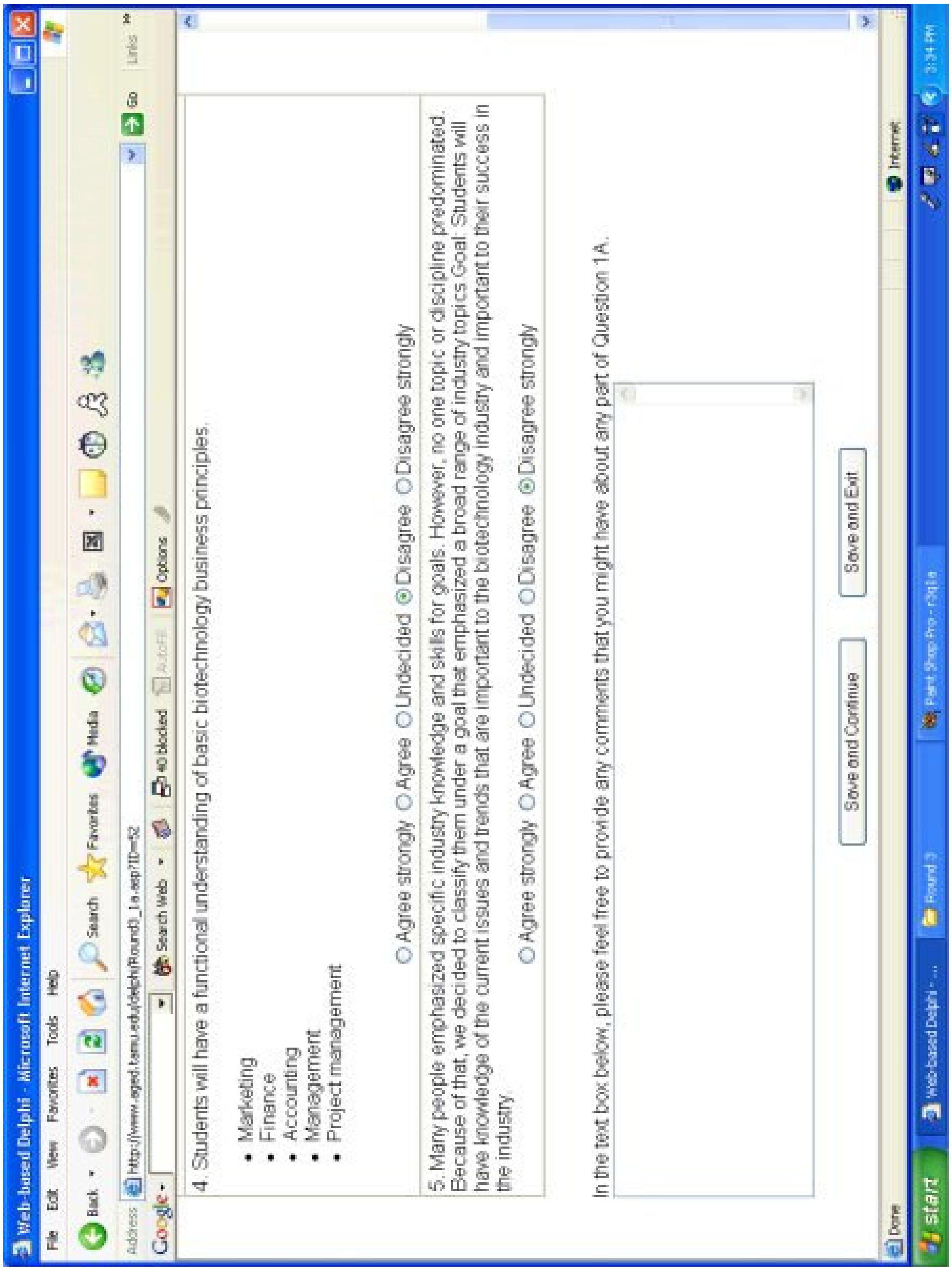
Goals

1. Students will demonstrate mastery of written and oral communication skills [literature review, writing in a variety of business and scientific formats, oral presentations supported by visual aids for technical and nontechnical audiences, communication for interpersonal and supervisory situations.]
   (•) Agree strongly ( ) Agree ( ) Undecided ( ) Disagree ( ) Disagree strongly

2. Students will participate in experiential learning opportunities that focus on working in the industry environment, including at least one internship in an industry setting.
   ( ) Agree strongly (•) Agree ( ) Undecided ( ) Disagree ( ) Disagree strongly

3. Students will demonstrate mastery in the theories and techniques of a scientific discipline **basic** to the biotechnology industry [molecular biology, biochemistry, cell biology].
   ( ) Agree strongly ( ) Agree (•) Undecided ( ) Disagree ( ) Disagree strongly

4. Students will have a functional understanding of basic biotechnology business principles.
   - Marketing
   - Finance
   - Accounting
   - Management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4. Students will have a functional understanding of basic biotechnology business principles.
• Marketing
• Finance
• Accounting
• Management
• Project management
Agree strongly Agree Undecided Disagree Disagree strongly
5. Many people emphasized specific industry knowledge and skills for goals. However, no one topic or discipline predominated. Because of that, we decided to classify them under a goal that emphasized a broad range of industry topics Goal: Students will have knowledge of the current issues and trends that are important to the biotechnology industry and important to their success in the industry.
Agree strongly Agree Undecided Disagree Disagree strongly
In the text box below, please feel free to provide any comments that you might have about any part of Question 1A.
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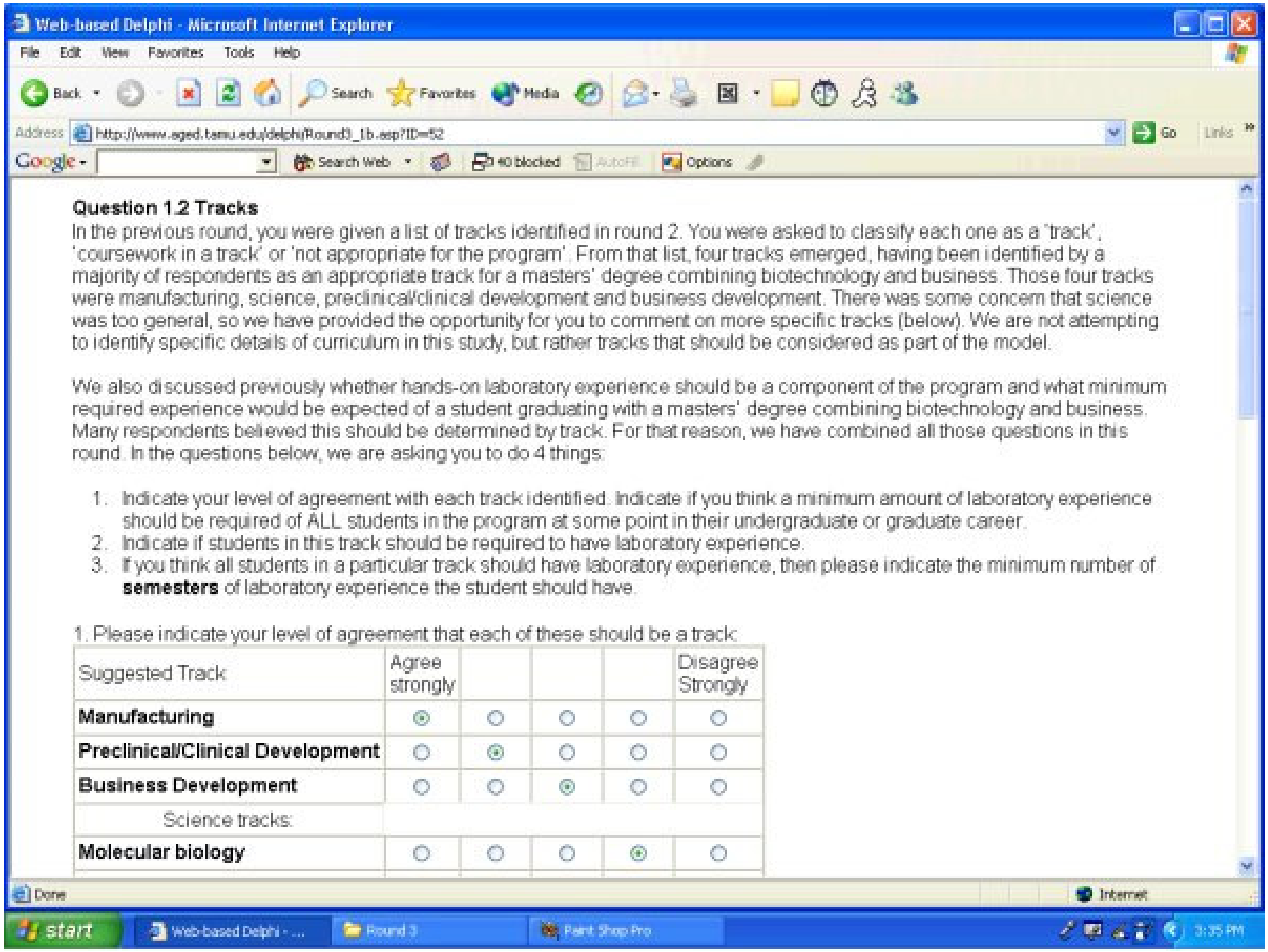

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Question 1.2 Tracks

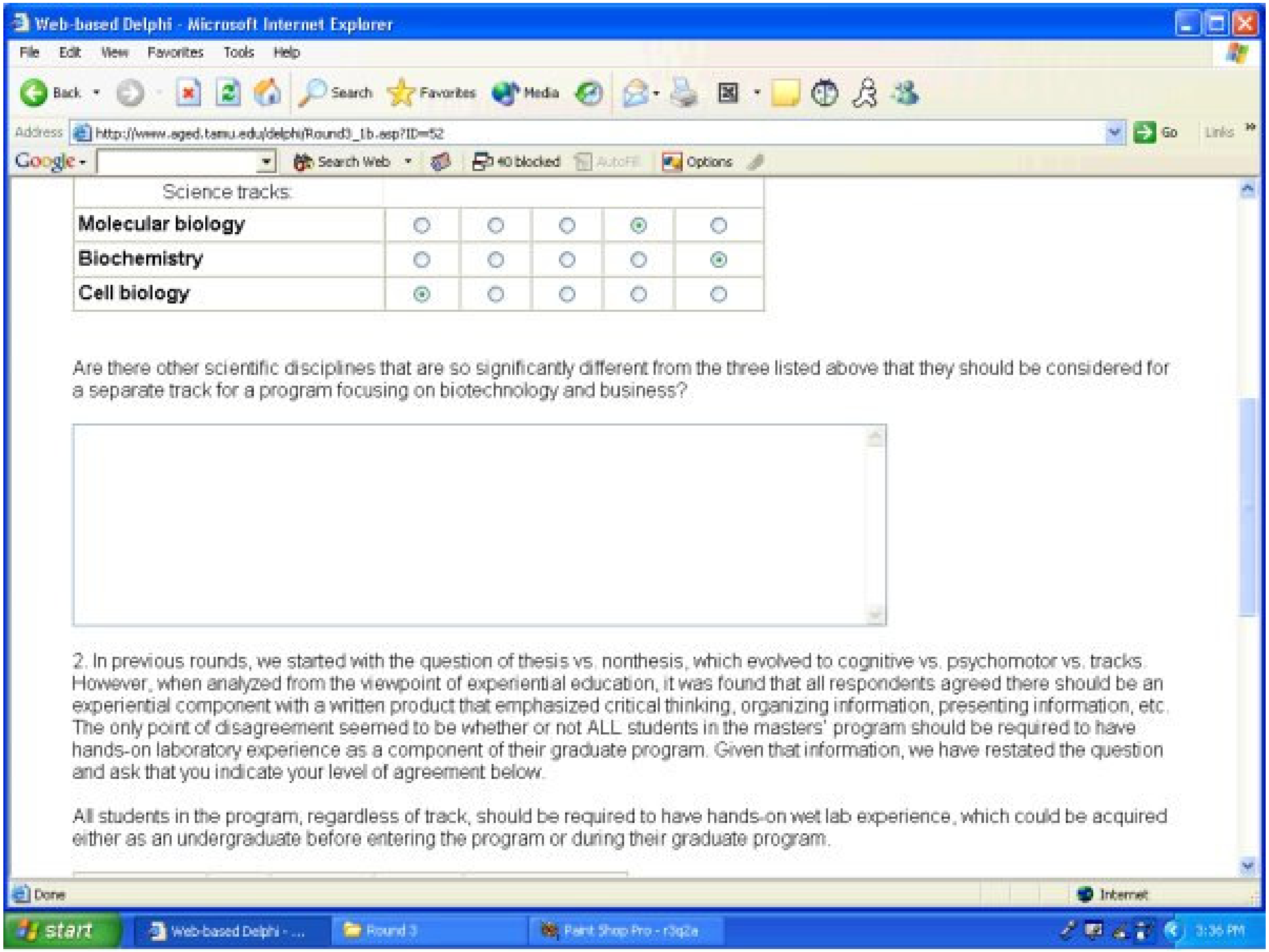
In the previous round, you were given a list of tracks identified in round 2. You were asked to classify each one as a 'track', 'coursework in a track' or 'not appropriate for the program'. From that list, four tracks emerged, having been identified by a majority of respondents as an appropriate track for a masters' degree combining biotechnology and business. Those four tracks were manufacturing, science, preclinical/clinical development and business development. There was some concern that science was too general, so we have provided the opportunity for you to comment on more specific tracks (below). We are not attempting to identify specific details of curriculum in this study, but rather tracks that should be considered as part of the model.

We also discussed previously whether hands-on laboratory experience should be a component of the program and what minimum required experience would be expected of a student graduating with a masters' degree combining biotechnology and business. Many respondents believed this should be determined by track. For that reason, we have combined all those questions in this round. In the questions below, we are asking you to do 4 things:

1. Indicate your level of agreement with each track identified. Indicate if you think a minimum amount of laboratory experience should be required of ALL students in the program at some point in their undergraduate or graduate career.
2. Indicate if students in this track should be required to have laboratory experience.
3. If you think all students in a particular track should have laboratory experience, then please indicate the minimum number of **semesters** of laboratory experience the student should have.

1. Please indicate your level of agreement that each of these should be a track:

Suggested Track	Agree strongly				Disagree Strongly
Manufacturing	◉	○	○	○	○
Preclinical/Clinical Development	○	◉	○	○	○
Business Development	○	○	◉	○	○
Science tracks:					
Molecular biology	○	○	○	◉	○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Science tracks:
Molecular biology
Biochemistry
Cell biology
Are there other scientific disciplines that are so significantly different from the three listed above that they should be considered for a separate track for a program focusing on biotechnology and business?
2. In previous rounds, we started with the question of thesis vs. nonthesis, which evolved to cognitive vs. psychomotor vs. tracks. However, when analyzed from the viewpoint of experiential education, it was found that all respondents agreed there should be an experiential component with a written product that emphasized critical thinking, organizing information, presenting information, etc. The only point of disagreement seemed to be whether or not ALL students in the masters' program should be required to have hands-on laboratory experience as a component of their graduate program. Given that information, we have restated the question and ask that you indicate your level of agreement below.
All students in the program, regardless of track, should be required to have hands-on wet lab experience, which could be acquired either as an undergraduate before entering the program or during their graduate program.
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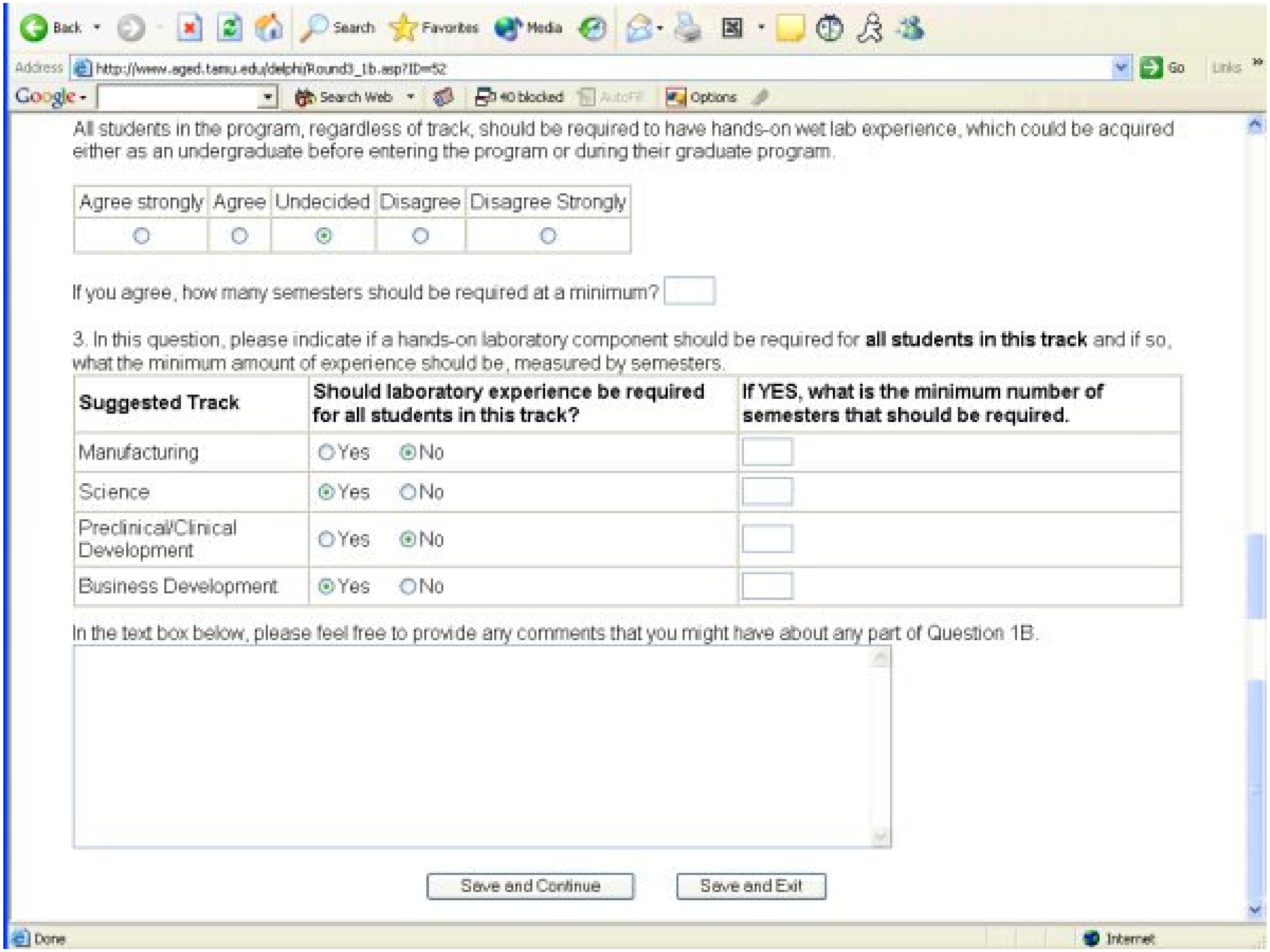

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All students in the program, regardless of track, should be required to have hands-on wet lab experience, which could be acquired either as an undergraduate before entering the program or during their graduate program.

Agree strongly	Agree	Undecided	Disagree	Disagree Strongly
○	○	◉	○	○

If you agree, how many semesters should be required at a minimum?

3. In this question, please indicate if a hands-on laboratory component should be required for **all students in this track** and if so, what the minimum amount of experience should be, measured by semesters.

Suggested Track	**Should laboratory experience be required for all students in this track?**	**If YES, what is the minimum number of semesters that should be required.**
Manufacturing	○Yes ◉No	
Science	◉Yes ○No	
Preclinical/Clinical Development	○Yes ◉No	
Business Development	◉Yes ○No	

In the text box below, please feel free to provide any comments that you might have about any part of Question 1B.

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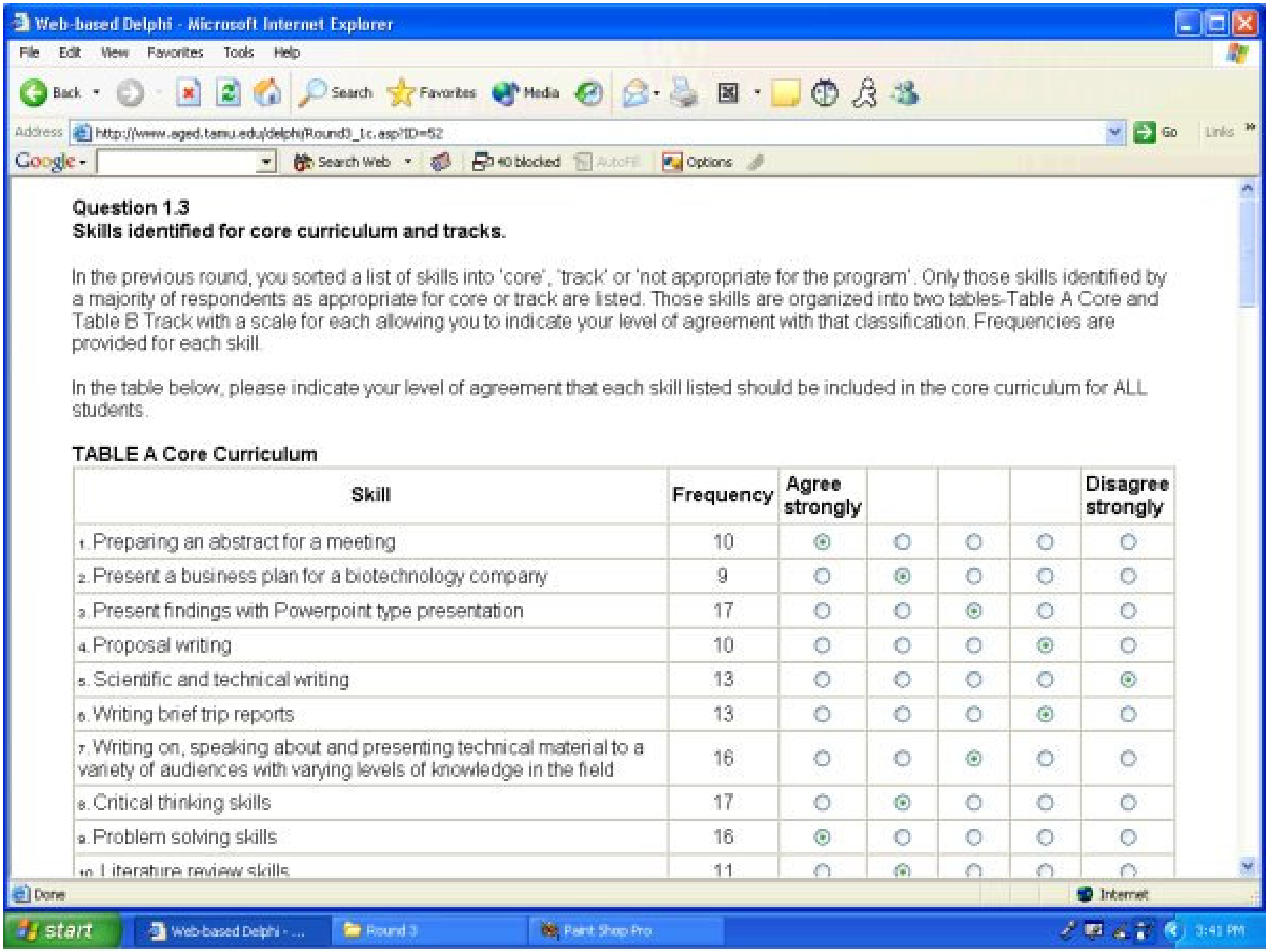

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Question 1.3
Skills identified for core curriculum and tracks.

In the previous round, you sorted a list of skills into 'core', 'track' or 'not appropriate for the program'. Only those skills identified by a majority of respondents as appropriate for core or track are listed. Those skills are organized into two tables-Table A Core and Table B Track with a scale for each allowing you to indicate your level of agreement with that classification. Frequencies are provided for each skill.

In the table below, please indicate your level of agreement that each skill listed should be included in the core curriculum for ALL students.

TABLE A Core Curriculum

Skill	Frequency	Agree strongly				Disagree strongly
1. Preparing an abstract for a meeting	10	◉	○	○	○	○
2. Present a business plan for a biotechnology company	9	○	◉	○	○	○
3. Present findings with Powerpoint type presentation	17	○	○	◉	○	○
4. Proposal writing	10	○	○	○	◉	○
5. Scientific and technical writing	13	○	○	○	○	◉
6. Writing brief trip reports	13	○	○	○	◉	○
7. Writing on, speaking about and presenting technical material to a variety of audiences with varying levels of knowledge in the field	16	○	○	◉	○	○
8. Critical thinking skills	17	○	◉	○	○	○
9. Problem solving skills	16	◉	○	○	○	○
10. Literature review skills	11	○	◉	○	○	○

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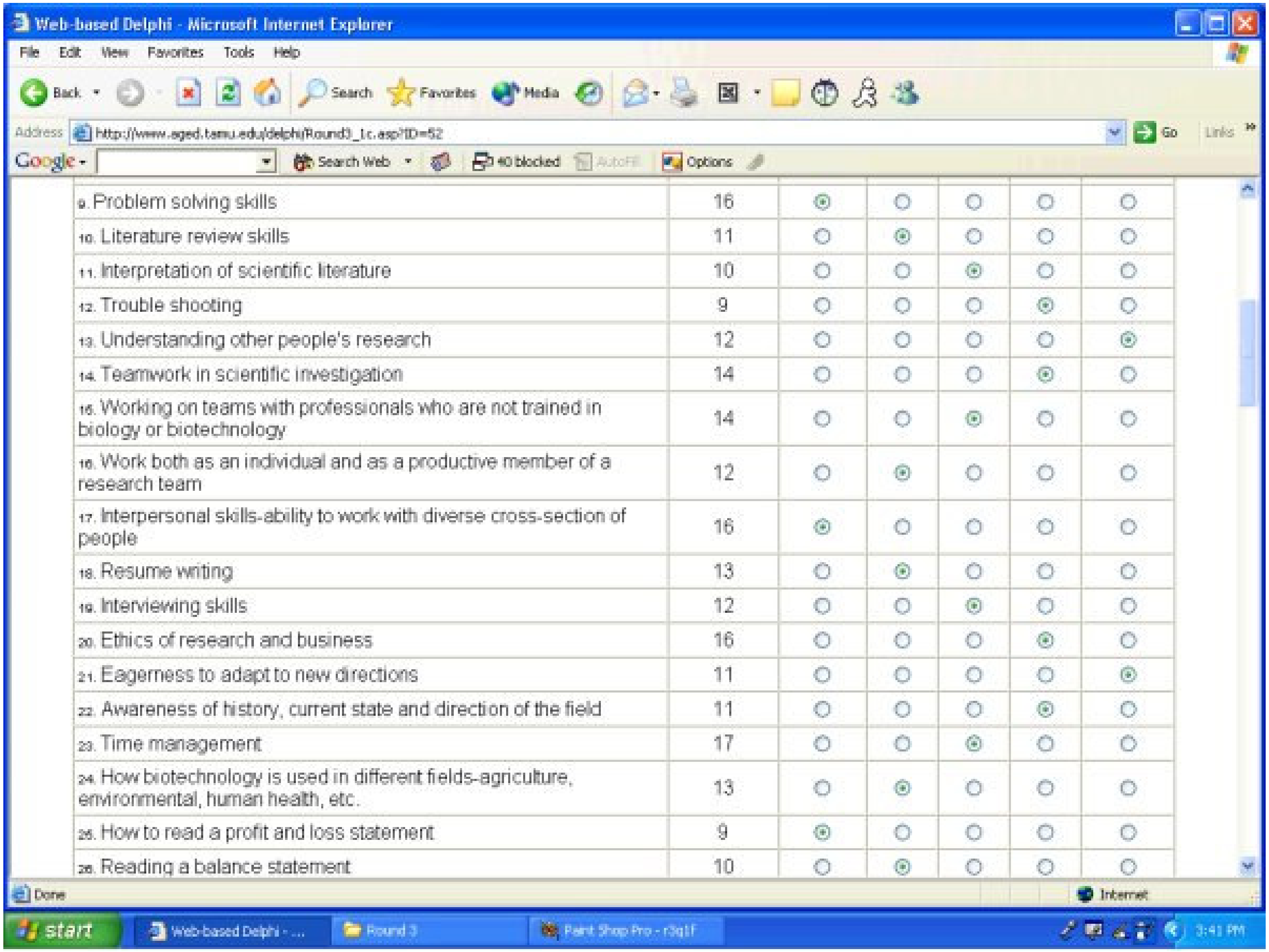
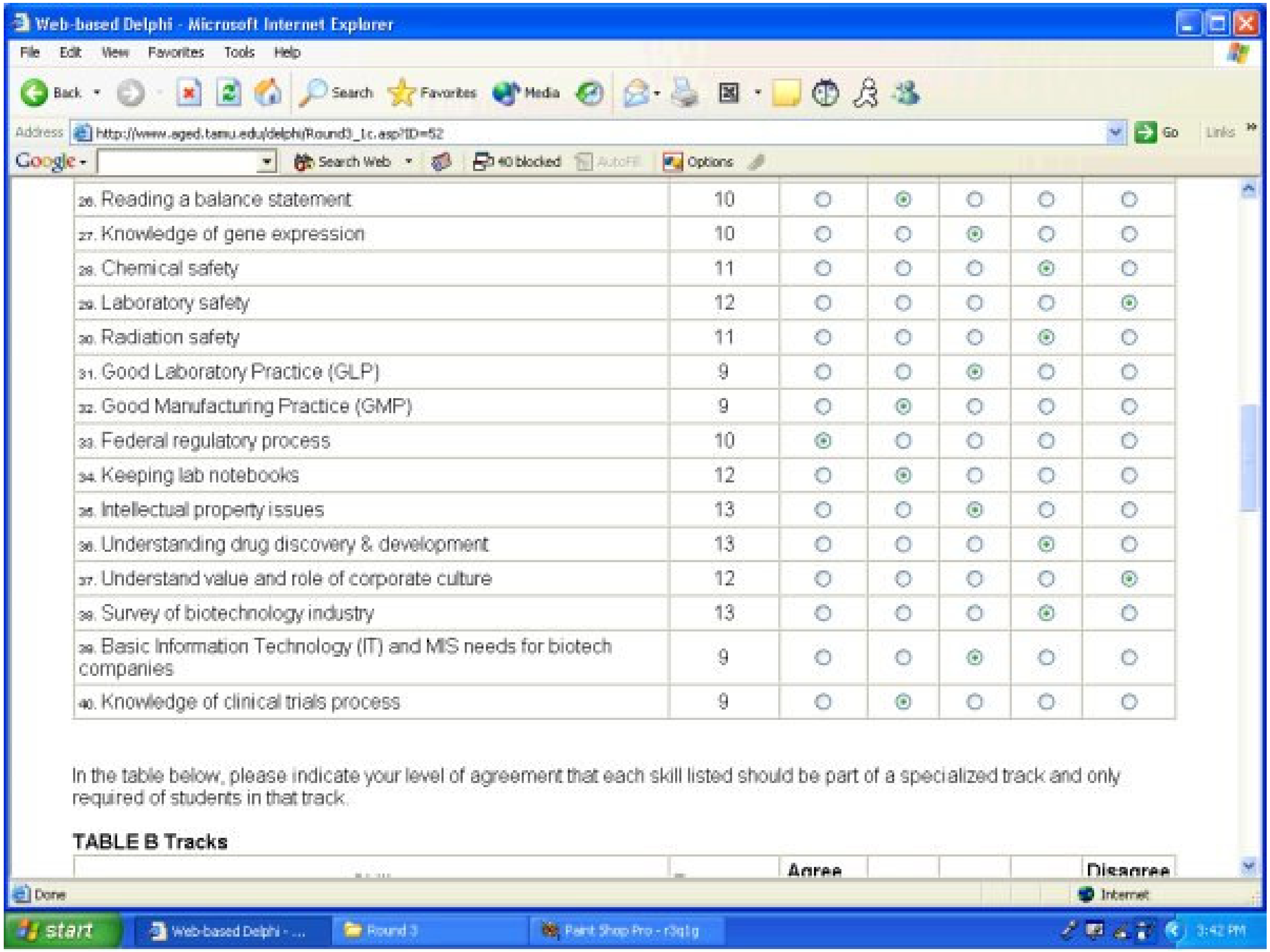


9. Problem solving skills	16	◉	○	○	○	○
10. Literature review skills	11	○	◉	○	○	○
11. Interpretation of scientific literature	10	○	○	◉	○	○
12. Trouble shooting	9	○	○	○	◉	○
13. Understanding other people's research	12	○	○	○	○	◉
14. Teamwork in scientific investigation	14	○	○	○	◉	○
15. Working on teams with professionals who are not trained in biology or biotechnology	14	○	○	◉	○	○
16. Work both as an individual and as a productive member of a research team	12	○	◉	○	○	○
17. Interpersonal skills-ability to work with diverse cross-section of people	16	◉	○	○	○	○
18. Resume writing	13	○	◉	○	○	○
19. Interviewing skills	12	○	○	◉	○	○
20. Ethics of research and business	16	○	○	○	◉	○
21. Eagerness to adapt to new directions	11	○	○	○	○	◉
22. Awareness of history, current state and direction of the field	11	○	○	○	◉	○
23. Time management	17	○	○	◉	○	○
24. How biotechnology is used in different fields-agriculture, environmental, human health, etc.	13	○	◉	○	○	○
25. How to read a profit and loss statement	9	◉	○	○	○	○
26. Reading a balance statement	10	○	◉	○	○	○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26. Reading a balance statement 10
27. Knowledge of gene expression 10
28. Chemical safety 11
29. Laboratory safety 12
30. Radiation safety 11
31. Good Laboratory Practice (GLP) 9
32. Good Manufacturing Practice (GMP) 9
33. Federal regulatory process 10
34. Keeping lab notebooks 12
35. Intellectual property issues 13
36. Understanding drug discovery & development 13
37. Understand value and role of corporate culture 12
38. Survey of biotechnology industry 13
39. Basic Information Technology (IT) and MIS needs for biotech companies 9
40. Knowledge of clinical trials process 9
In the table below, please indicate your level of agreement that each skill listed should be part of a specialized track and only required of students in that track.
TABLE B Tracks
Agree
Disagree
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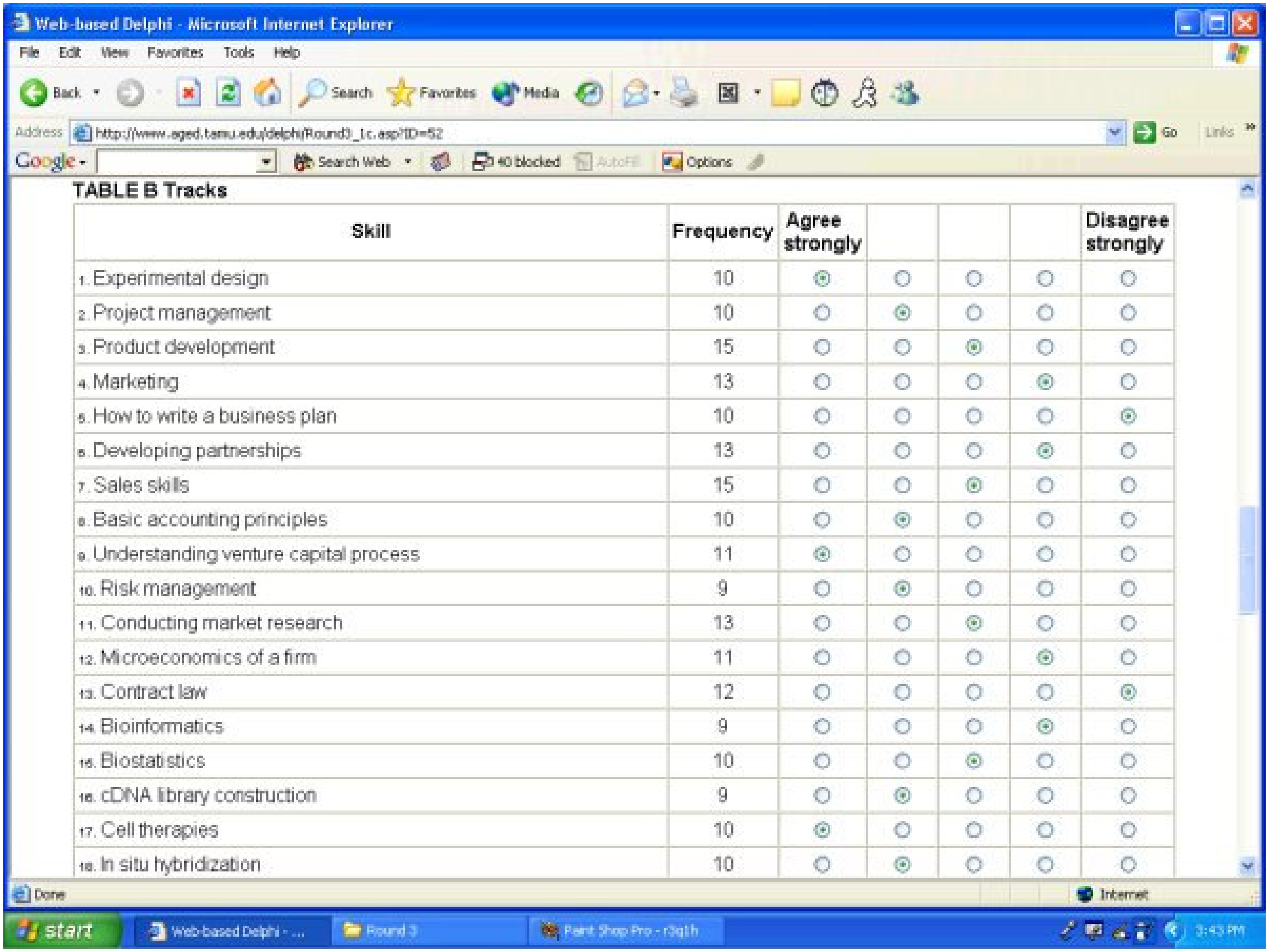
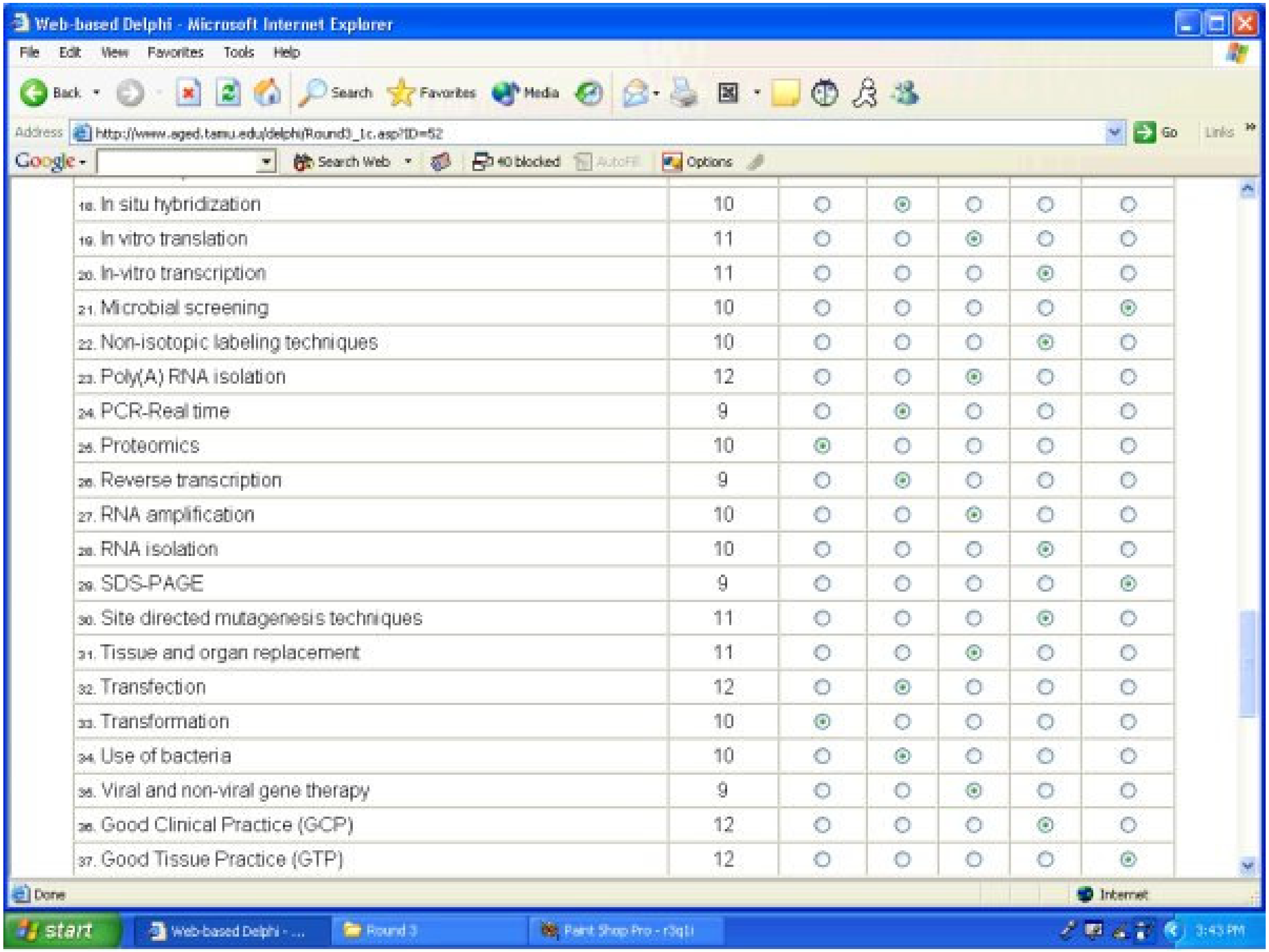


TABLE B Tracks

Skill	Frequency	Agree strongly				Disagree strongly
1. Experimental design	10	◉	○	○	○	○
2. Project management	10	○	◉	○	○	○
3. Product development	15	○	○	◉	○	○
4. Marketing	13	○	○	○	◉	○
5. How to write a business plan	10	○	○	○	○	◉
6. Developing partnerships	13	○	○	○	◉	○
7. Sales skills	15	○	○	◉	○	○
8. Basic accounting principles	10	○	◉	○	○	○
9. Understanding venture capital process	11	◉	○	○	○	○
10. Risk management	9	○	◉	○	○	○
11. Conducting market research	13	○	○	◉	○	○
12. Microeconomics of a firm	11	○	○	○	◉	○
13. Contract law	12	○	○	○	○	◉
14. Bioinformatics	9	○	○	○	◉	○
15. Biostatistics	10	○	○	◉	○	○
16. cDNA library construction	9	○	◉	○	○	○
17. Cell therapies	10	◉	○	○	○	○
18. In situ hybridization	10	○	◉	○	○	○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18. In situ hybridization 10
19. In vitro translation 11
20. In-vitro transcription 11
21. Microbial screening 10
22. Non-isotopic labeling techniques 10
23. Poly(A) RNA isolation 12
24. PCR-Real time 9
25. Proteomics 10
26. Reverse transcription 9
27. RNA amplification 10
28. RNA isolation 10
29. SDS-PAGE 9
30. Site directed mutagenesis techniques 11
31. Tissue and organ replacement 11
32. Transfection 12
33. Transformation 10
34. Use of bacteria 10
35. Viral and non-viral gene therapy 9
36. Good Clinical Practice (GCP) 12
37. Good Tissue Practice (GTP) 12
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37. Good Tissue Practice (GTP)	12	○	○	○	○	◉
38. 21CFRx00	10	○	○	○	◉	○
39. Points to Consider documents	11	○	○	◉	○	○
40. Guidance documents	9	○	◉	○	○	○
41. Know about current drugs under development	12	◉	○	○	○	○
42. Know about medical devices under development	12	○	◉	○	○	○
43. Acquiring funding for biotech companies	13	○	○	◉	○	○
44. ISO 9000	11	○	○	○	◉	○
45. Biotechnology market knowledge	10	○	○	○	○	◉
46. Facility design and engineering (*Basic understanding of HVAC, water systems, facility layout and design)	12	○	○	○	◉	○
47. Quality Assurance	11	○	○	◉	○	○
48. National and International Scope of Interest	10	○	◉	○	○	○
49. Preclinical testing	13	◉	○	○	○	○
50. Human Factors testing	13	○	◉	○	○	○
51. Clinical testing	13	○	○	◉	○	○
52. Medical writing	13	○	○	○	◉	○

In the text box below, please feel free to provide any comments that you might have about any part of Question 1C.

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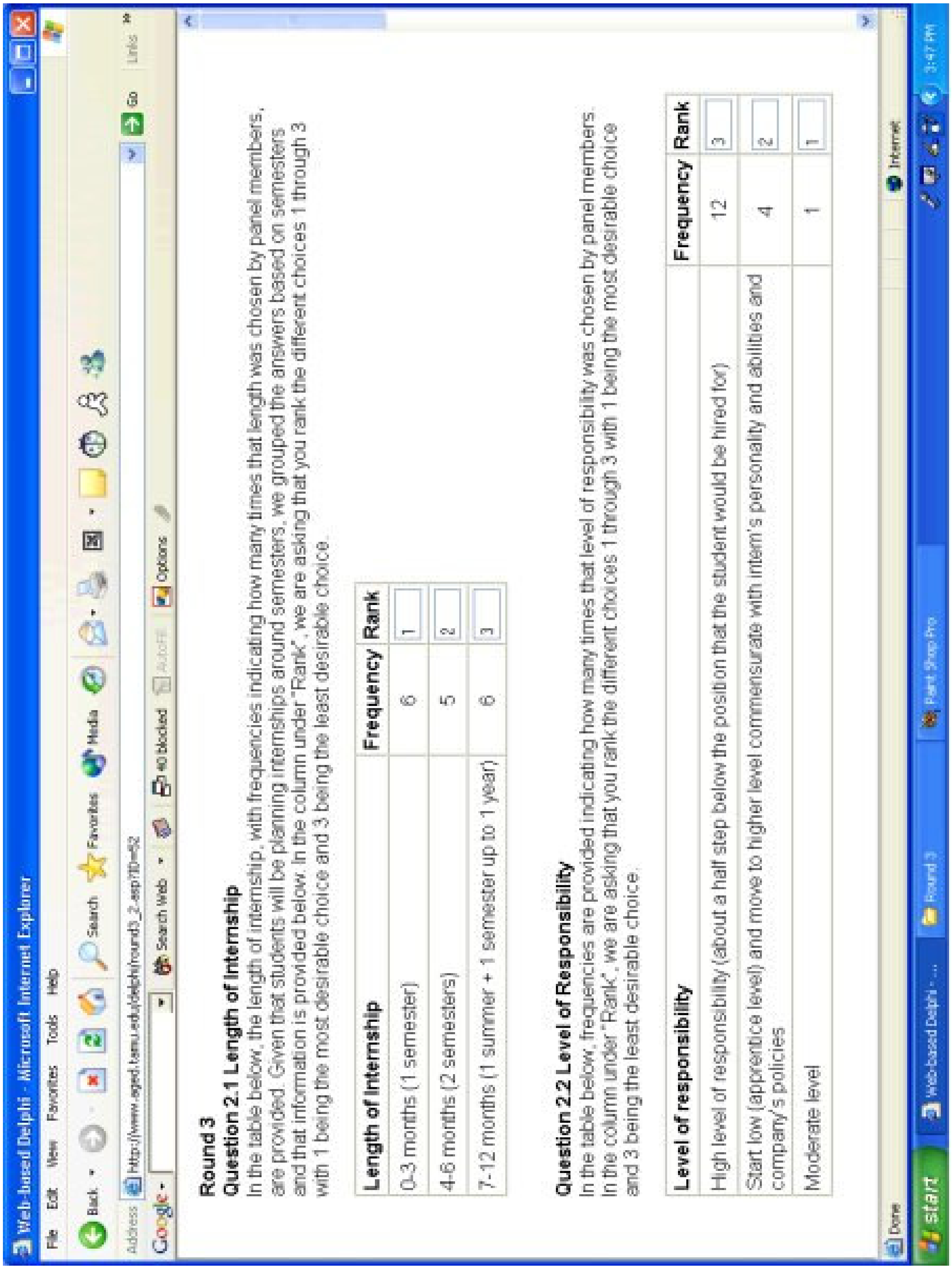

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Round 3

Question 2.1 Length of Internship

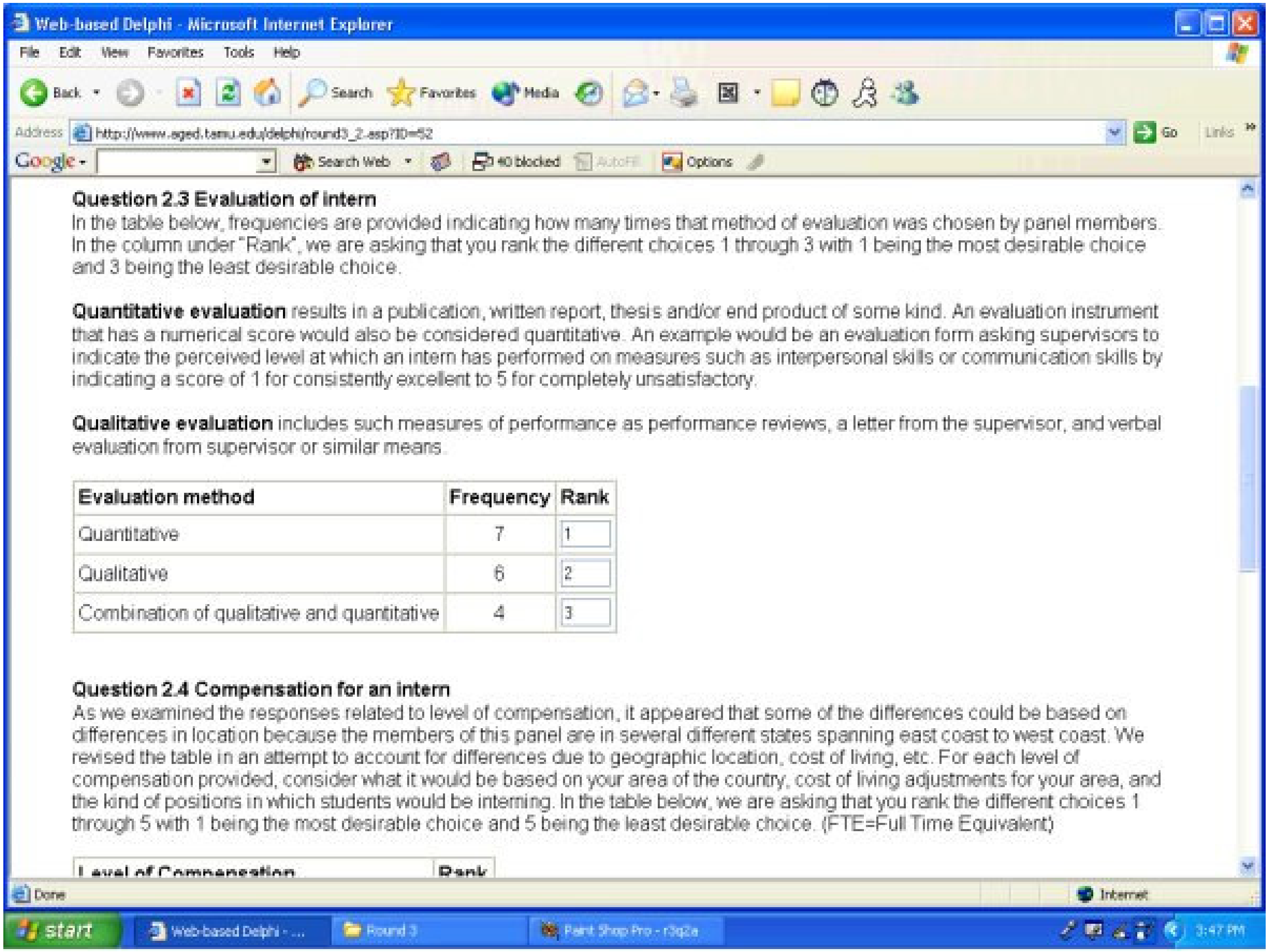
In the table below, the length of internship, with frequencies indicating how many times that length was chosen by panel members, are provided. Given that students will be planning internships around semesters, we grouped the answers based on semesters and that information is provided below. In the column under "Rank", we are asking that you rank the different choices 1 through 3 with 1 being the most desirable choice and 3 being the least desirable choice.

Length of Internship	Frequency	Rank
0-3 months (1 semester)	6	1
4-6 months (2 semesters)	5	2
7-12 months (1 summer + 1 semester up to 1 year)	6	3

Question 2.2 Level of Responsibility

In the table below, frequencies are provided indicating how many times that level of responsibility was chosen by panel members. In the column under "Rank", we are asking that you rank the different choices 1 through 3 with 1 being the most desirable choice and 3 being the least desirable choice.

Level of responsibility	Frequency	Rank
High level of responsibility (about a half step below the position that the student would be hired for)	12	3
Start low (apprentice level) and move to higher level commensurate with intern's personality and abilities and company's policies	4	2
Moderate level	1	1



Question 2.3 Evaluation of intern
In the table below, frequencies are provided indicating how many times that method of evaluation was chosen by panel members. In the column under "Rank", we are asking that you rank the different choices 1 through 3 with 1 being the most desirable choice and 3 being the least desirable choice.

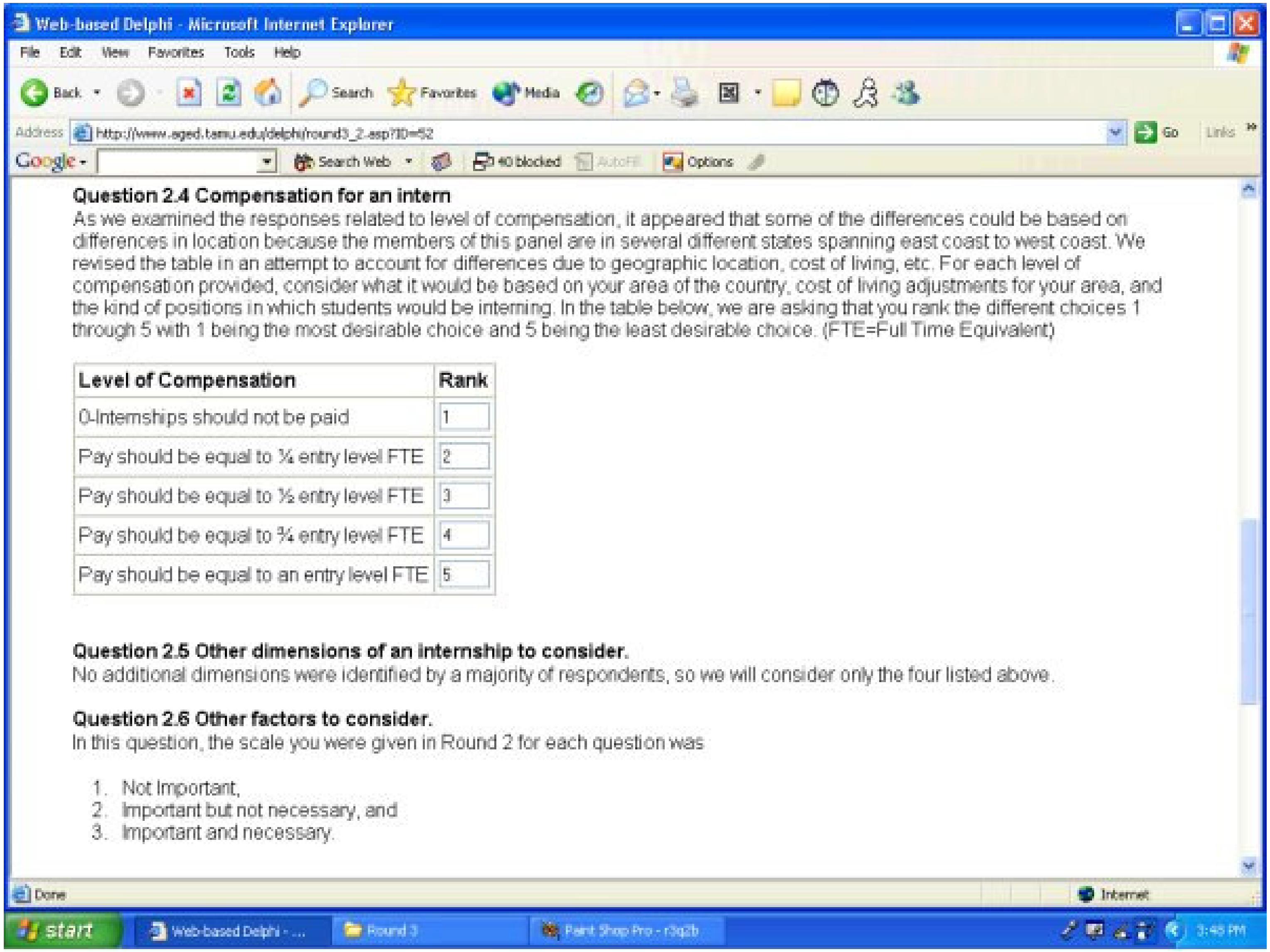
Quantitative evaluation results in a publication, written report, thesis and/or end product of some kind. An evaluation instrument that has a numerical score would also be considered quantitative. An example would be an evaluation form asking supervisors to indicate the perceived level at which an intern has performed on measures such as interpersonal skills or communication skills by indicating a score of 1 for consistently excellent to 5 for completely unsatisfactory.

Qualitative evaluation includes such measures of performance as performance reviews, a letter from the supervisor, and verbal evaluation from supervisor or similar means.

Evaluation method	Frequency	Rank
Quantitative	7	1
Qualitative	6	2
Combination of qualitative and quantitative	4	3

Question 2.4 Compensation for an intern
As we examined the responses related to level of compensation, it appeared that some of the differences could be based on differences in location because the members of this panel are in several different states spanning east coast to west coast. We revised the table in an attempt to account for differences due to geographic location, cost of living, etc. For each level of compensation provided, consider what it would be based on your area of the country, cost of living adjustments for your area, and the kind of positions in which students would be interning. In the table below, we are asking that you rank the different choices 1 through 5 with 1 being the most desirable choice and 5 being the least desirable choice. (FTE=Full Time Equivalent)

Level of Compensation	Rank



Question 2.4 Compensation for an intern

As we examined the responses related to level of compensation, it appeared that some of the differences could be based on differences in location because the members of this panel are in several different states spanning east coast to west coast. We revised the table in an attempt to account for differences due to geographic location, cost of living, etc. For each level of compensation provided, consider what it would be based on your area of the country, cost of living adjustments for your area, and the kind of positions in which students would be interning. In the table below, we are asking that you rank the different choices 1 through 5 with 1 being the most desirable choice and 5 being the least desirable choice. (FTE=Full Time Equivalent)

Level of Compensation	Rank
0-Internships should not be paid	1
Pay should be equal to ¼ entry level FTE	2
Pay should be equal to ½ entry level FTE	3
Pay should be equal to ¾ entry level FTE	4
Pay should be equal to an entry level FTE	5

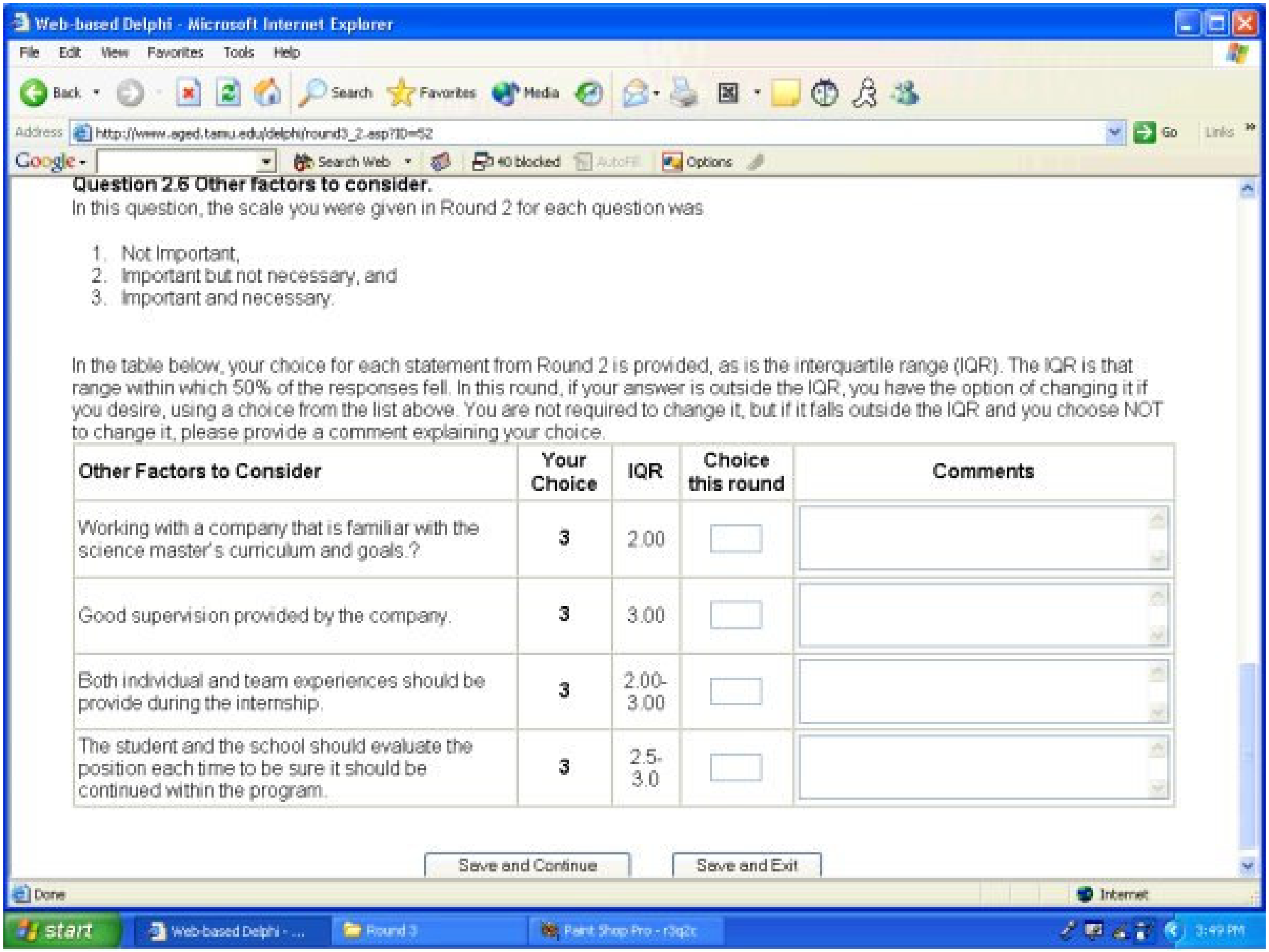
Question 2.5 Other dimensions of an internship to consider.

No additional dimensions were identified by a majority of respondents, so we will consider only the four listed above.

Question 2.6 Other factors to consider.

In this question, the scale you were given in Round 2 for each question was

1. Not Important,
2. Important but not necessary, and
3. Important and necessary.



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Question 2.6 Other factors to consider.

In this question, the scale you were given in Round 2 for each question was

1. Not Important,
2. Important but not necessary, and
3. Important and necessary.

In the table below, your choice for each statement from Round 2 is provided, as is the interquartile range (IQR). The IQR is that range within which 50% of the responses fell. In this round, if your answer is outside the IQR, you have the option of changing it if you desire, using a choice from the list above. You are not required to change it, but if it falls outside the IQR and you choose NOT to change it, please provide a comment explaining your choice.

Other Factors to Consider	Your Choice	IQR	Choice this round	Comments
Working with a company that is familiar with the science master's curriculum and goals.?	3	2.00		
Good supervision provided by the company.	3	3.00		
Both individual and team experiences should be provide during the internship.	3	2.00-3.00		
The student and the school should evaluate the position each time to be sure it should be continued within the program.	3	2.5-3.0		

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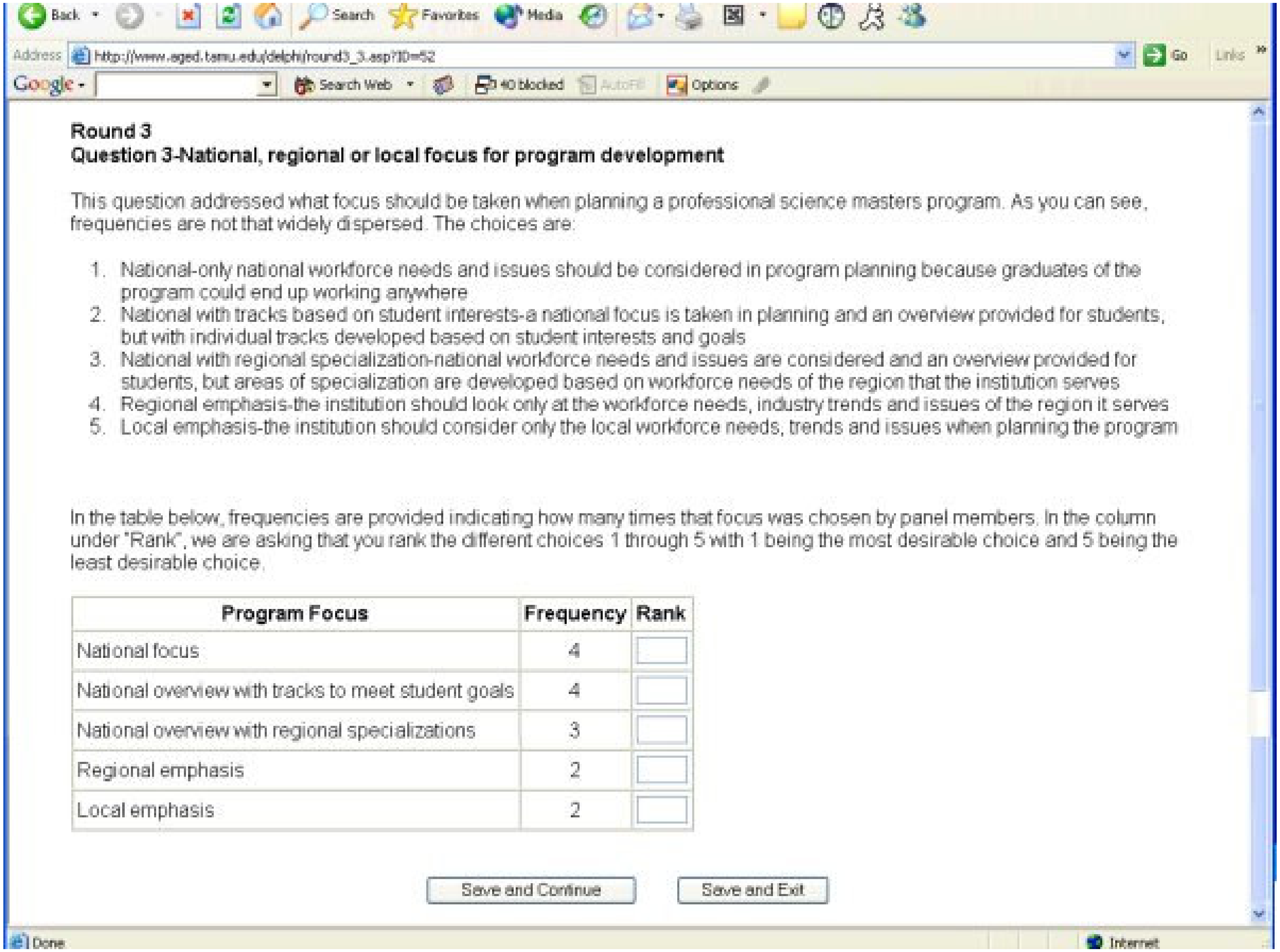

Round 3

Question 3-National, regional or local focus for program development

This question addressed what focus should be taken when planning a professional science masters program. As you can see, frequencies are not that widely dispersed. The choices are:

1. National-only national workforce needs and issues should be considered in program planning because graduates of the program could end up working anywhere
2. National with tracks based on student interests-a national focus is taken in planning and an overview provided for students, but with individual tracks developed based on student interests and goals
3. National with regional specialization-national workforce needs and issues are considered and an overview provided for students, but areas of specialization are developed based on workforce needs of the region that the institution serves
4. Regional emphasis-the institution should look only at the workforce needs, industry trends and issues of the region it serves
5. Local emphasis-the institution should consider only the local workforce needs, trends and issues when planning the program

In the table below, frequencies are provided indicating how many times that focus was chosen by panel members. In the column under "Rank", we are asking that you rank the different choices 1 through 5 with 1 being the most desirable choice and 5 being the least desirable choice.

Program Focus	Frequency	Rank
National focus	4	
National overview with tracks to meet student goals	4	
National overview with regional specializations	3	
Regional emphasis	2	
Local emphasis	2	

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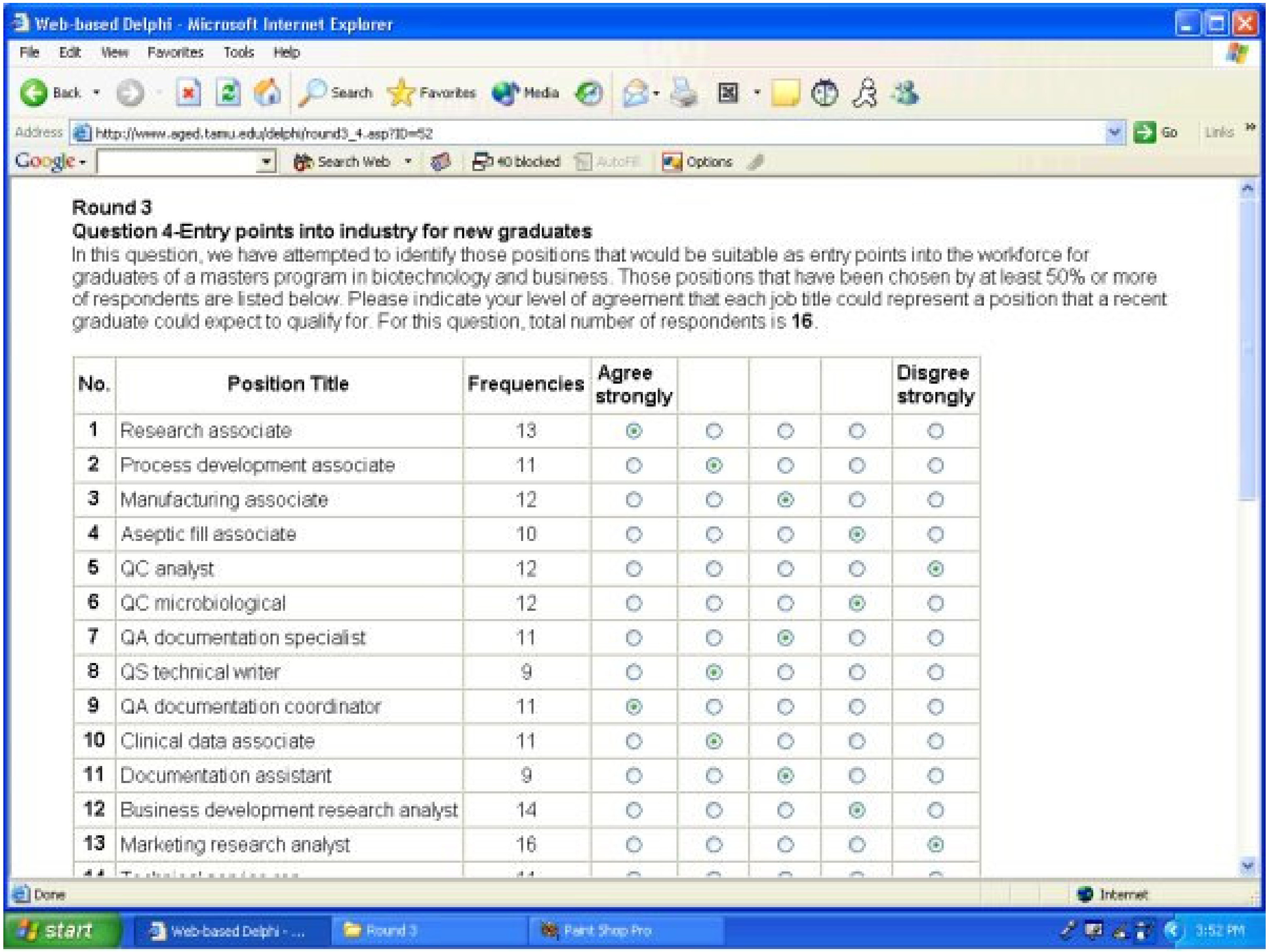

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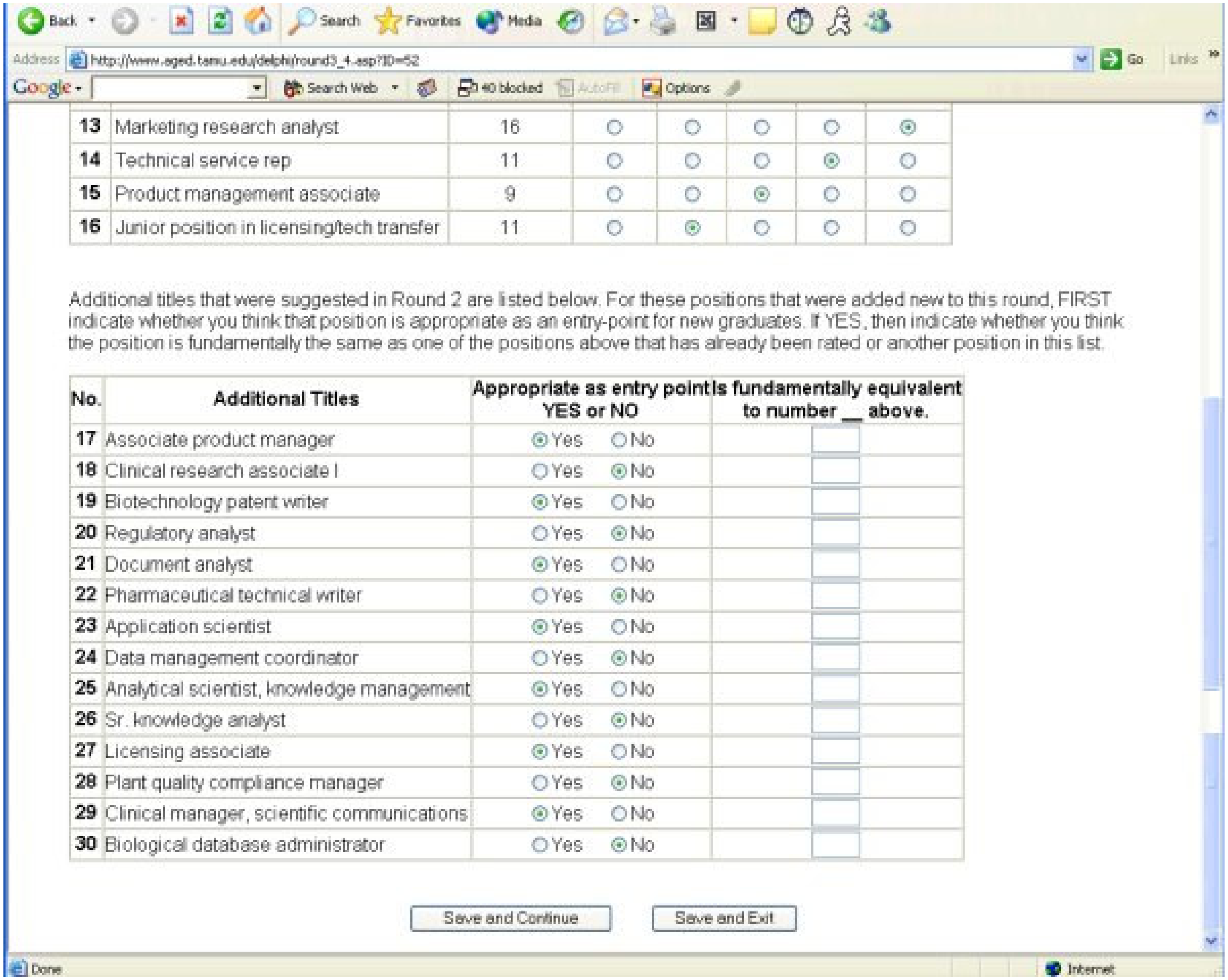
Round 3

Question 4-Entry points into industry for new graduates

In this question, we have attempted to identify those positions that would be suitable as entry points into the workforce for graduates of a masters program in biotechnology and business. Those positions that have been chosen by at least 50% or more of respondents are listed below. Please indicate your level of agreement that each job title could represent a position that a recent graduate could expect to qualify for. For this question, total number of respondents is **16**.

No.	Position Title	Frequencies	Agree strongly				Disgree strongly
1	Research associate	13	◉	○	○	○	○
2	Process development associate	11	○	◉	○	○	○
3	Manufacturing associate	12	○	○	◉	○	○
4	Aseptic fill associate	10	○	○	○	◉	○
5	QC analyst	12	○	○	○	○	◉
6	QC microbiological	12	○	○	○	◉	○
7	QA documentation specialist	11	○	○	◉	○	○
8	QS technical writer	9	○	◉	○	○	○
9	QA documentation coordinator	11	◉	○	○	○	○
10	Clinical data associate	11	○	◉	○	○	○
11	Documentation assistant	9	○	○	◉	○	○
12	Business development research analyst	14	○	○	○	◉	○
13	Marketing research analyst	16	○	○	○	○	◉



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13	Marketing research analyst	16	( )	( )	( )	( )	(•)
14	Technical service rep	11	( )	( )	( )	(•)	( )
15	Product management associate	9	( )	( )	(•)	( )	( )
16	Junior position in licensing/tech transfer	11	( )	(•)	( )	( )	( )

Additional titles that were suggested in Round 2 are listed below. For these positions that were added new to this round, FIRST indicate whether you think that position is appropriate as an entry-point for new graduates. If YES, then indicate whether you think the position is fundamentally the same as one of the positions above that has already been rated or another position in this list.

No.	Additional Titles	Appropriate as entry point YES or NO	Is fundamentally equivalent to number __ above.
17	Associate product manager	(•) Yes ( ) No	
18	Clinical research associate I	( ) Yes (•) No	
19	Biotechnology patent writer	(•) Yes ( ) No	
20	Regulatory analyst	( ) Yes (•) No	
21	Document analyst	(•) Yes ( ) No	
22	Pharmaceutical technical writer	( ) Yes (•) No	
23	Application scientist	(•) Yes ( ) No	
24	Data management coordinator	( ) Yes (•) No	
25	Analytical scientist, knowledge management	(•) Yes ( ) No	
26	Sr. knowledge analyst	( ) Yes (•) No	
27	Licensing associate	(•) Yes ( ) No	
28	Plant quality compliance manager	( ) Yes (•) No	
29	Clinical manager, scientific communications	(•) Yes ( ) No	
30	Biological database administrator	( ) Yes (•) No	

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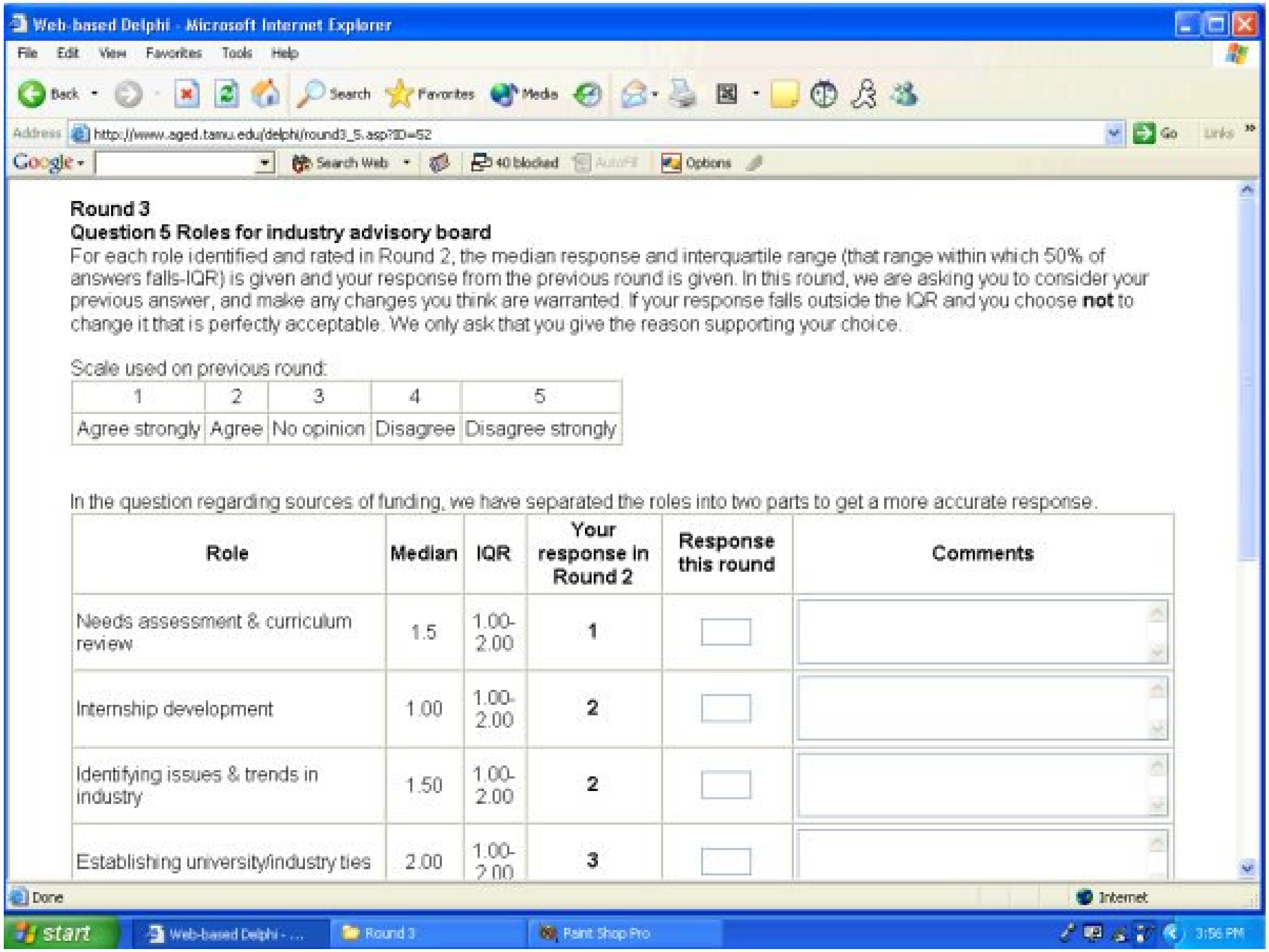

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Round 3

Question 5 Roles for industry advisory board

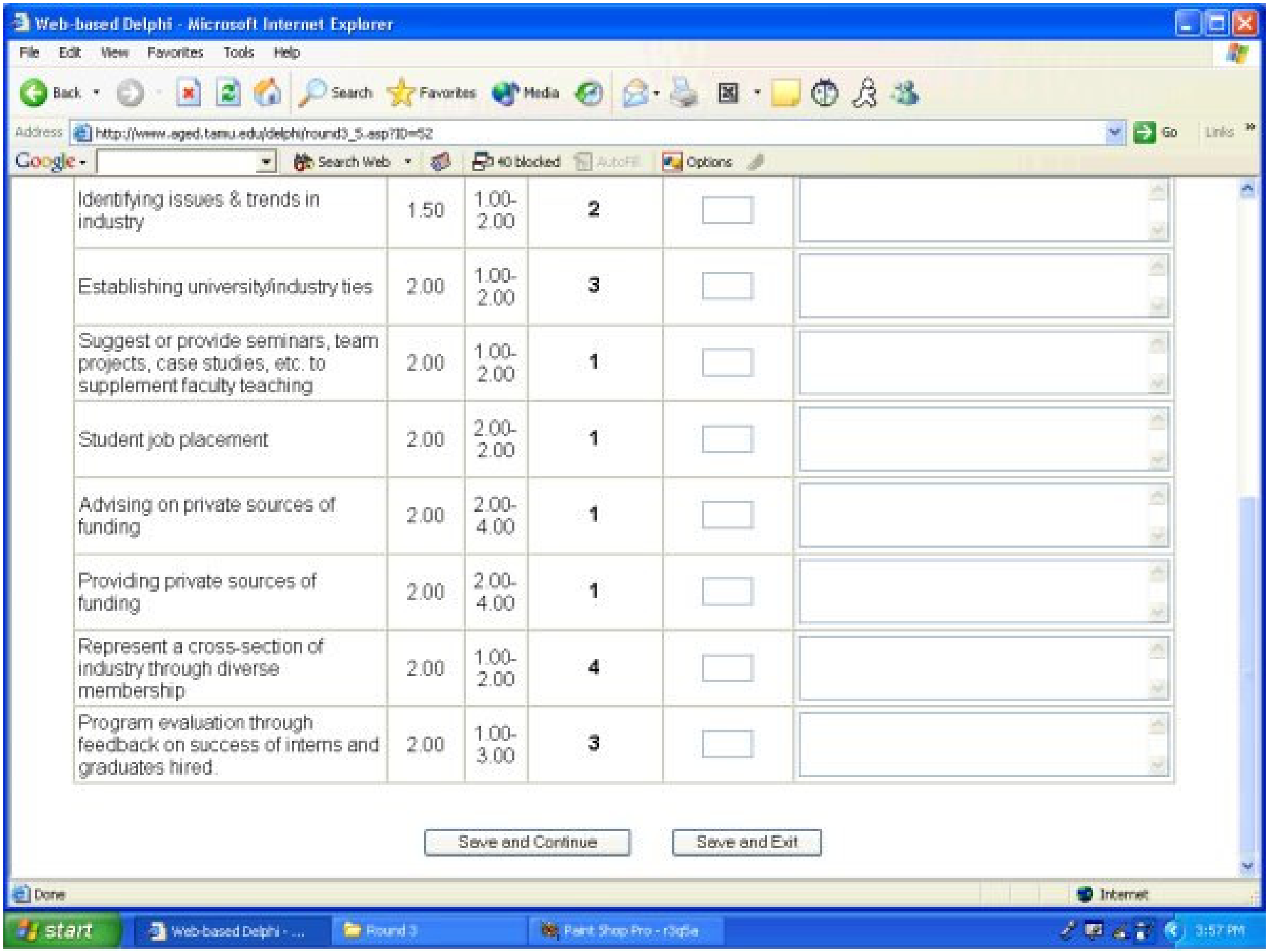
For each role identified and rated in Round 2, the median response and interquartile range (that range within which 50% of answers falls-IQR) is given and your response from the previous round is given. In this round, we are asking you to consider your previous answer, and make any changes you think are warranted. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you give the reason supporting your choice.

Scale used on previous round:

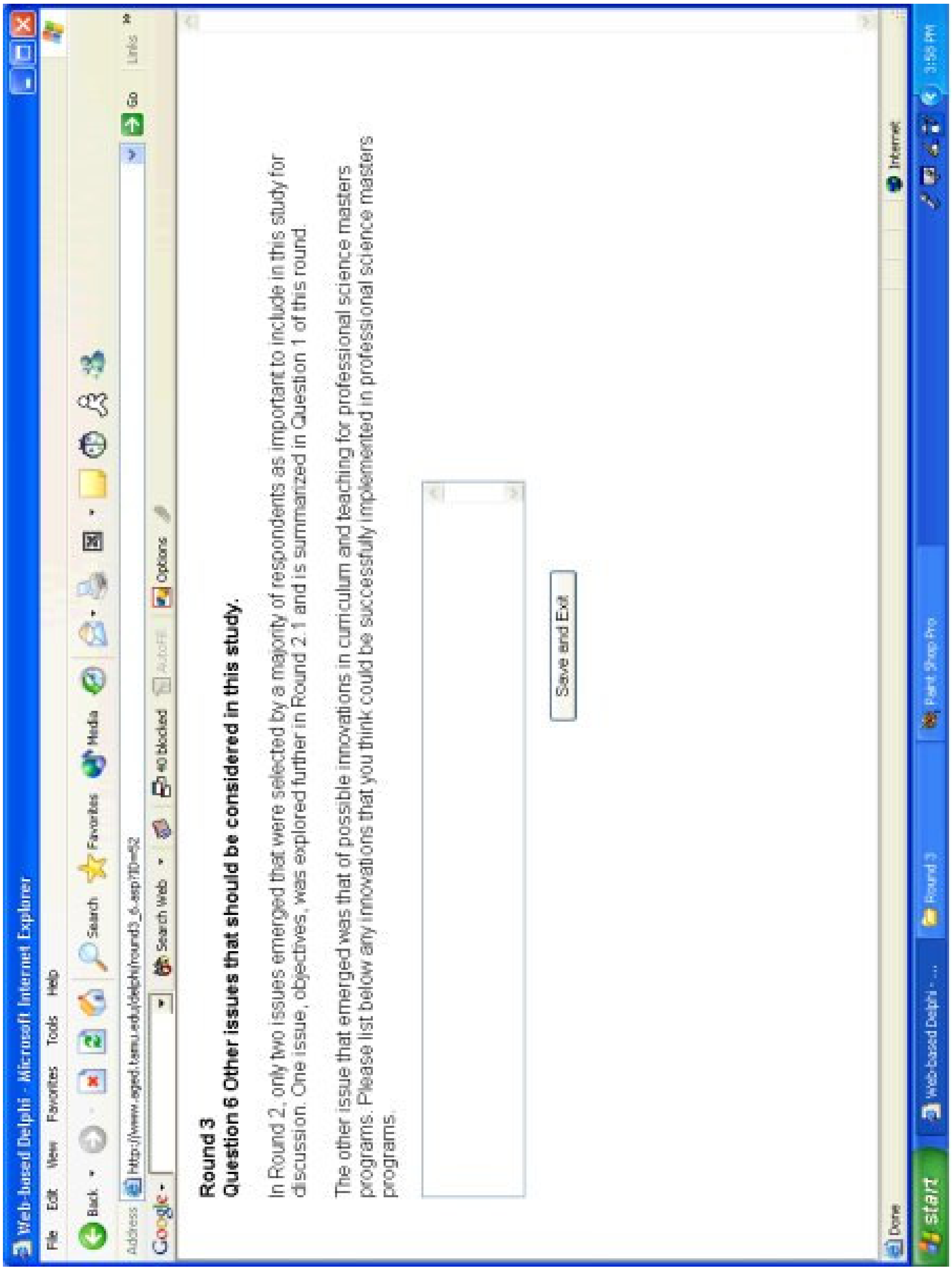
1	2	3	4	5
Agree strongly	Agree	No opinion	Disagree	Disagree strongly

In the question regarding sources of funding, we have separated the roles into two parts to get a more accurate response.

Role	Median	IQR	Your response in Round 2	Response this round	Comments
Needs assessment & curriculum review	1.5	1.00-2.00	1		
Internship development	1.00	1.00-2.00	2		
Identifying issues & trends in industry	1.50	1.00-2.00	2		
Establishing university/industry ties	2.00	1.00-2.00	3		



Identifying issues & trends in industry	1.50	1.00-2.00	**2**		
Establishing university/industry ties	2.00	1.00-2.00	**3**		
Suggest or provide seminars, team projects, case studies, etc. to supplement faculty teaching	2.00	1.00-2.00	**1**		
Student job placement	2.00	2.00-2.00	**1**		
Advising on private sources of funding	2.00	2.00-4.00	**1**		
Providing private sources of funding	2.00	2.00-4.00	**1**		
Represent a cross-section of industry through diverse membership	2.00	1.00-2.00	**4**		
Program evaluation through feedback on success of interns and graduates hired.	2.00	1.00-3.00	**3**		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Round 3
Question 6 Other issues that should be considered in this study.
In Round 2, only two issues emerged that were selected by a majority of respondents as important to include in this study for discussion. One issue, objectives, was explored further in Round 2.1 and is summarized in Question 1 of this round.
The other issue that emerged was that of possible innovations in curriculum and teaching for professional science masters programs. Please list below any innovations that you think could be successfully implemented in professional science masters programs.
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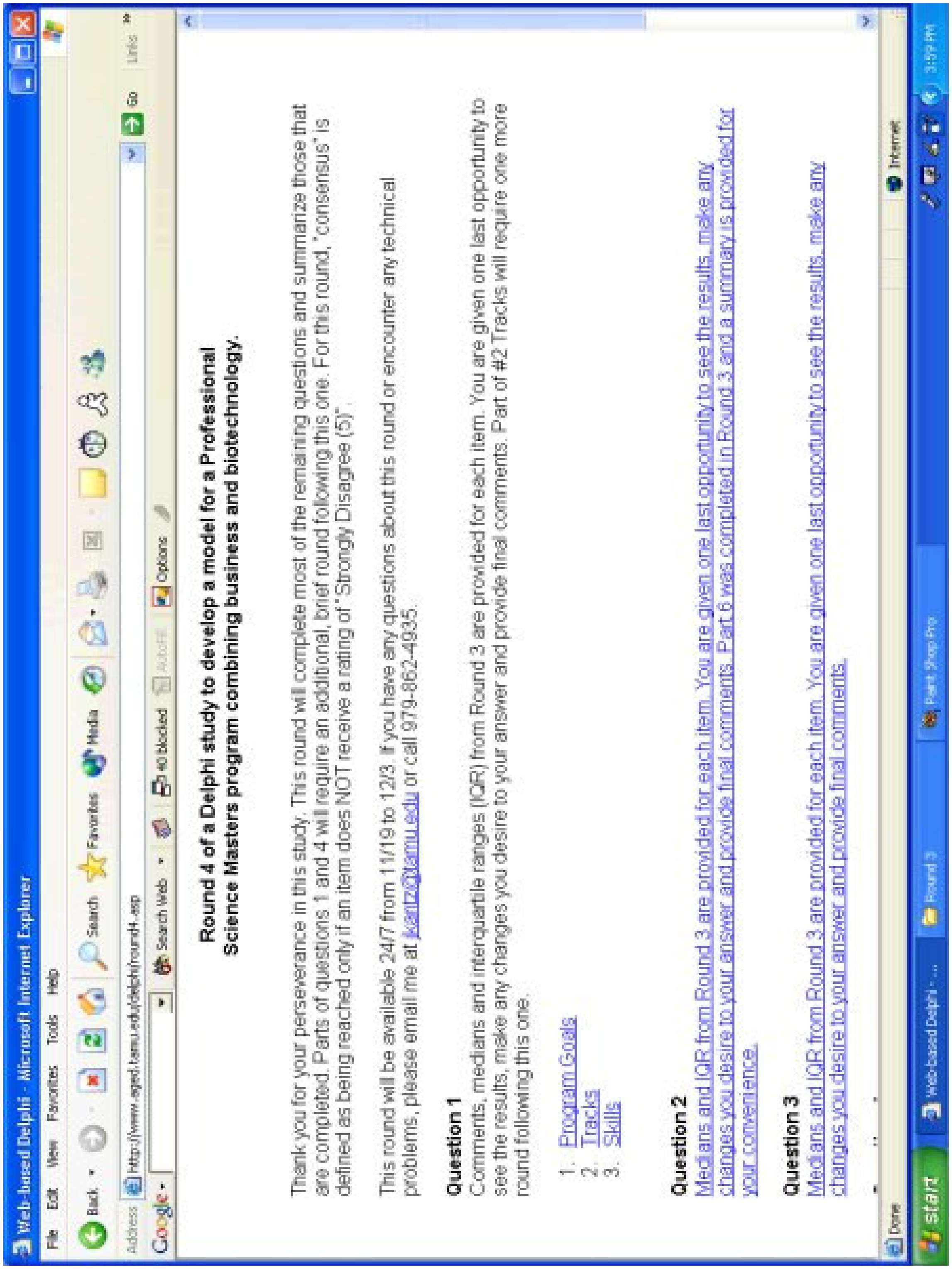
APPENDIX G

ROUND 4 INSTRUMENT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Round 4 of a Delphi study to develop a model for a Professional Science Masters program combining business and biotechnology.
Thank you for your perseverance in this study. This round will complete most of the remaining questions and summarize those that are completed. Parts of questions 1 and 4 will require an additional, brief round following this one. For this round, "consensus" is defined as being reached only if an item does NOT receive a rating of "Strongly Disagree (5)".
This round will be available 24/7 from 11/19 to 12/3. If you have any questions about this round or encounter any technical problems, please email me at jkantz@tamu.edu or call 979-862-4935.
Question 1
Comments, medians and interquartile ranges (IQR) from Round 3 are provided for each item. You are given one last opportunity to see the results, make any changes you desire to your answer and provide final comments. Part of #2 Tracks will require one more round following this one.
1. Program Goals
2. Tracks
3. Skills
Question 2
Medians and IQR from Round 3 are provided for each item. You are given one last opportunity to see the results, make any changes you desire to your answer and provide final comments. Part 6 was completed in Round 3 and a summary is provided for your convenience.
Question 3
Medians and IQR from Round 3 are provided for each item. You are given one last opportunity to see the results, make any changes you desire to your answer and provide final comments.
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Round 3
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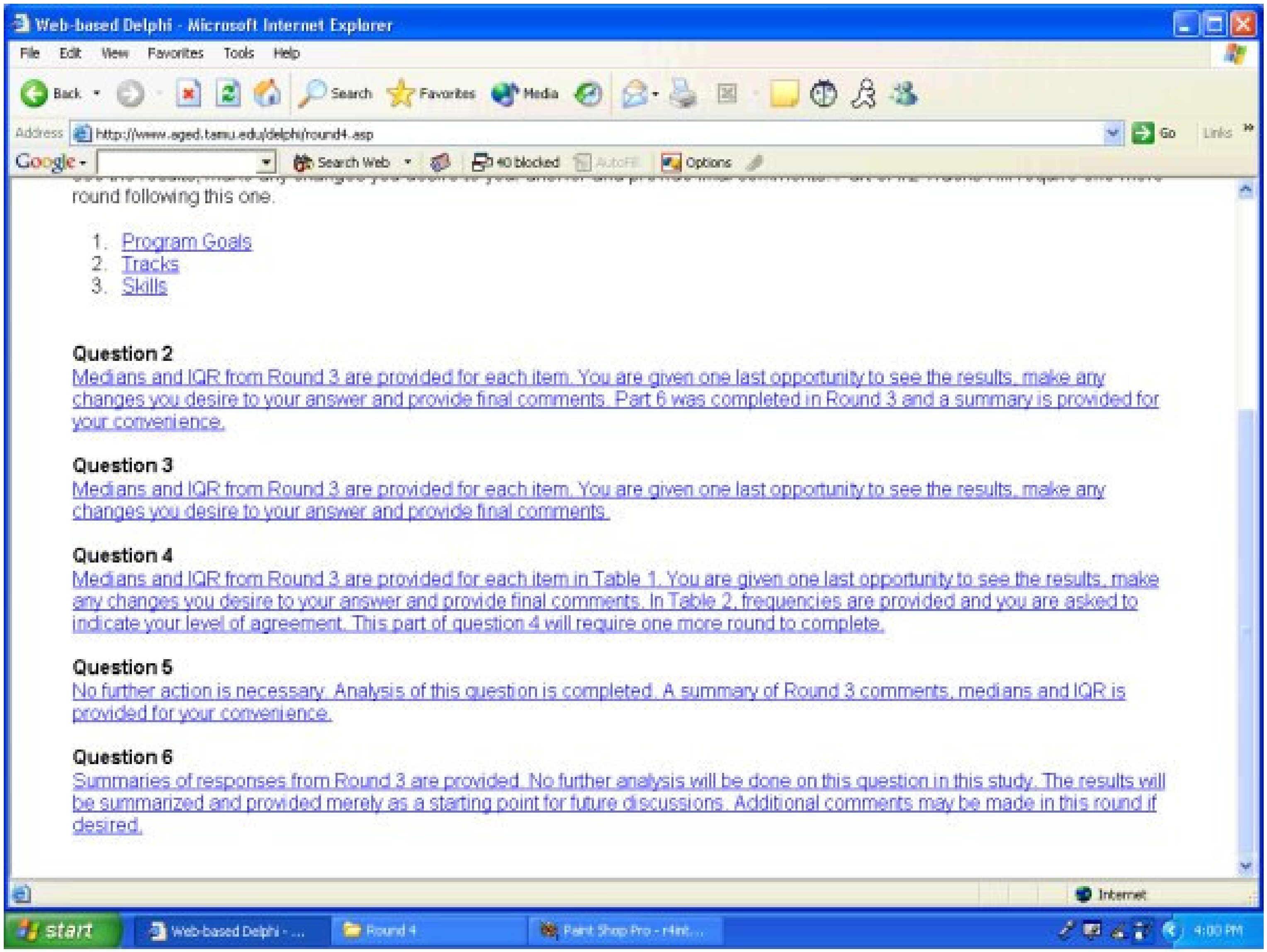
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round following this one.
1. Program Goals
2. Tracks
3. Skills
Question 2
Medians and IQR from Round 3 are provided for each item. You are given one last opportunity to see the results, make any changes you desire to your answer and provide final comments. Part 6 was completed in Round 3 and a summary is provided for your convenience.
Question 3
Medians and IQR from Round 3 are provided for each item. You are given one last opportunity to see the results, make any changes you desire to your answer and provide final comments.
Question 4
Medians and IQR from Round 3 are provided for each item in Table 1. You are given one last opportunity to see the results, make any changes you desire to your answer and provide final comments. In Table 2, frequencies are provided and you are asked to indicate your level of agreement. This part of question 4 will require one more round to complete.
Question 5
No further action is necessary. Analysis of this question is completed. A summary of Round 3 comments, medians and IQR is provided for your convenience.
Question 6
Summaries of responses from Round 3 are provided. No further analysis will be done on this question in this study. The results will be summarized and provided merely as a starting point for future discussions. Additional comments may be made in this round if desired.
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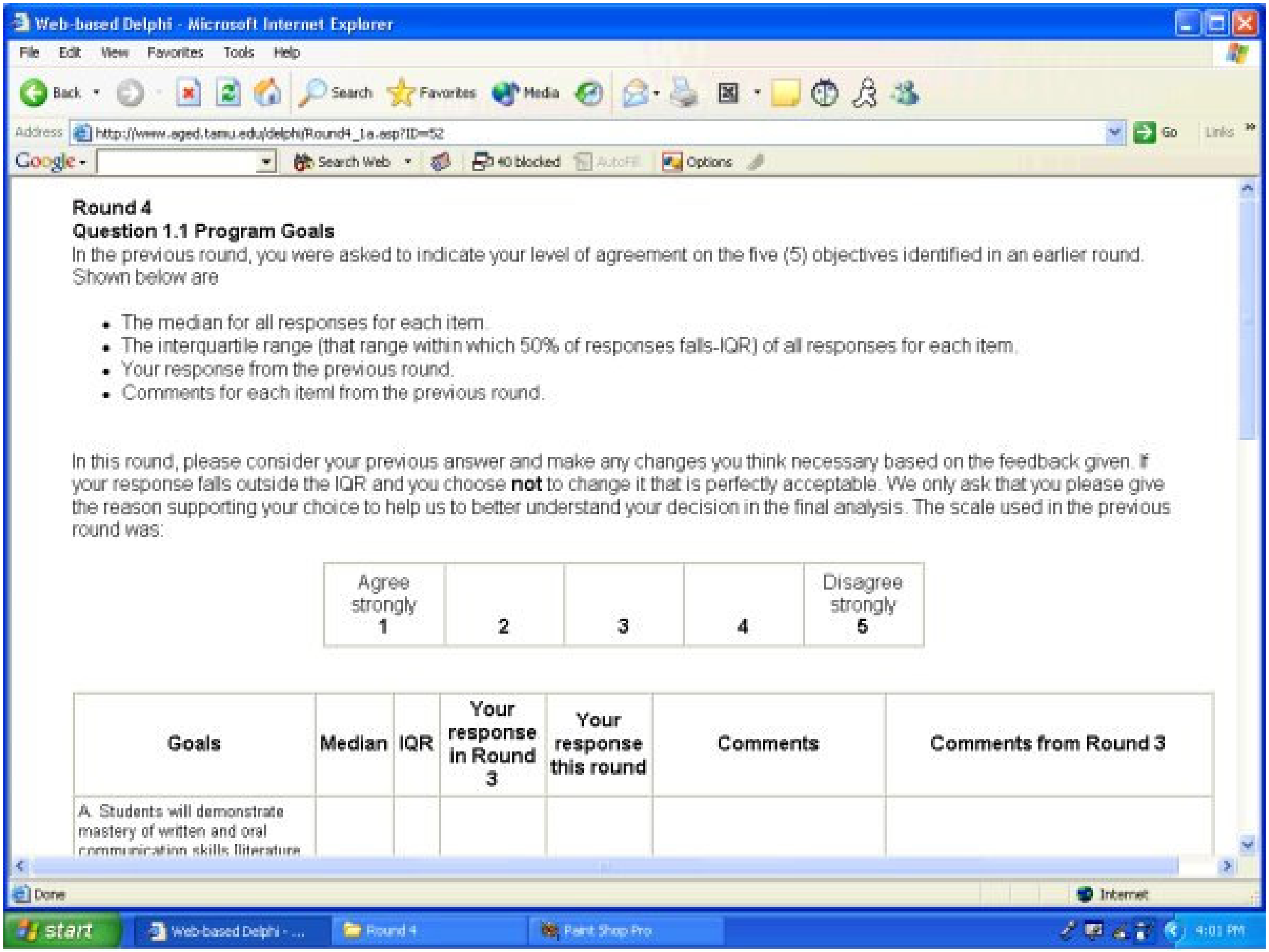

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Round 4
Question 1.1 Program Goals
In the previous round, you were asked to indicate your level of agreement on the five (5) objectives identified in an earlier round. Shown below are

- The median for all responses for each item.
- The interquartile range (that range within which 50% of responses falls-IQR) of all responses for each item.
- Your response from the previous round.
- Comments for each iteml from the previous round.

In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:

Agree strongly 1	2	3	4	Disagree strongly 5

Goals	Median	IQR	Your response in Round 3	Your response this round	Comments	Comments from Round 3
A. Students will demonstrate mastery of written and oral communication skills literature						

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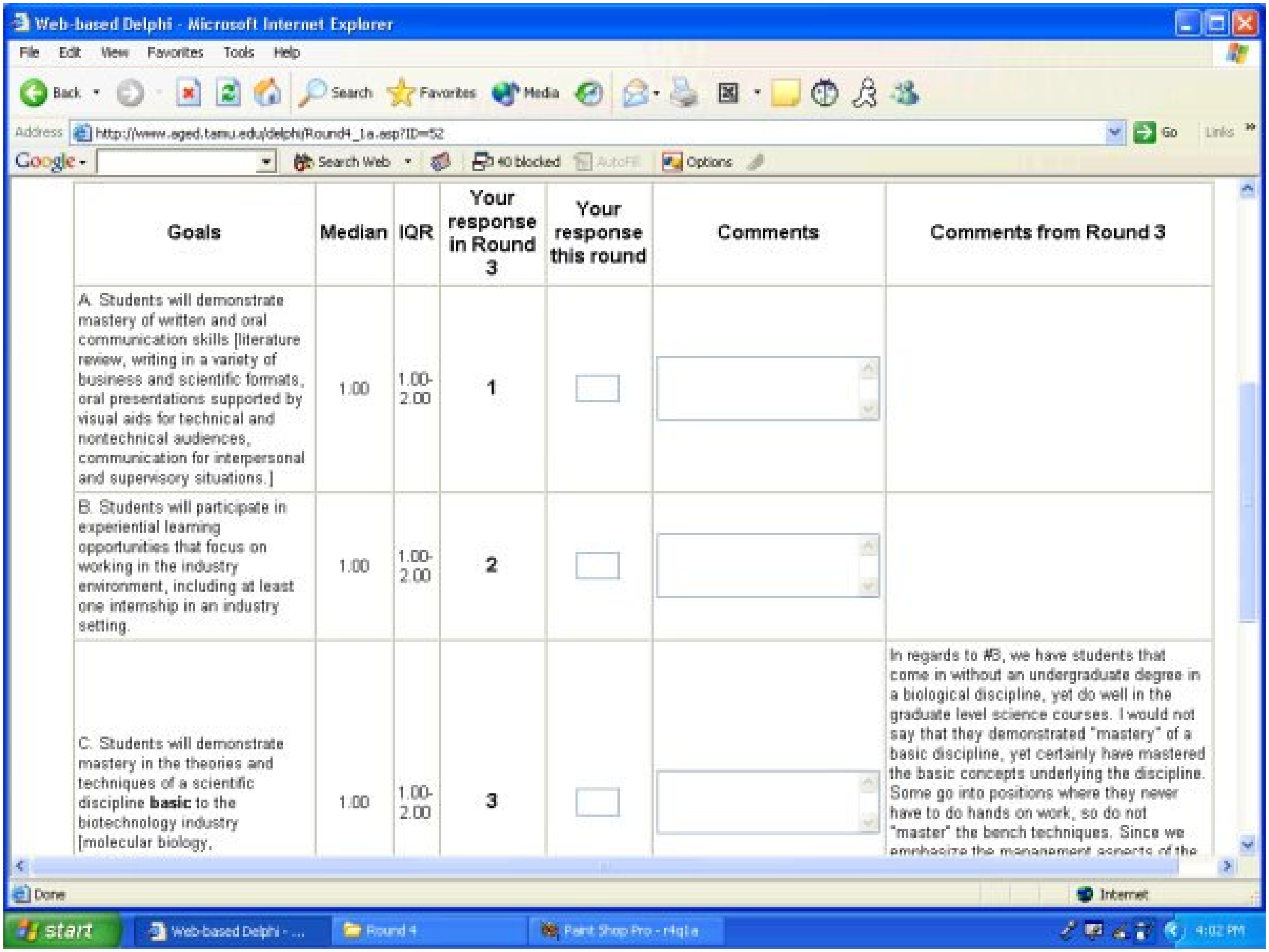
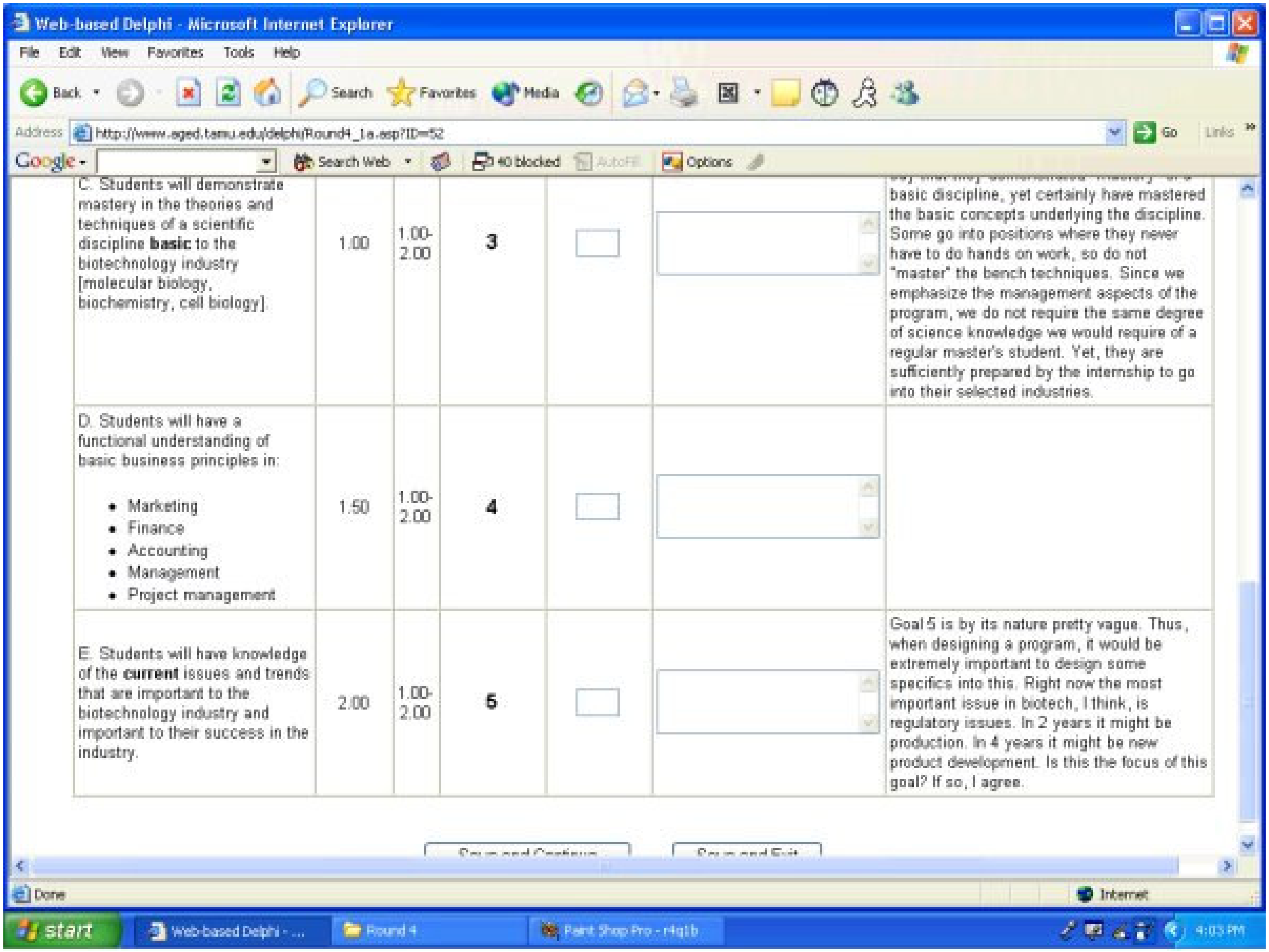
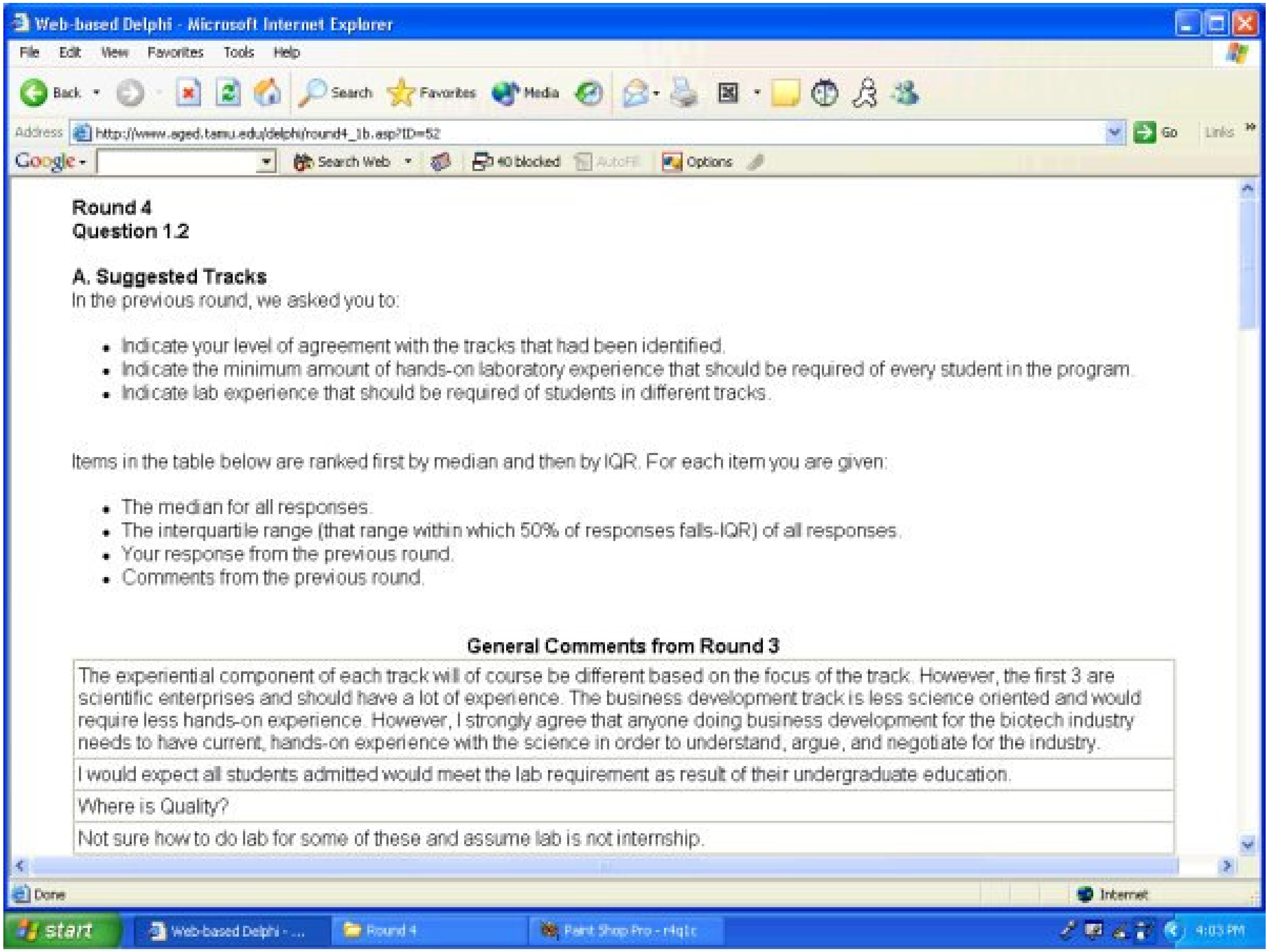


Goals	Median	IQR	Your response in Round 3	Your response this round	Comments	Comments from Round 3
A. Students will demonstrate mastery of written and oral communication skills [literature review, writing in a variety of business and scientific formats, oral presentations supported by visual aids for technical and nontechnical audiences, communication for interpersonal and supervisory situations.]	1.00	1.00-2.00	1			
B. Students will participate in experiential learning opportunities that focus on working in the industry environment, including at least one internship in an industry setting.	1.00	1.00-2.00	2			
C. Students will demonstrate mastery in the theories and techniques of a scientific discipline **basic** to the biotechnology industry [molecular biology,	1.00	1.00-2.00	3			In regards to #3, we have students that come in without an undergraduate degree in a biological discipline, yet do well in the graduate level science courses. I would not say that they demonstrated "mastery" of a basic discipline, yet certainly have mastered the basic concepts underlying the discipline. Some go into positions where they never have to do hands on work, so do not "master" the bench techniques. Since we emphasize the management aspects of the



C. Students will demonstrate mastery in the theories and techniques of a scientific discipline **basic** to the biotechnology industry [molecular biology, biochemistry, cell biology].	1.00	1.00-2.00	**3**			basic discipline, yet certainly have mastered the basic concepts underlying the discipline. Some go into positions where they never have to do hands on work, so do not "master" the bench techniques. Since we emphasize the management aspects of the program, we do not require the same degree of science knowledge we would require of a regular master's student. Yet, they are sufficiently prepared by the internship to go into their selected industries.
D. Students will have a functional understanding of basic business principles in: • Marketing • Finance • Accounting • Management • Project management	1.50	1.00-2.00	**4**			
E. Students will have knowledge of the **current** issues and trends that are important to the biotechnology industry and important to their success in the industry.	2.00	1.00-2.00	**5**			Goal 5 is by its nature pretty vague. Thus, when designing a program, it would be extremely important to design some specifics into this. Right now the most important issue in biotech, I think, is regulatory issues. In 2 years it might be production. In 4 years it might be new product development. Is this the focus of this goal? If so, I agree.



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Round 4
Question 1.2

A. Suggested Tracks
In the previous round, we asked you to:

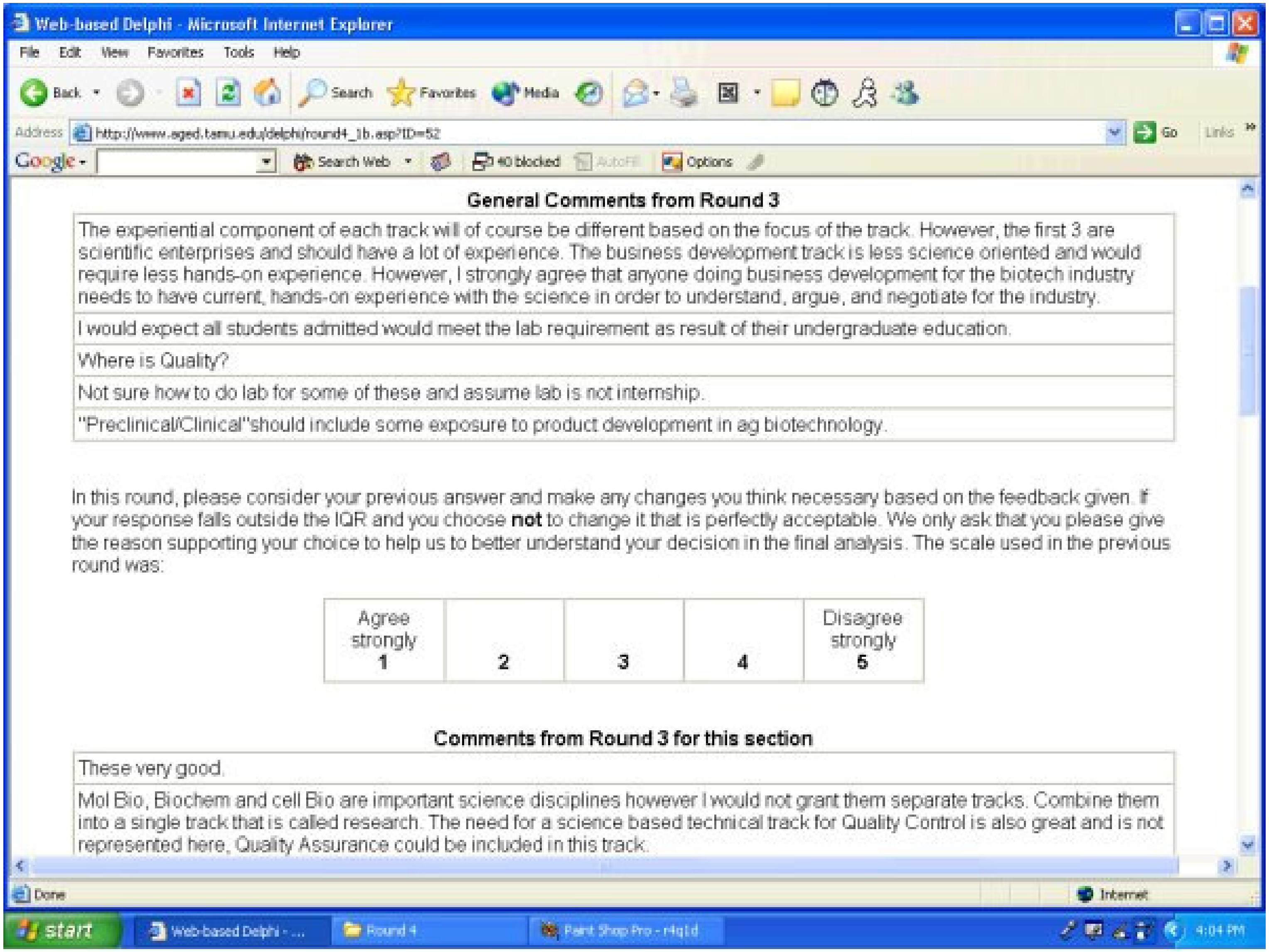
- Indicate your level of agreement with the tracks that had been identified.
- Indicate the minimum amount of hands-on laboratory experience that should be required of every student in the program.
- Indicate lab experience that should be required of students in different tracks.

Items in the table below are ranked first by median and then by IQR. For each item you are given:

- The median for all responses.
- The interquartile range (that range within which 50% of responses falls-IQR) of all responses.
- Your response from the previous round.
- Comments from the previous round.

General Comments from Round 3

The experiential component of each track will of course be different based on the focus of the track. However, the first 3 are scientific enterprises and should have a lot of experience. The business development track is less science oriented and would require less hands-on experience. However, I strongly agree that anyone doing business development for the biotech industry needs to have current, hands-on experience with the science in order to understand, argue, and negotiate for the industry.
I would expect all students admitted would meet the lab requirement as result of their undergraduate education.
Where is Quality?
Not sure how to do lab for some of these and assume lab is not internship.



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General Comments from Round 3

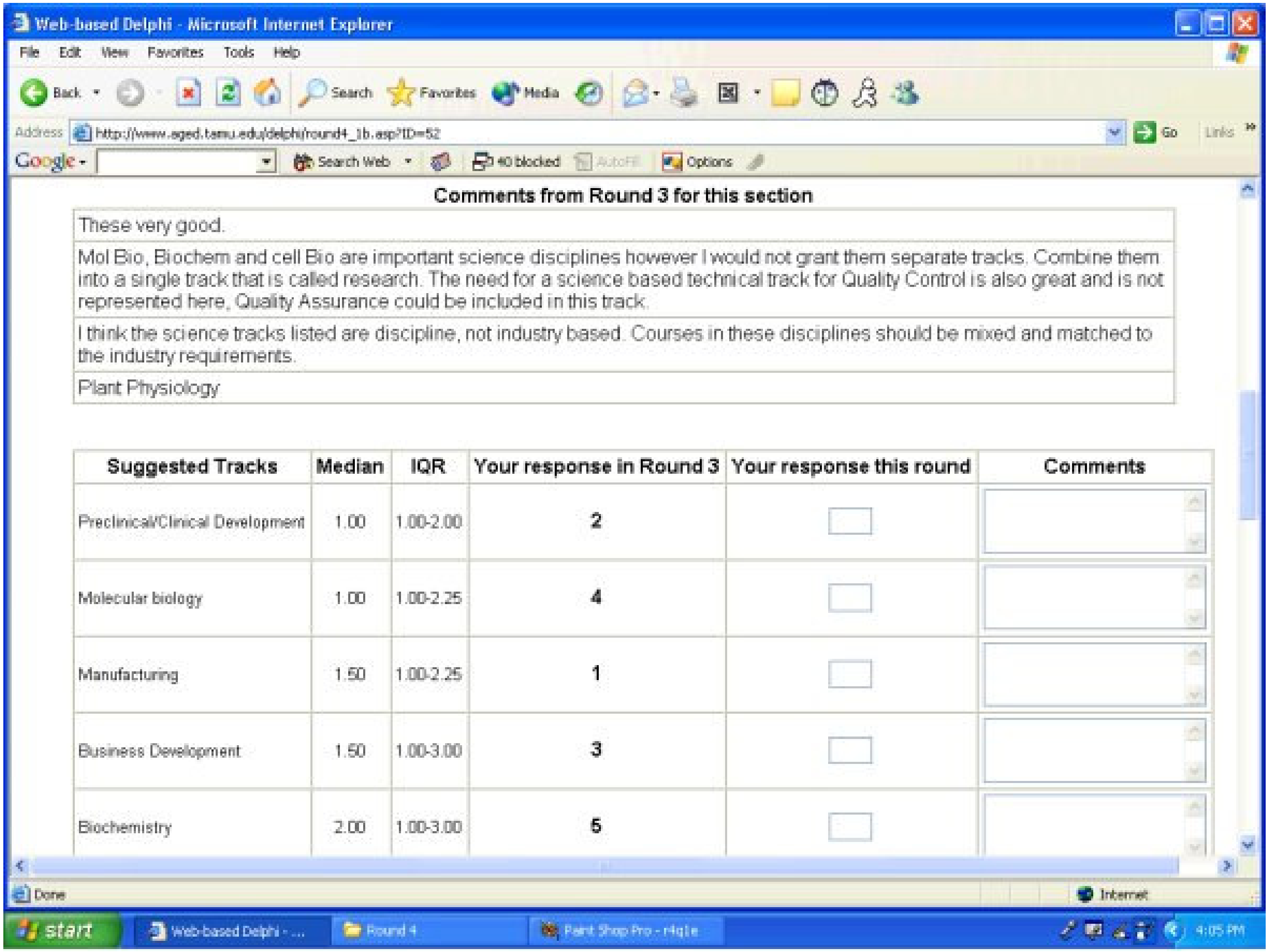
The experiential component of each track will of course be different based on the focus of the track. However, the first 3 are scientific enterprises and should have a lot of experience. The business development track is less science oriented and would require less hands-on experience. However, I strongly agree that anyone doing business development for the biotech industry needs to have current, hands-on experience with the science in order to understand, argue, and negotiate for the industry.
I would expect all students admitted would meet the lab requirement as result of their undergraduate education.
Where is Quality?
Not sure how to do lab for some of these and assume lab is not internship.
"Preclinical/Clinical"should include some exposure to product development in ag biotechnology.

In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:

Agree strongly **1**	**2**	**3**	**4**	Disagree strongly **5**

Comments from Round 3 for this section

These very good.
Mol Bio, Biochem and cell Bio are important science disciplines however I would not grant them separate tracks. Combine them into a single track that is called research. The need for a science based technical track for Quality Control is also great and is not represented here, Quality Assurance could be included in this track.



Comments from Round 3 for this section

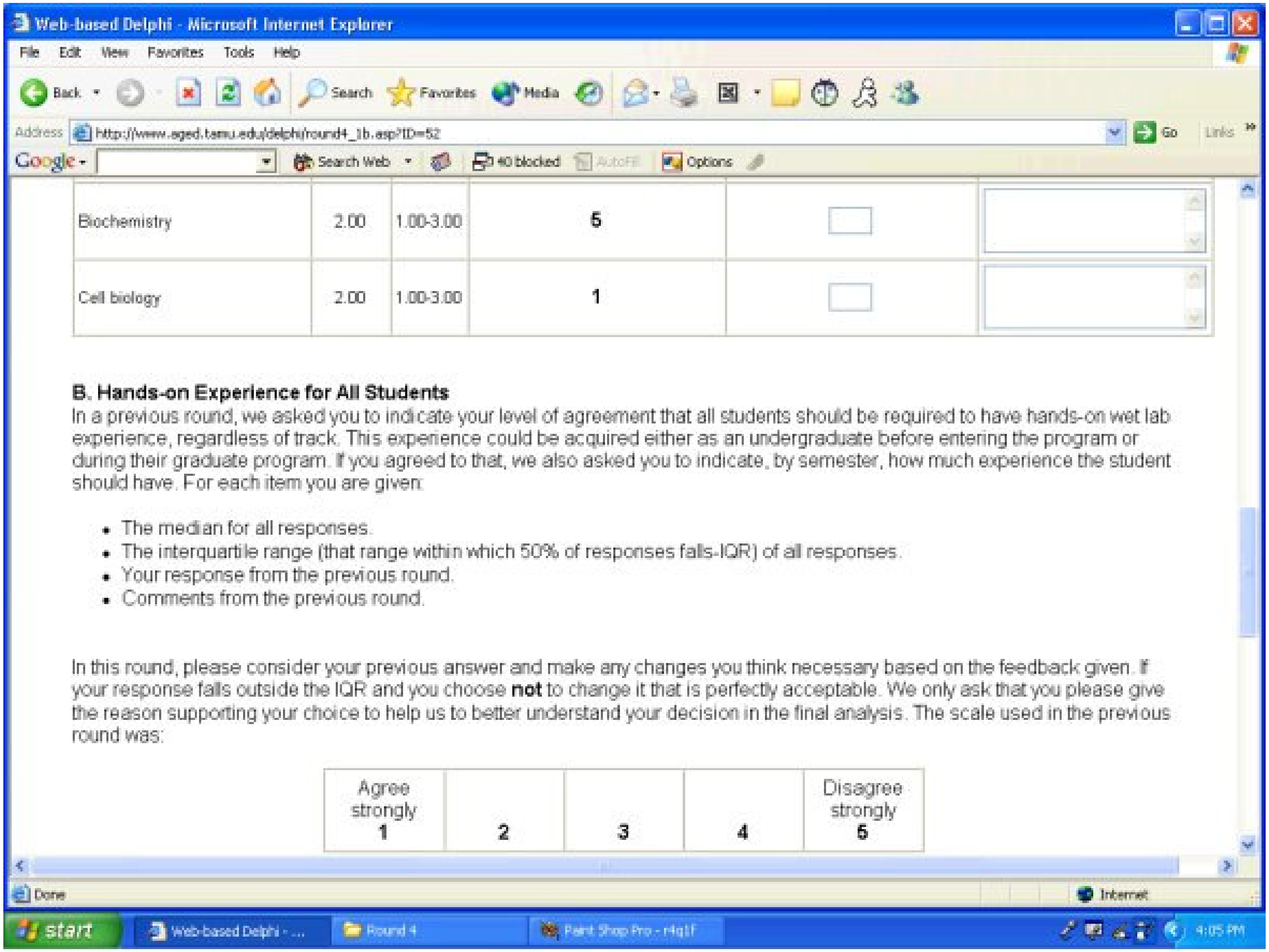
These very good.

Mol Bio, Biochem and cell Bio are important science disciplines however I would not grant them separate tracks. Combine them into a single track that is called research. The need for a science based technical track for Quality Control is also great and is not represented here, Quality Assurance could be included in this track.

I think the science tracks listed are discipline, not industry based. Courses in these disciplines should be mixed and matched to the industry requirements.

Plant Physiology

Suggested Tracks	Median	IQR	Your response in Round 3	Your response this round	Comments
Preclinical/Clinical Development	1.00	1.00-2.00	2		
Molecular biology	1.00	1.00-2.25	4		
Manufacturing	1.50	1.00-2.25	1		
Business Development	1.50	1.00-3.00	3		
Biochemistry	2.00	1.00-3.00	5		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Biochemistry	2.00	1.00-3.00	5		
Cell biology	2.00	1.00-3.00	1		

B. Hands-on Experience for All Students

In a previous round, we asked you to indicate your level of agreement that all students should be required to have hands-on wet lab experience, regardless of track. This experience could be acquired either as an undergraduate before entering the program or during their graduate program. If you agreed to that, we also asked you to indicate, by semester, how much experience the student should have. For each item you are given:

- The median for all responses.
- The interquartile range (that range within which 50% of responses falls-IQR) of all responses.
- Your response from the previous round.
- Comments from the previous round.

In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:

Agree strongly **1**	**2**	**3**	**4**	Disagree strongly **5**

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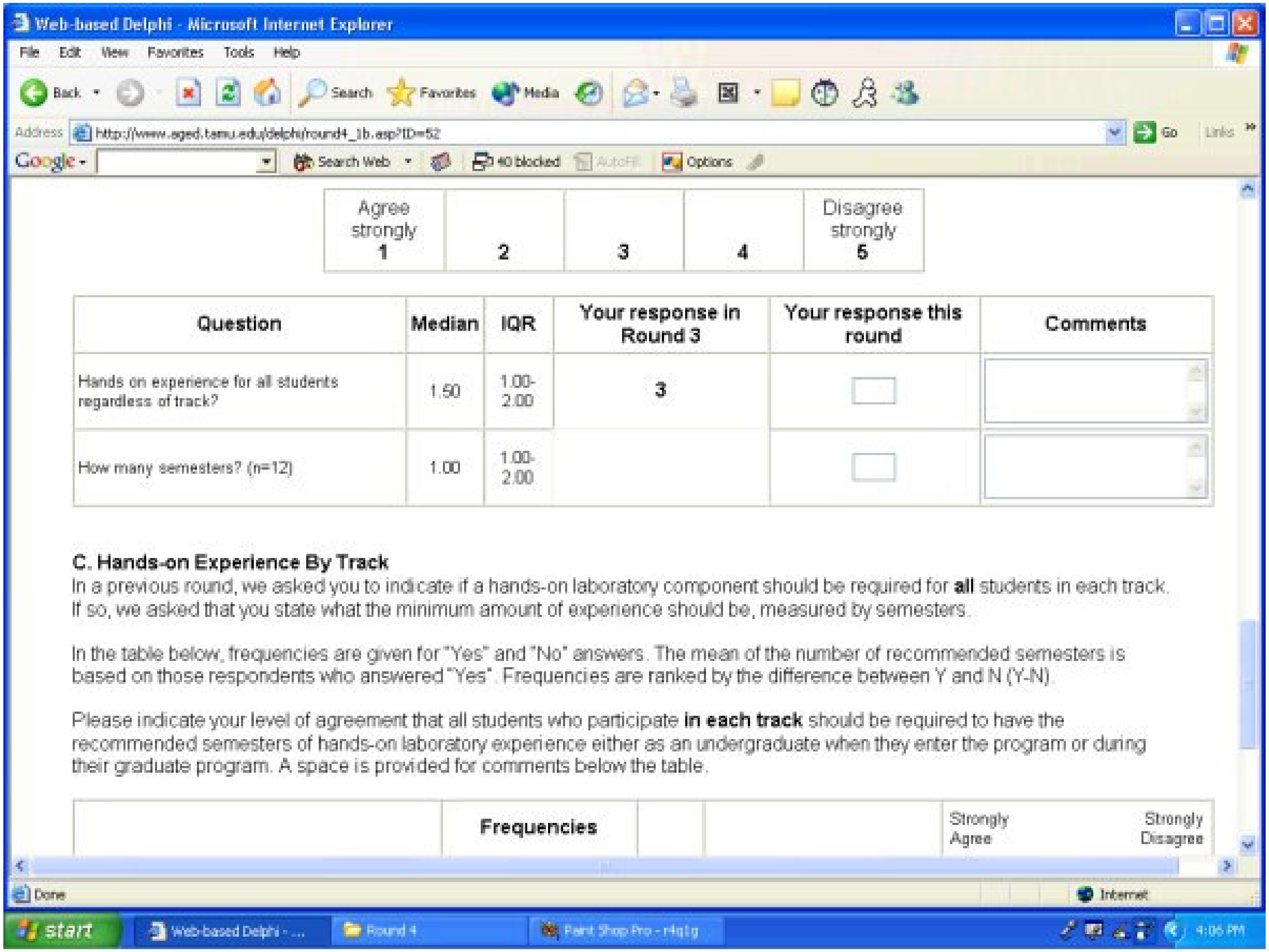


Agree strongly 1	2	3	4	Disagree strongly 5

Question	Median	IQR	Your response in Round 3	Your response this round	Comments
Hands on experience for all students regardless of track?	1.50	1.00-2.00	3		
How many semesters? (n=12)	1.00	1.00-2.00			

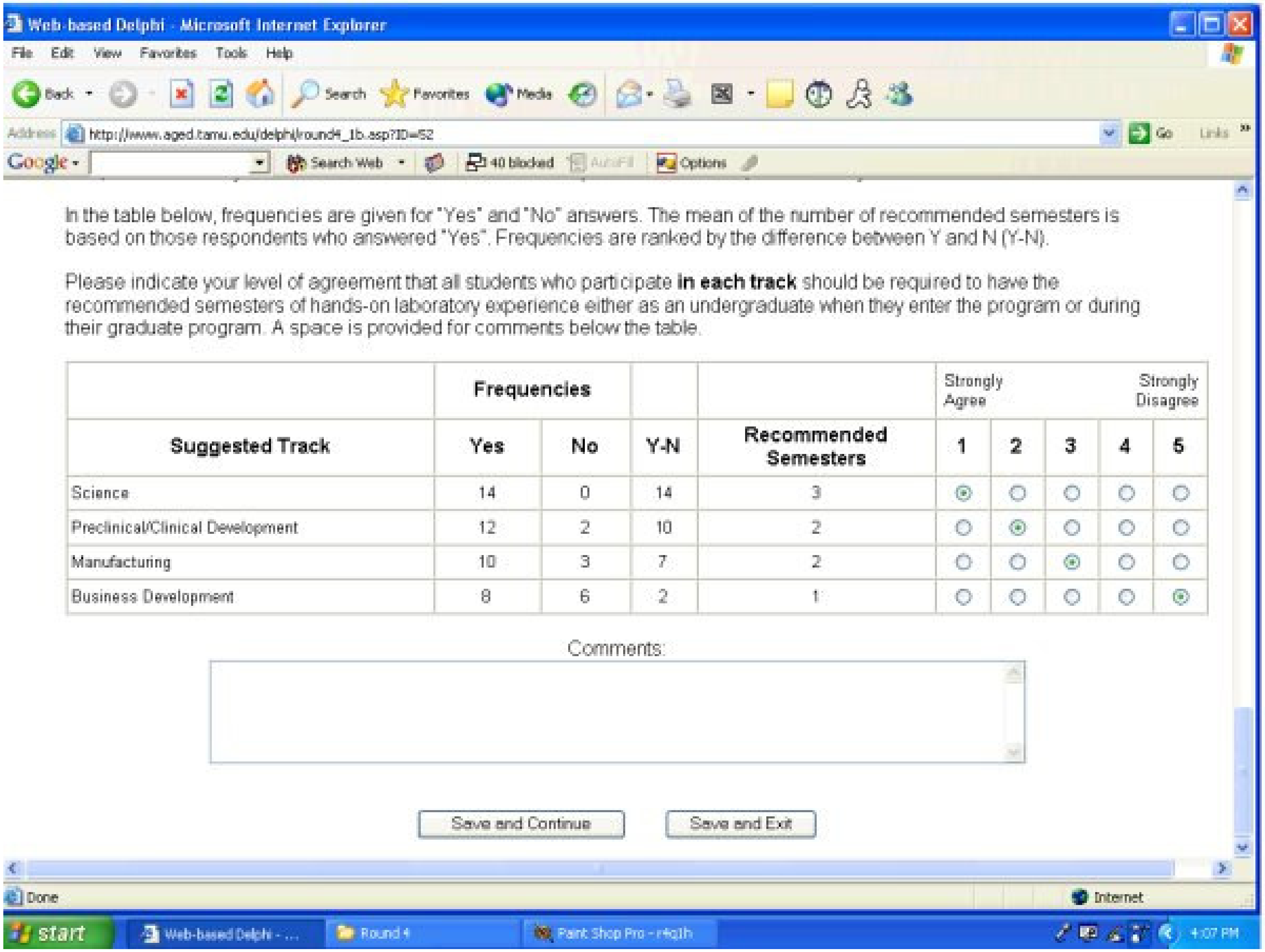
C. Hands-on Experience By Track

In a previous round, we asked you to indicate if a hands-on laboratory component should be required for **all** students in each track. If so, we asked that you state what the minimum amount of experience should be, measured by semesters.

In the table below, frequencies are given for "Yes" and "No" answers. The mean of the number of recommended semesters is based on those respondents who answered "Yes". Frequencies are ranked by the difference between Y and N (Y-N).

Please indicate your level of agreement that all students who participate **in each track** should be required to have the recommended semesters of hands-on laboratory experience either as an undergraduate when they enter the program or during their graduate program. A space is provided for comments below the table.

	Frequencies			Strongly Agree	Strongly Disagree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In the table below, frequencies are given for "Yes" and "No" answers. The mean of the number of recommended semesters is based on those respondents who answered "Yes". Frequencies are ranked by the difference between Y and N (Y-N).

Please indicate your level of agreement that all students who participate **in each track** should be required to have the recommended semesters of hands-on laboratory experience either as an undergraduate when they enter the program or during their graduate program. A space is provided for comments below the table.

	Frequencies				Strongly Agree				Strongly Disagree
Suggested Track	**Yes**	**No**	**Y-N**	**Recommended Semesters**	**1**	**2**	**3**	**4**	**5**
Science	14	0	14	3	◉	○	○	○	○
Preclinical/Clinical Development	12	2	10	2	○	◉	○	○	○
Manufacturing	10	3	7	2	○	○	◉	○	○
Business Development	8	6	2	1	○	○	○	○	◉

Comments:

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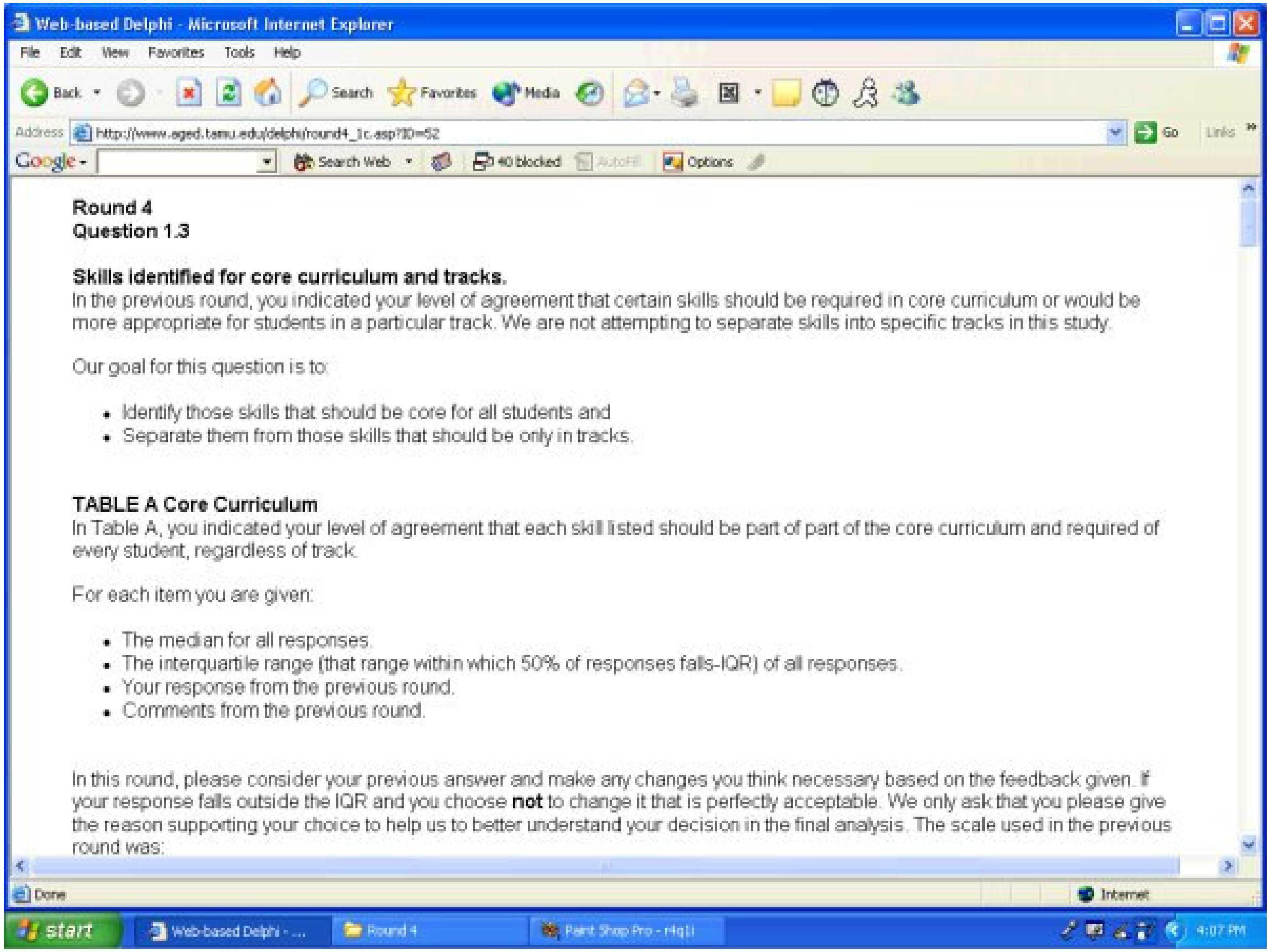
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Round 4
Question 1.3
Skills identified for core curriculum and tracks.
In the previous round, you indicated your level of agreement that certain skills should be required in core curriculum or would be more appropriate for students in a particular track. We are not attempting to separate skills into specific tracks in this study.
Our goal for this question is to:
• Identify those skills that should be core for all students and
• Separate them from those skills that should be only in tracks.
TABLE A Core Curriculum
In Table A, you indicated your level of agreement that each skill listed should be part of part of the core curriculum and required of every student, regardless of track.
For each item you are given:
• The median for all responses.
• The interquartile range (that range within which 50% of responses falls-IQR) of all responses.
• Your response from the previous round.
• Comments from the previous round.
In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose not to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:
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Round 4
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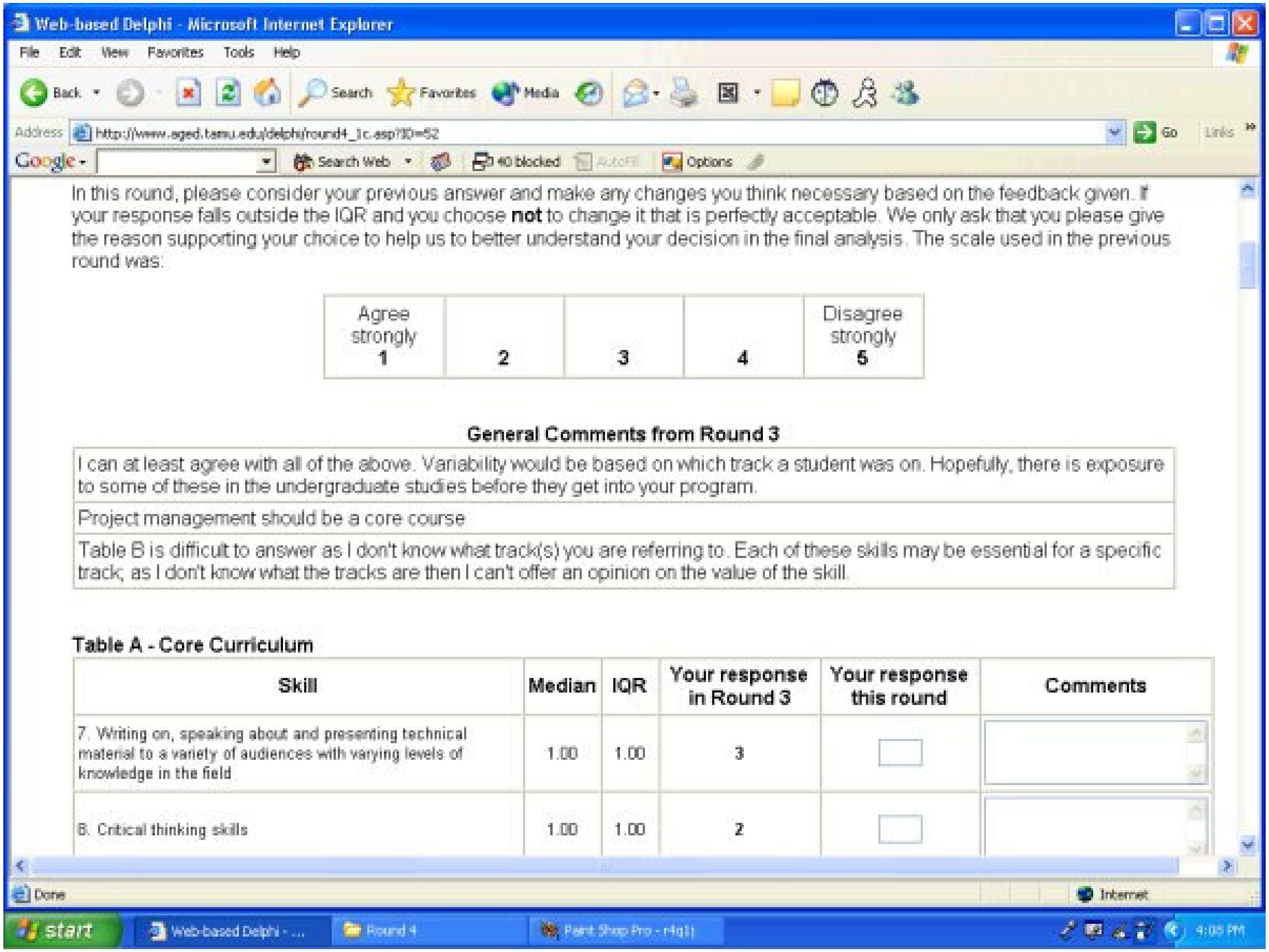
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In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:

Agree strongly **1**	**2**	**3**	**4**	Disagree strongly **5**

General Comments from Round 3

I can at least agree with all of the above. Variability would be based on which track a student was on. Hopefully, there is exposure to some of these in the undergraduate studies before they get into your program.
Project management should be a core course
Table B is difficult to answer as I don't know what track(s) you are referring to. Each of these skills may be essential for a specific track; as I don't know what the tracks are then I can't offer an opinion on the value of the skill.

Table A - Core Curriculum

Skill	Median	IQR	Your response in Round 3	Your response this round	Comments
7. Writing on, speaking about and presenting technical material to a variety of audiences with varying levels of knowledge in the field	1.00	1.00	3		
8. Critical thinking skills	1.00	1.00	2		

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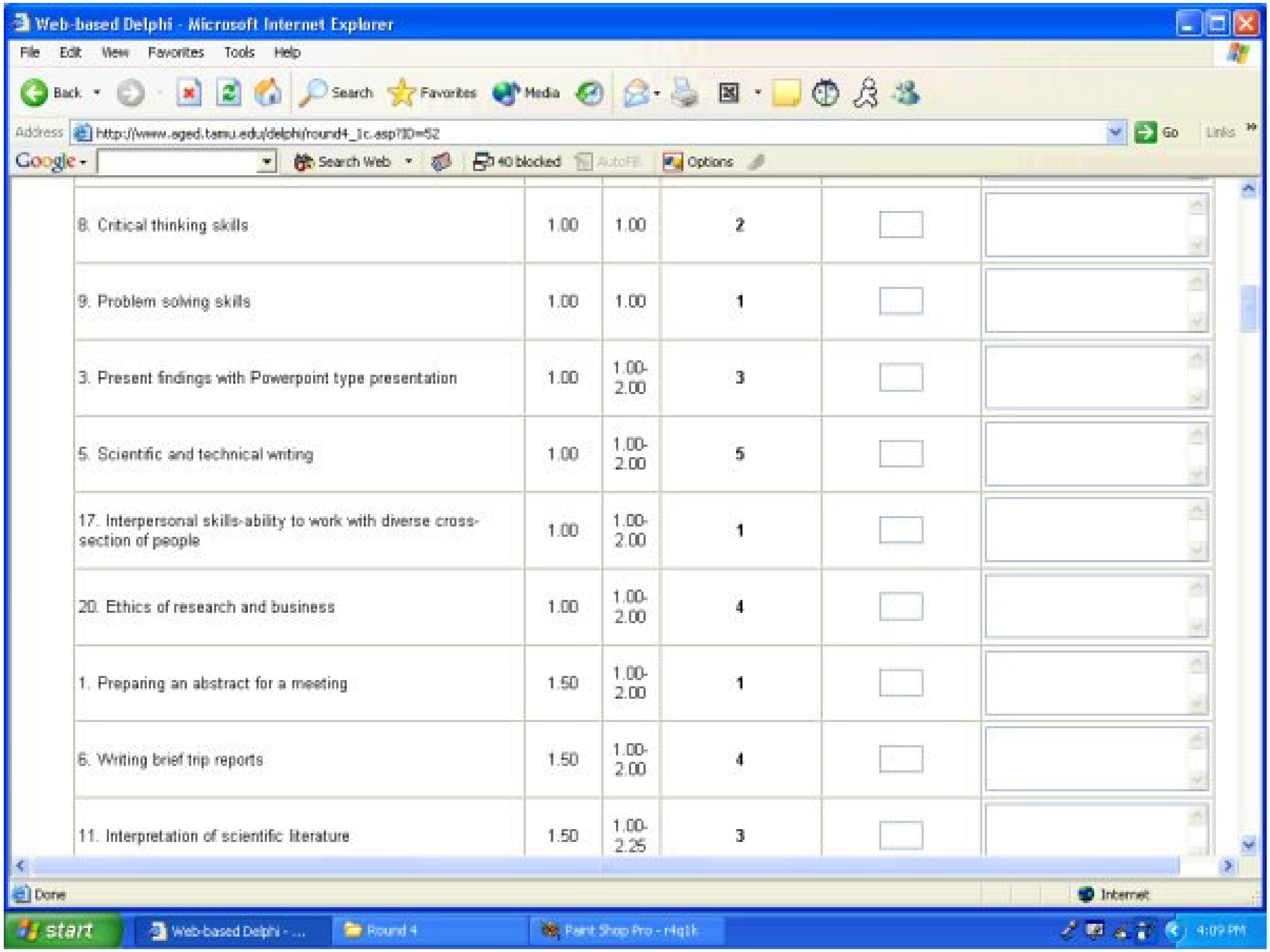

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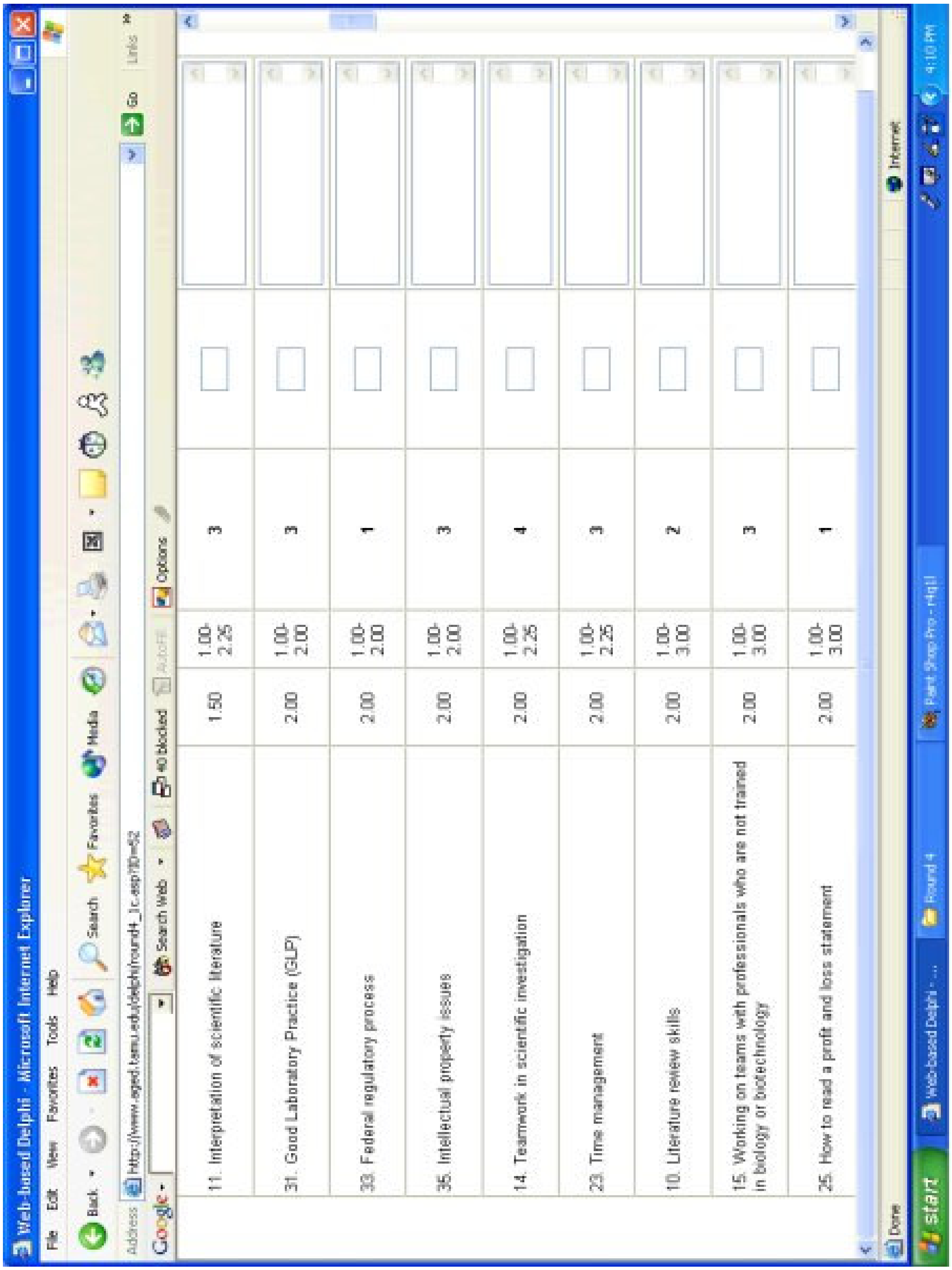
8. Critical thinking skills	1.00	1.00	2		
9. Problem solving skills	1.00	1.00	1		
3. Present findings with Powerpoint type presentation	1.00	1.00-2.00	3		
5. Scientific and technical writing	1.00	1.00-2.00	5		
17. Interpersonal skills-ability to work with diverse cross-section of people	1.00	1.00-2.00	1		
20. Ethics of research and business	1.00	1.00-2.00	4		
1. Preparing an abstract for a meeting	1.50	1.00-2.00	1		
6. Writing brief trip reports	1.50	1.00-2.00	4		
11. Interpretation of scientific literature	1.50	1.00-2.25	3		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Go Links
11. Interpretation of scientific literature 1.50 1.00-2.25 3
31. Good Laboratory Practice (GLP) 2.00 1.00-2.00 3
33. Federal regulatory process 2.00 1.00-2.00 1
35. Intellectual property issues 2.00 1.00-2.00 3
14. Teamwork in scientific investigation 2.00 1.00-2.25 4
23. Time management 2.00 1.00-2.25 3
10. Literature review skills 2.00 1.00-3.00 2
15. Working on teams with professionals who are not trained in biology or biotechnology 2.00 1.00-3.00 3
25. How to read a profit and loss statement 2.00 1.00-3.00 1
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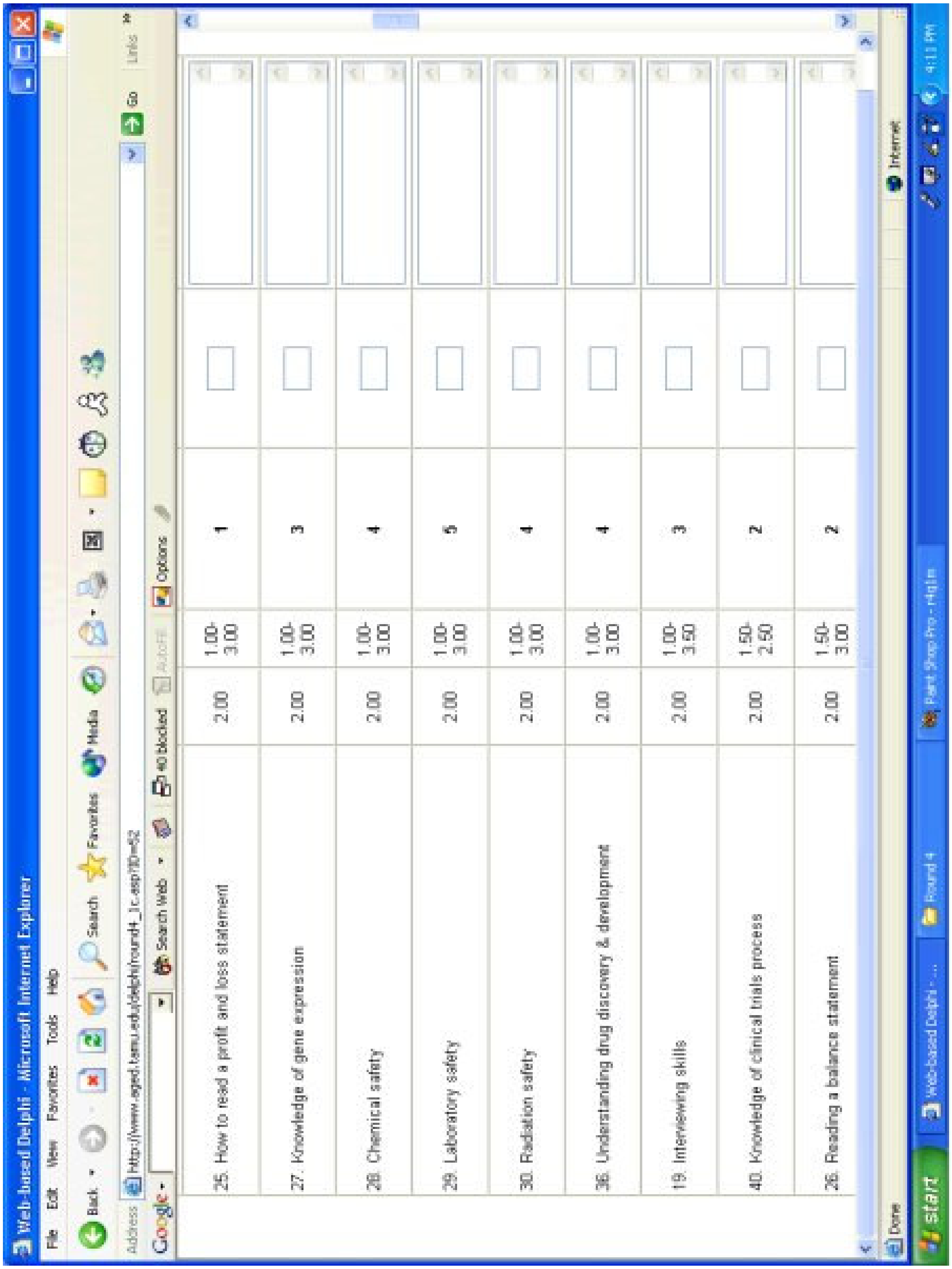
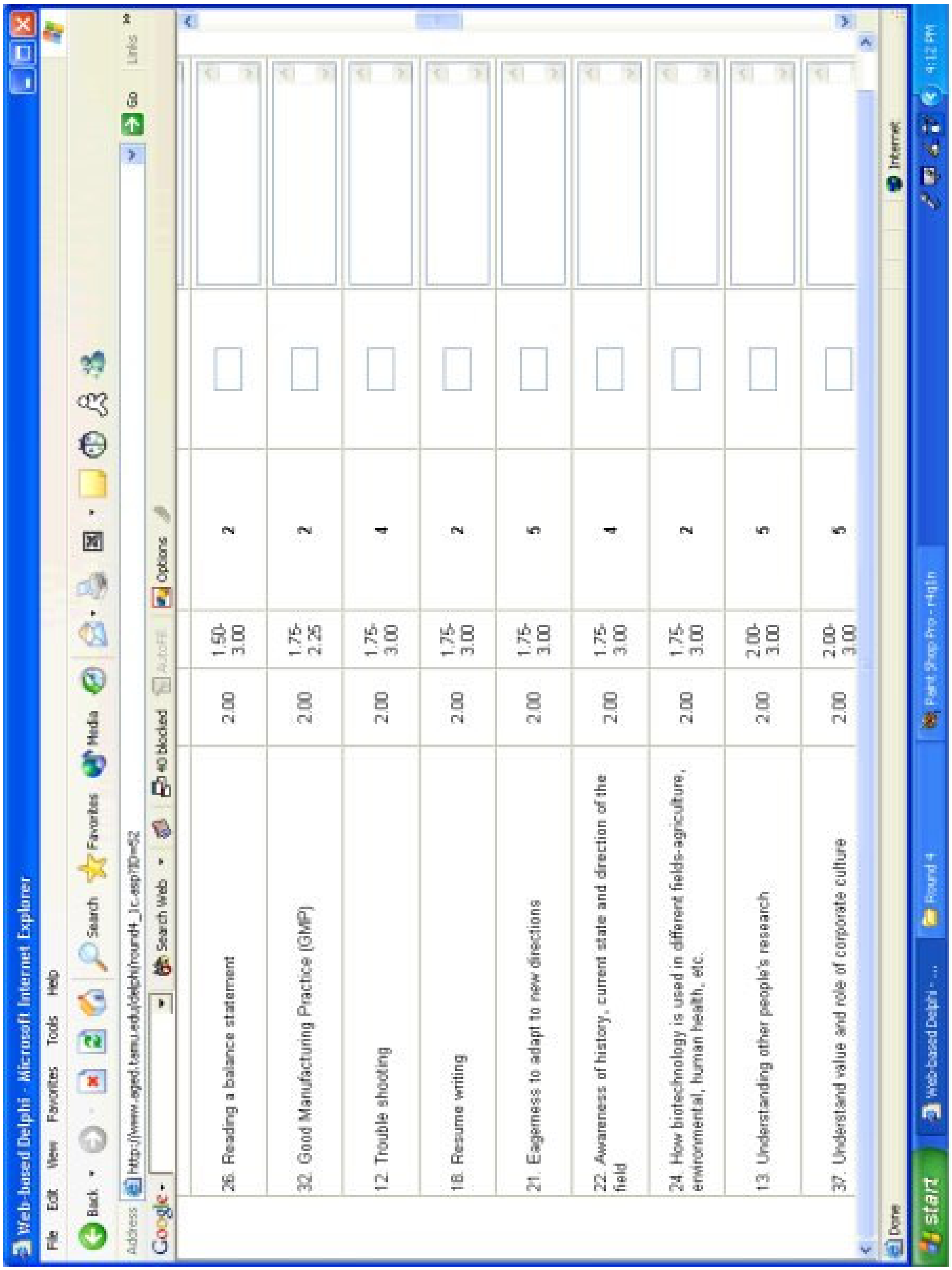
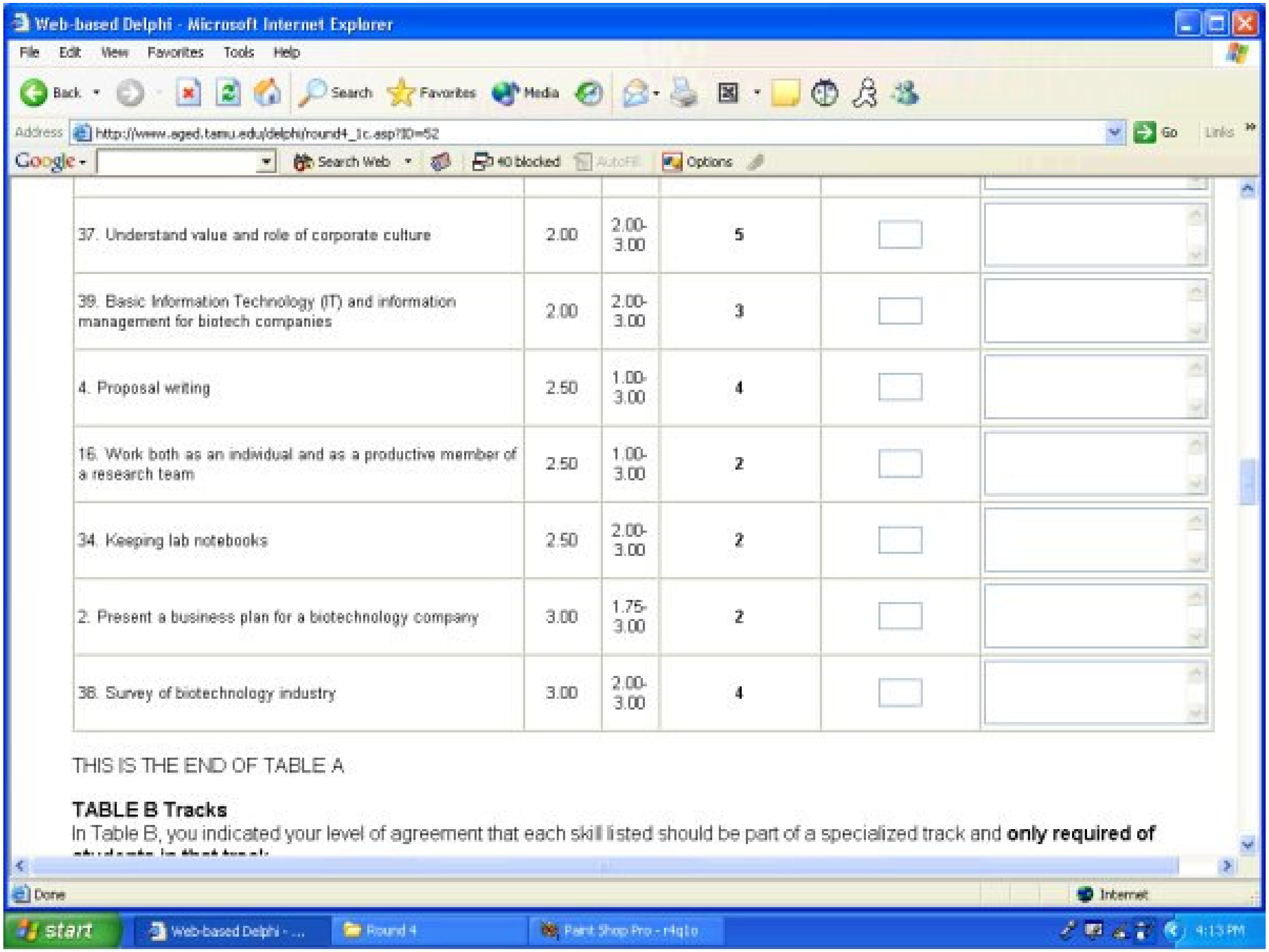


25. How to read a profit and loss statement	2.00	1.00-3.00	1
27. Knowledge of gene expression	2.00	1.00-3.00	3
28. Chemical safety	2.00	1.00-3.00	4
29. Laboratory safety	2.00	1.00-3.00	5
30. Radiation safety	2.00	1.00-3.00	4
36. Understanding drug discovery & development	2.00	1.00-3.00	4
19. Interviewing skills	2.00	1.00-3.50	3
40. Knowledge of clinical trials process	2.00	1.50-2.50	2
26. Reading a balance statement	2.00	1.50-3.00	2



Web-based Delphi - Microsoft Internet Explorer

26. Reading a balance statement	2.00	1.50-3.00	2	
32. Good Manufacturing Practice (GMP)	2.00	1.75-2.25	2	
12. Trouble shooting	2.00	1.75-3.00	4	
18. Resume writing	2.00	1.75-3.00	2	
21. Eagerness to adapt to new directions	2.00	1.75-3.00	5	
22. Awareness of history, current state and direction of the field	2.00	1.75-3.00	4	
24. How biotechnology is used in different fields-agriculture, environmental, human health, etc.	2.00	1.75-3.00	2	
13. Understanding other people's research	2.00	2.00-3.00	5	
37. Understand value and role of corporate culture	2.00	2.00-3.00	5	



37. Understand value and role of corporate culture	2.00	2.00-3.00	5		
39. Basic Information Technology (IT) and information management for biotech companies	2.00	2.00-3.00	3		
4. Proposal writing	2.50	1.00-3.00	4		
16. Work both as an individual and as a productive member of a research team	2.50	1.00-3.00	2		
34. Keeping lab notebooks	2.50	2.00-3.00	2		
2. Present a business plan for a biotechnology company	3.00	1.75-3.00	2		
38. Survey of biotechnology industry	3.00	2.00-3.00	4		

THIS IS THE END OF TABLE A

TABLE B Tracks

In Table B, you indicated your level of agreement that each skill listed should be part of a specialized track and **only required of**

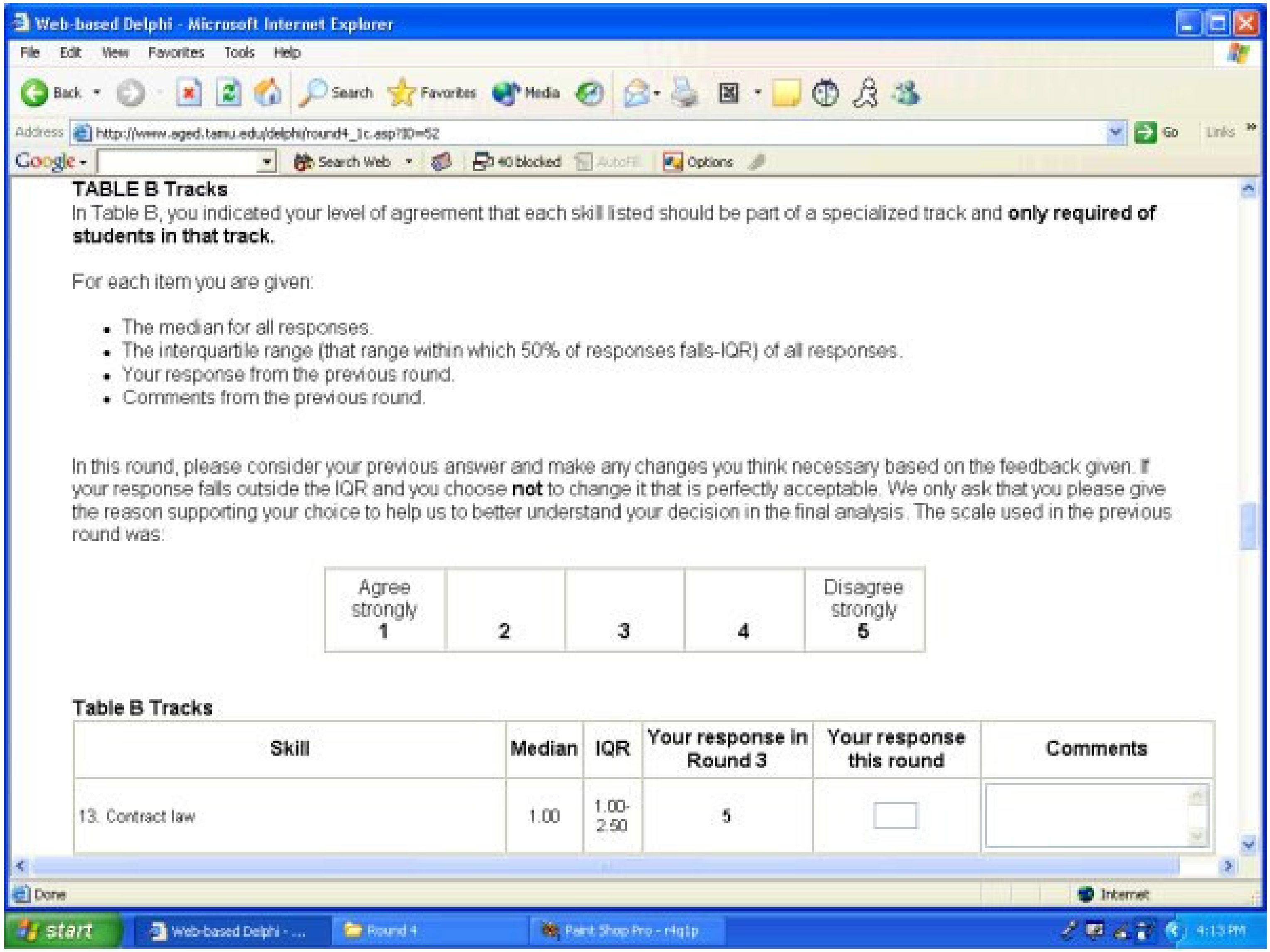


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TABLE B Tracks

In Table B, you indicated your level of agreement that each skill listed should be part of a specialized track and **only required of students in that track.**

For each item you are given:

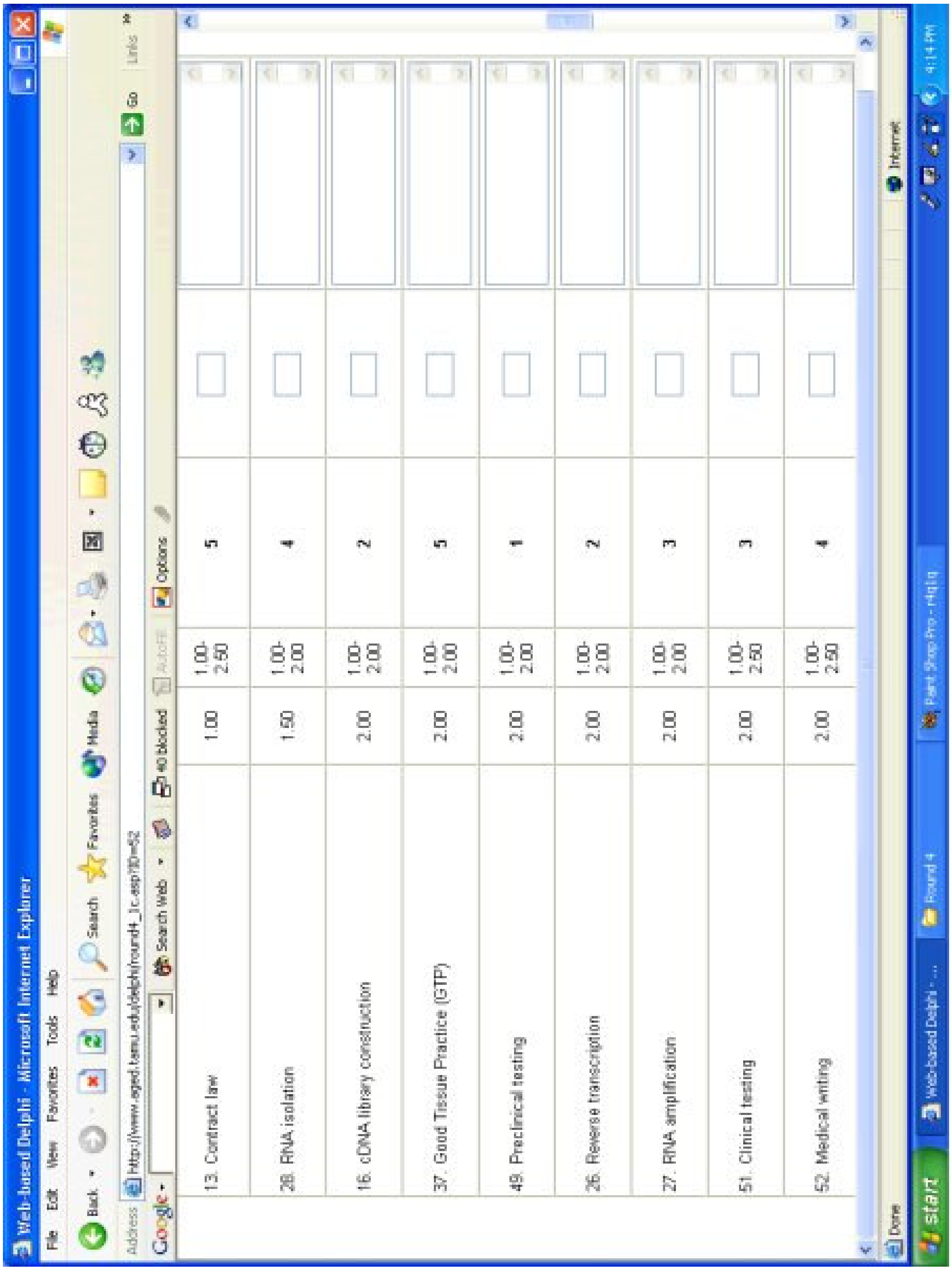
- The median for all responses.
- The interquartile range (that range within which 50% of responses falls-IQR) of all responses.
- Your response from the previous round.
- Comments from the previous round.

In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:

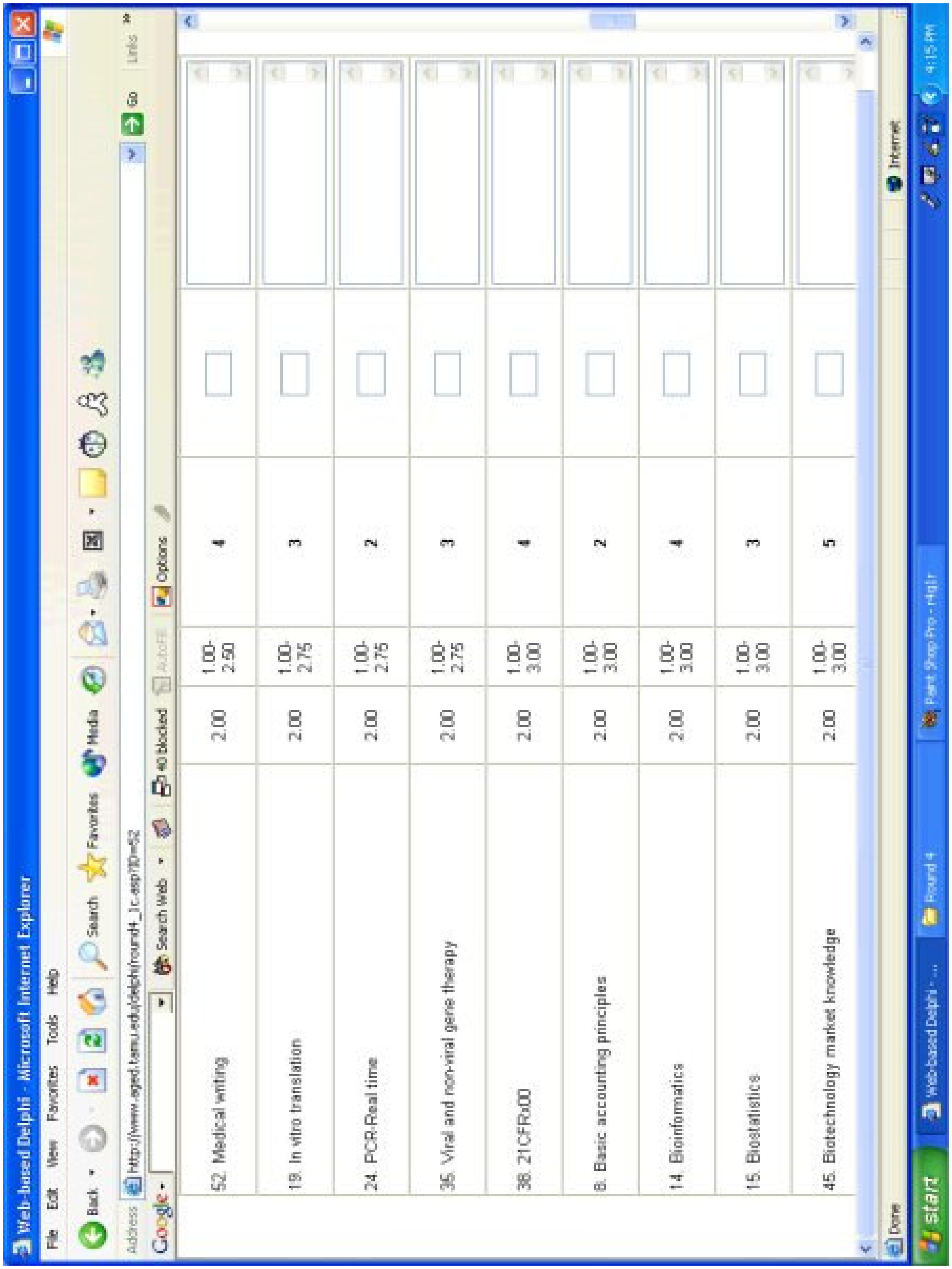
Agree strongly **1**	**2**	**3**	**4**	Disagree strongly **5**

Table B Tracks

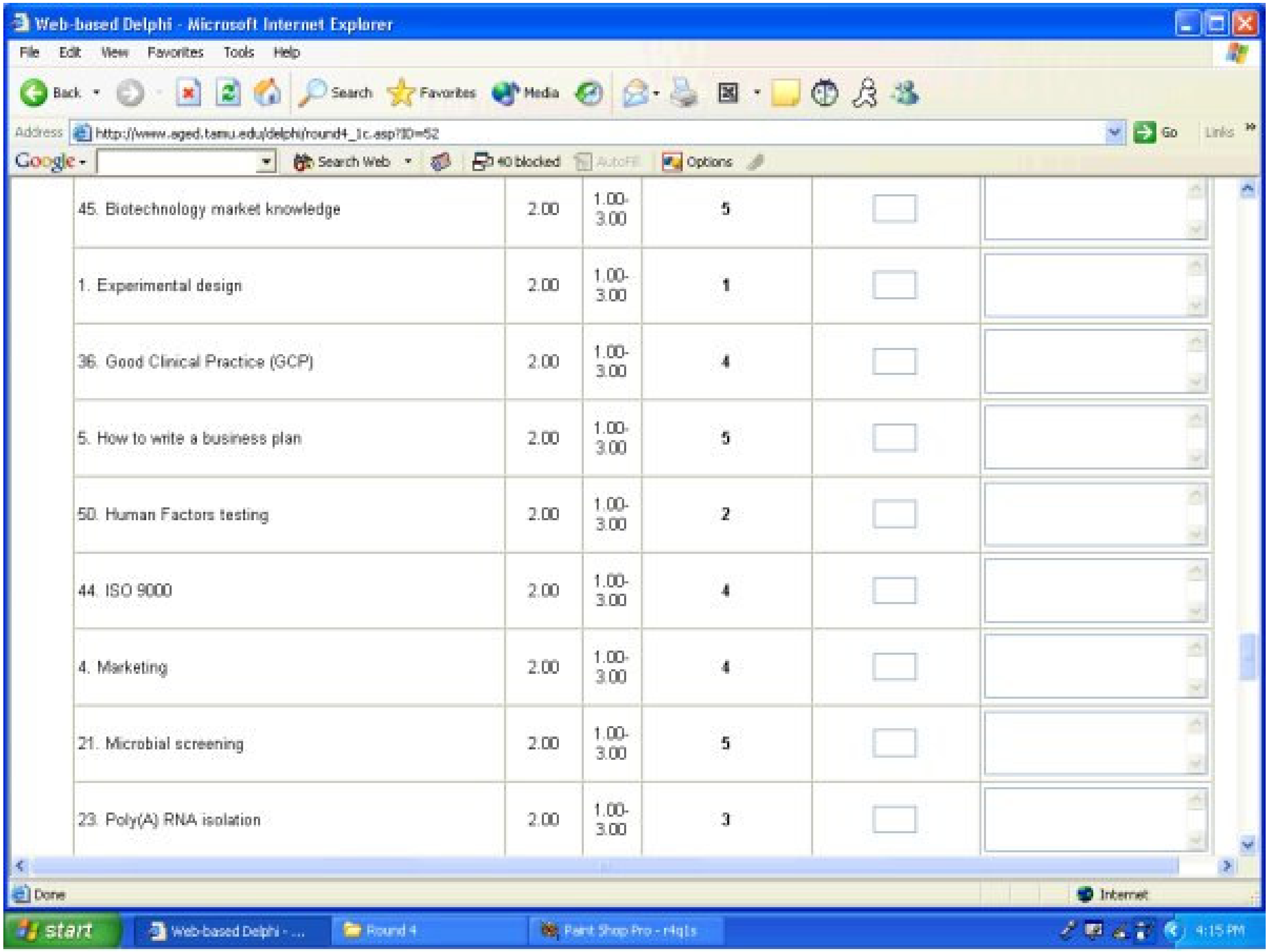
Skill	Median	IQR	Your response in Round 3	Your response this round	Comments
13. Contract law	1.00	1.00-2.50	5		



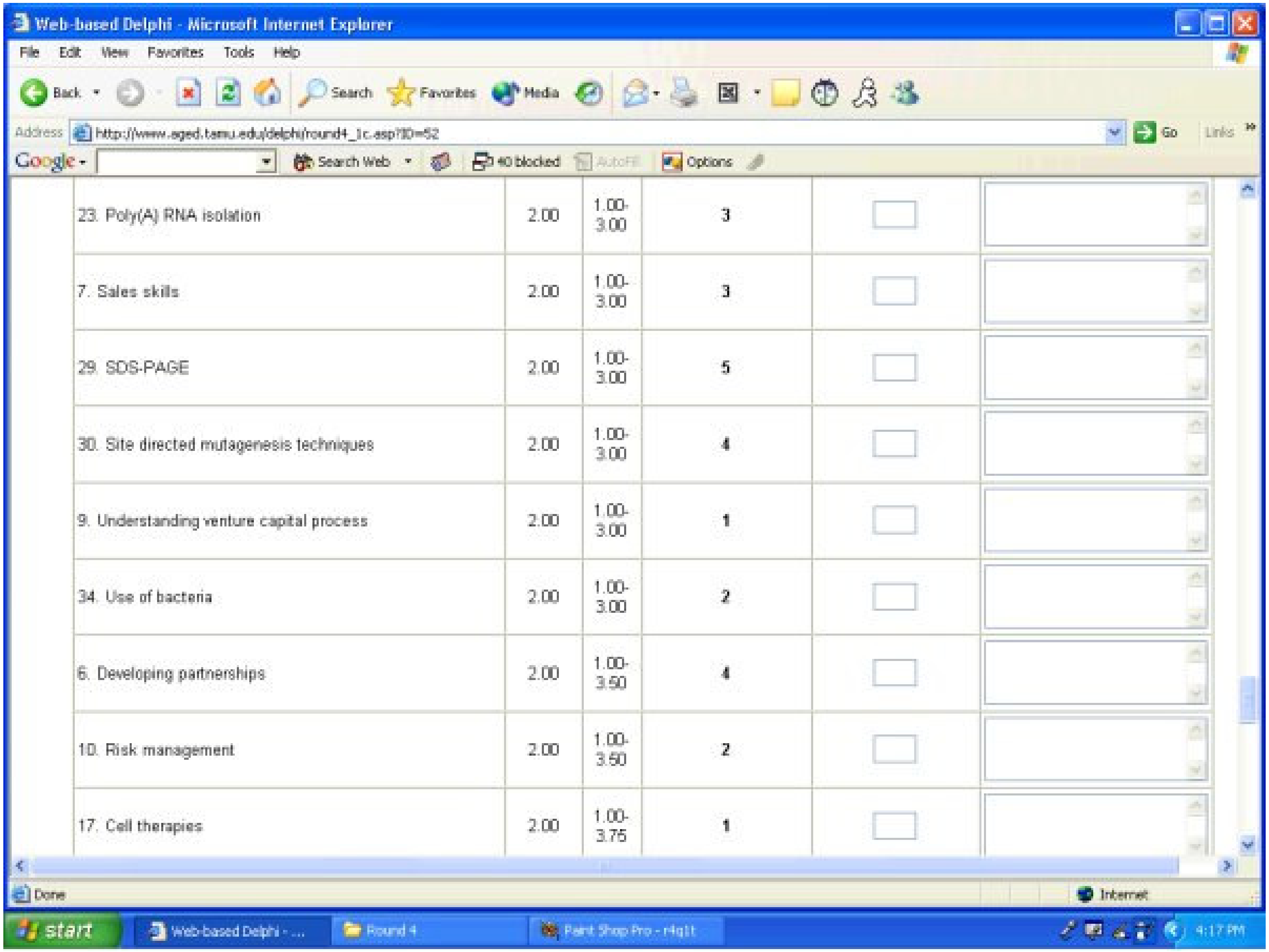
13. Contract law	1.00	1.00-2.50	5
28. RNA isolation	1.50	1.00-2.00	4
16. cDNA library construction	2.00	1.00-2.00	2
37. Good Tissue Practice (GTP)	2.00	1.00-2.00	5
49. Preclinical testing	2.00	1.00-2.00	1
26. Reverse transcription	2.00	1.00-2.00	2
27. RNA amplification	2.00	1.00-2.00	3
51. Clinical testing	2.00	1.00-2.50	3
52. Medical writing	2.00	1.00-2.50	4



52. Medical writing	2.00	1.00-2.50	4		
19. In vitro translation	2.00	1.00-2.75	3		
24. PCR-Real time	2.00	1.00-2.75	2		
35. Viral and non-viral gene therapy	2.00	1.00-2.75	3		
38. 21CFRx00	2.00	1.00-3.00	4		
8. Basic accounting principles	2.00	1.00-3.00	2		
14. Bioinformatics	2.00	1.00-3.00	4		
15. Biostatistics	2.00	1.00-3.00	3		
45. Biotechnology market knowledge	2.00	1.00-3.00	5		



45. Biotechnology market knowledge	2.00	1.00-3.00	5
1. Experimental design	2.00	1.00-3.00	1
36. Good Clinical Practice (GCP)	2.00	1.00-3.00	4
5. How to write a business plan	2.00	1.00-3.00	5
50. Human Factors testing	2.00	1.00-3.00	2
44. ISO 9000	2.00	1.00-3.00	4
4. Marketing	2.00	1.00-3.00	4
21. Microbial screening	2.00	1.00-3.00	5
23. Poly(A) RNA isolation	2.00	1.00-3.00	3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23. Poly(A) RNA isolation 2.00 1.00-3.00 3
7. Sales skills 2.00 1.00-3.00 3
29. SDS-PAGE 2.00 1.00-3.00 5
30. Site directed mutagenesis techniques 2.00 1.00-3.00 4
9. Understanding venture capital process 2.00 1.00-3.00 1
34. Use of bacteria 2.00 1.00-3.00 2
6. Developing partnerships 2.00 1.00-3.50 4
10. Risk management 2.00 1.00-3.50 2
17. Cell therapies 2.00 1.00-3.75 1
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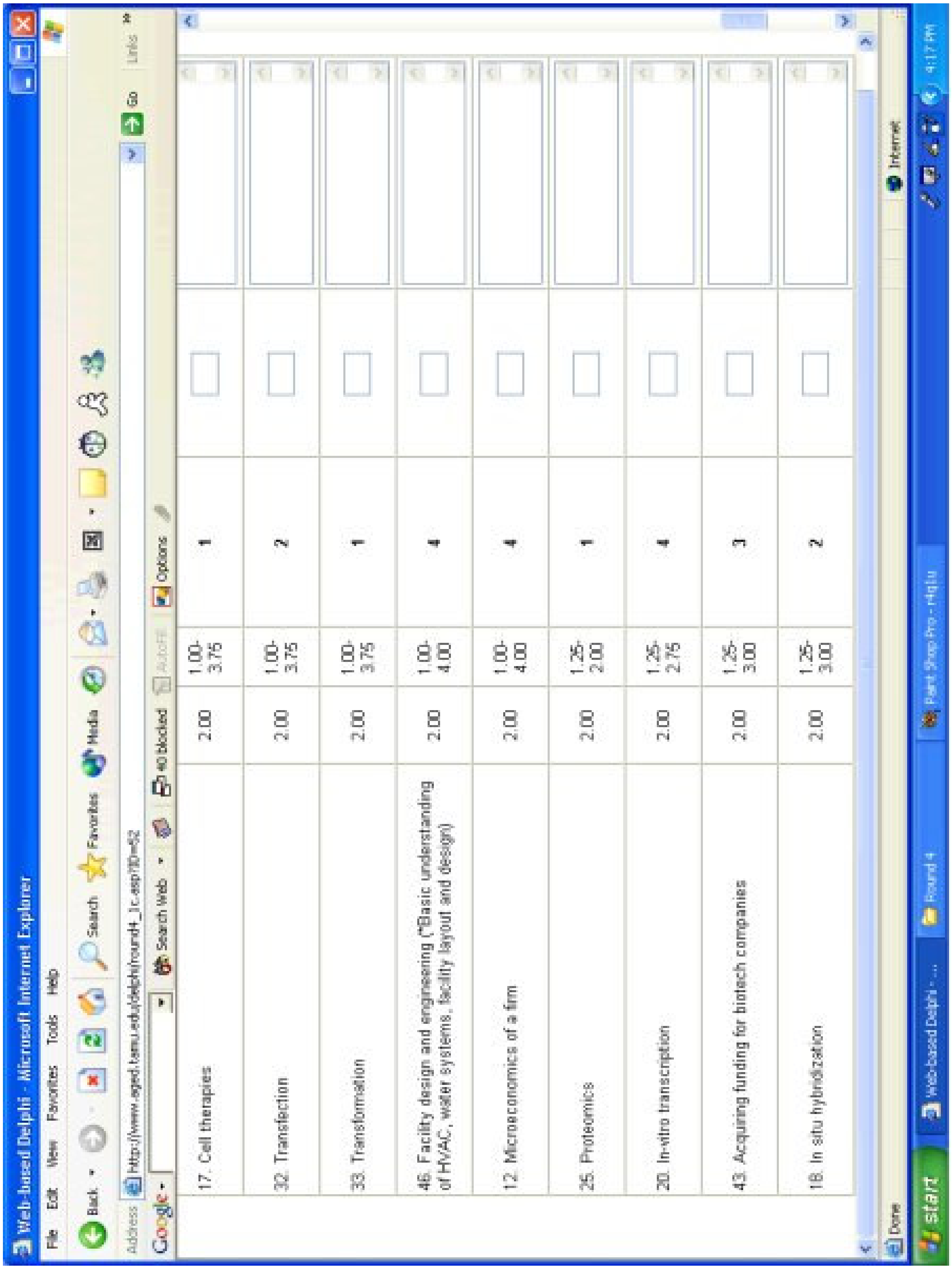
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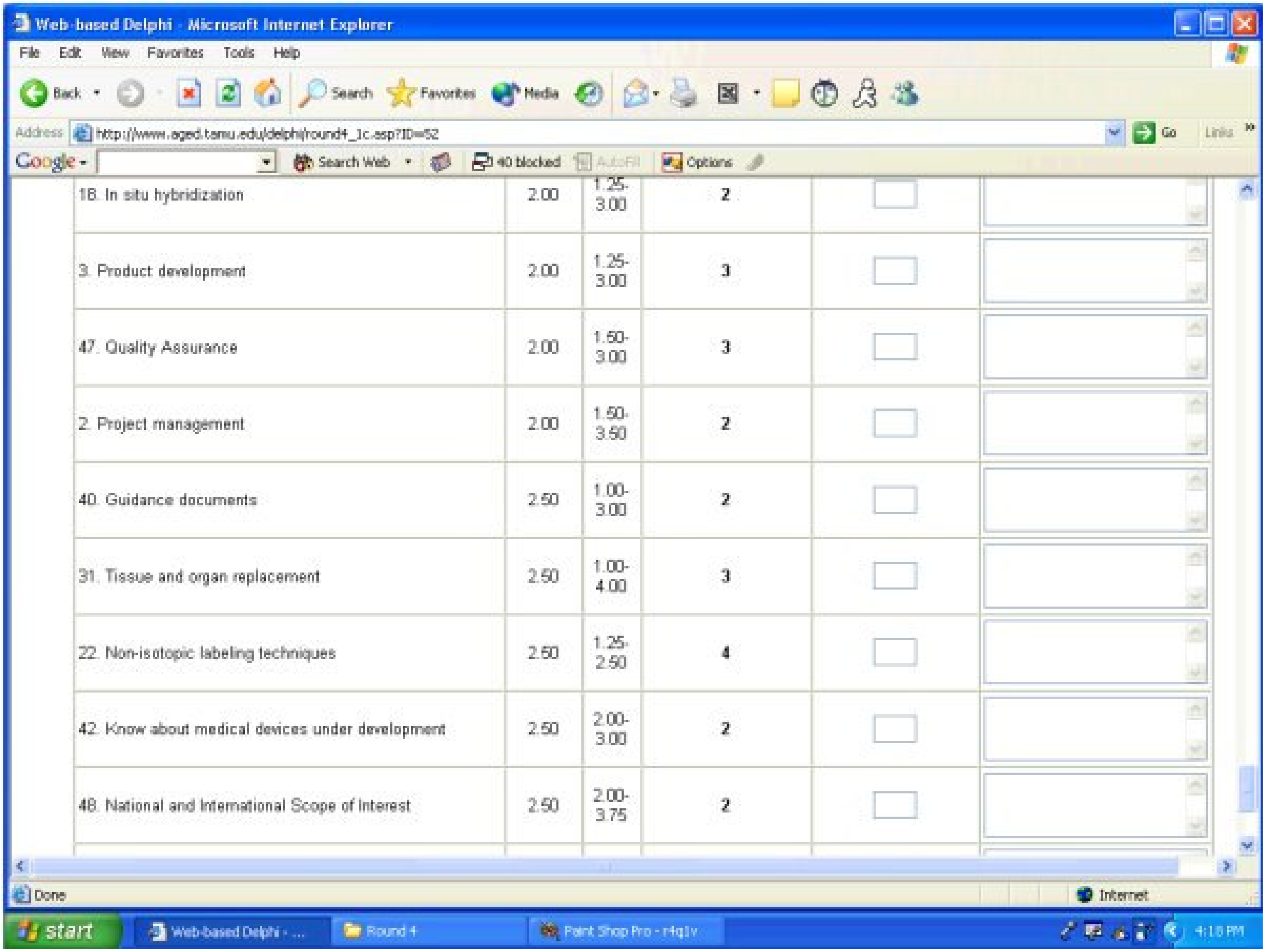
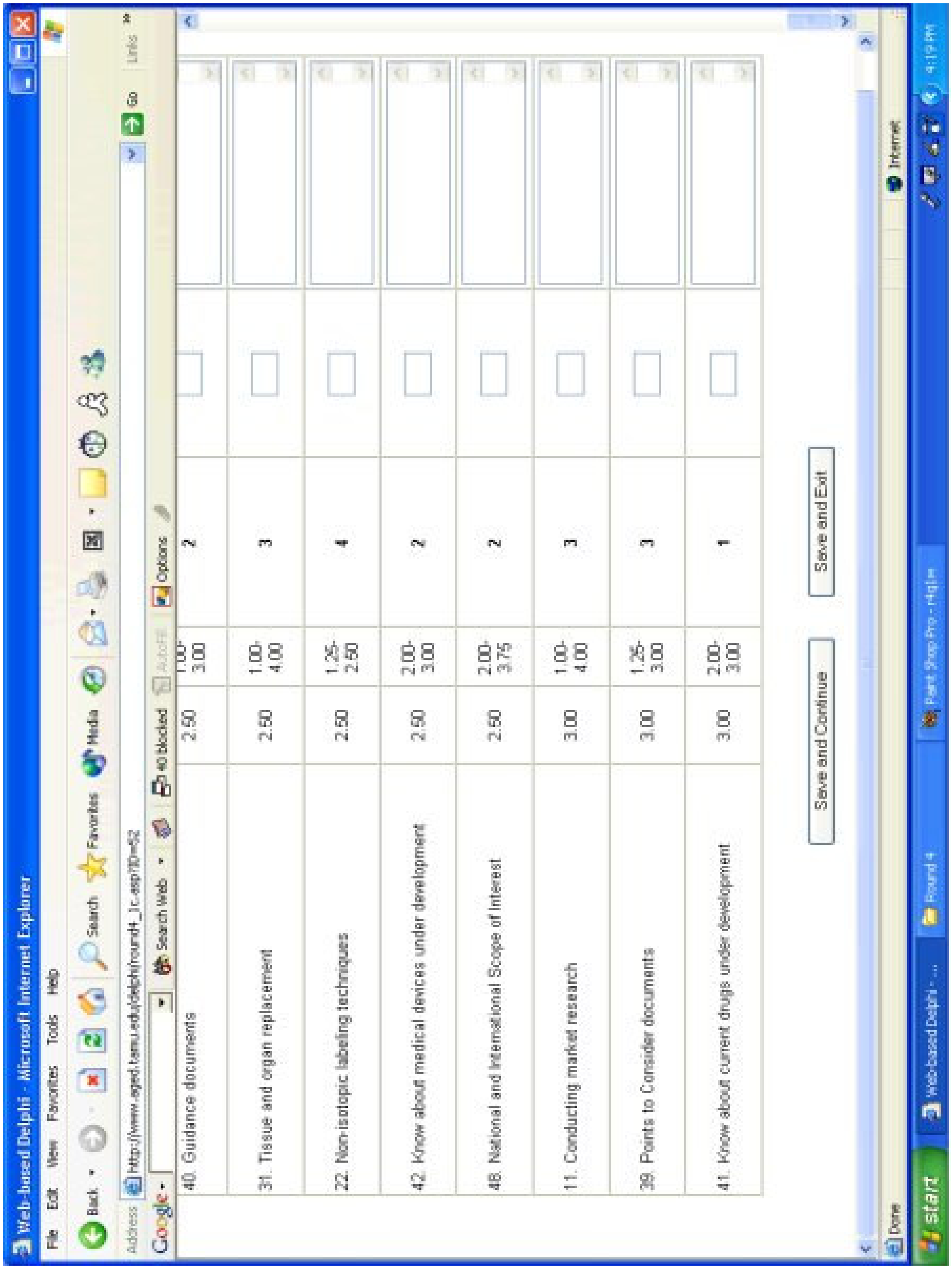
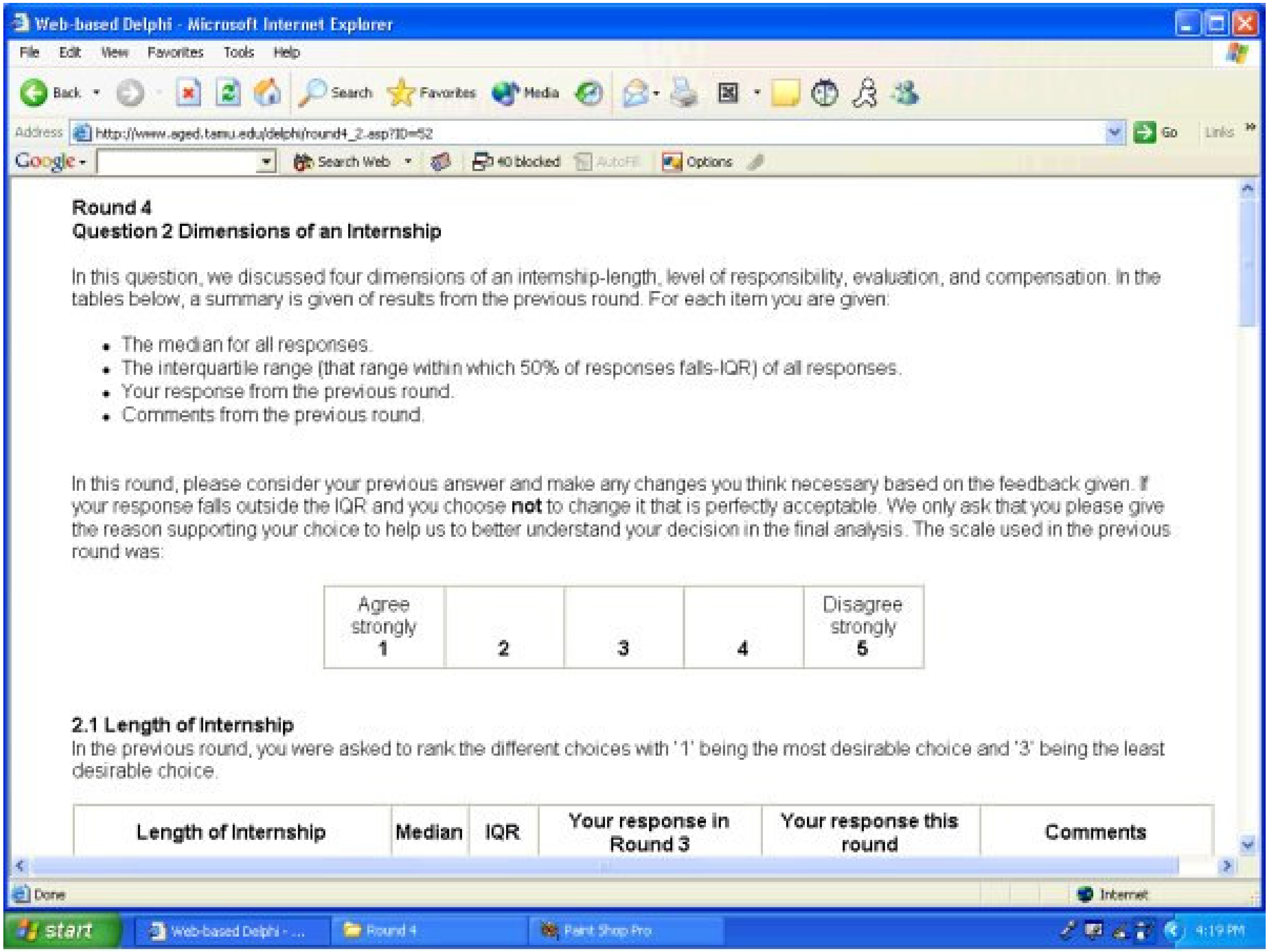
17. Cell therapies 2.00 1.00-3.75 1
32. Transfection 2.00 1.00-3.75 2
33. Transformation 2.00 1.00-3.75 1
46. Facility design and engineering (*Basic understanding of HVAC, water systems, facility layout and design) 2.00 1.00-4.00 4
12. Microeconomics of a firm 2.00 1.00-4.00 4
25. Proteomics 2.00 1.25-2.00 1
20. In-vitro transcription 2.00 1.25-2.75 4
43. Acquiring funding for biotech companies 2.00 1.25-3.00 3
18. In situ hybridization 2.00 1.25-3.00 2



18. In situ hybridization	2.00	1.25-3.00	2		
3. Product development	2.00	1.25-3.00	3		
47. Quality Assurance	2.00	1.50-3.00	3		
2. Project management	2.00	1.50-3.50	2		
40. Guidance documents	2.50	1.00-3.00	2		
31. Tissue and organ replacement	2.50	1.00-4.00	3		
22. Non-isotopic labeling techniques	2.50	1.25-2.50	4		
42. Know about medical devices under development	2.50	2.00-3.00	2		
48. National and International Scope of Interest	2.50	2.00-3.75	2		



40. Guidance documents	2.50	1.00-3.00	2		
31. Tissue and organ replacement	2.50	1.00-4.00	3		
22. Non-isotopic labeling techniques	2.50	1.25-2.50	4		
42. Know about medical devices under development	2.50	2.00-3.00	2		
48. National and International Scope of Interest	2.50	2.00-3.75	2		
11. Conducting market research	3.00	1.00-4.00	3		
39. Points to Consider documents	3.00	1.25-3.00	3		
41. Know about current drugs under development	3.00	2.00-3.00	1		



Round 4
Question 2 Dimensions of an Internship

In this question, we discussed four dimensions of an internship-length, level of responsibility, evaluation, and compensation. In the tables below, a summary is given of results from the previous round. For each item you are given:

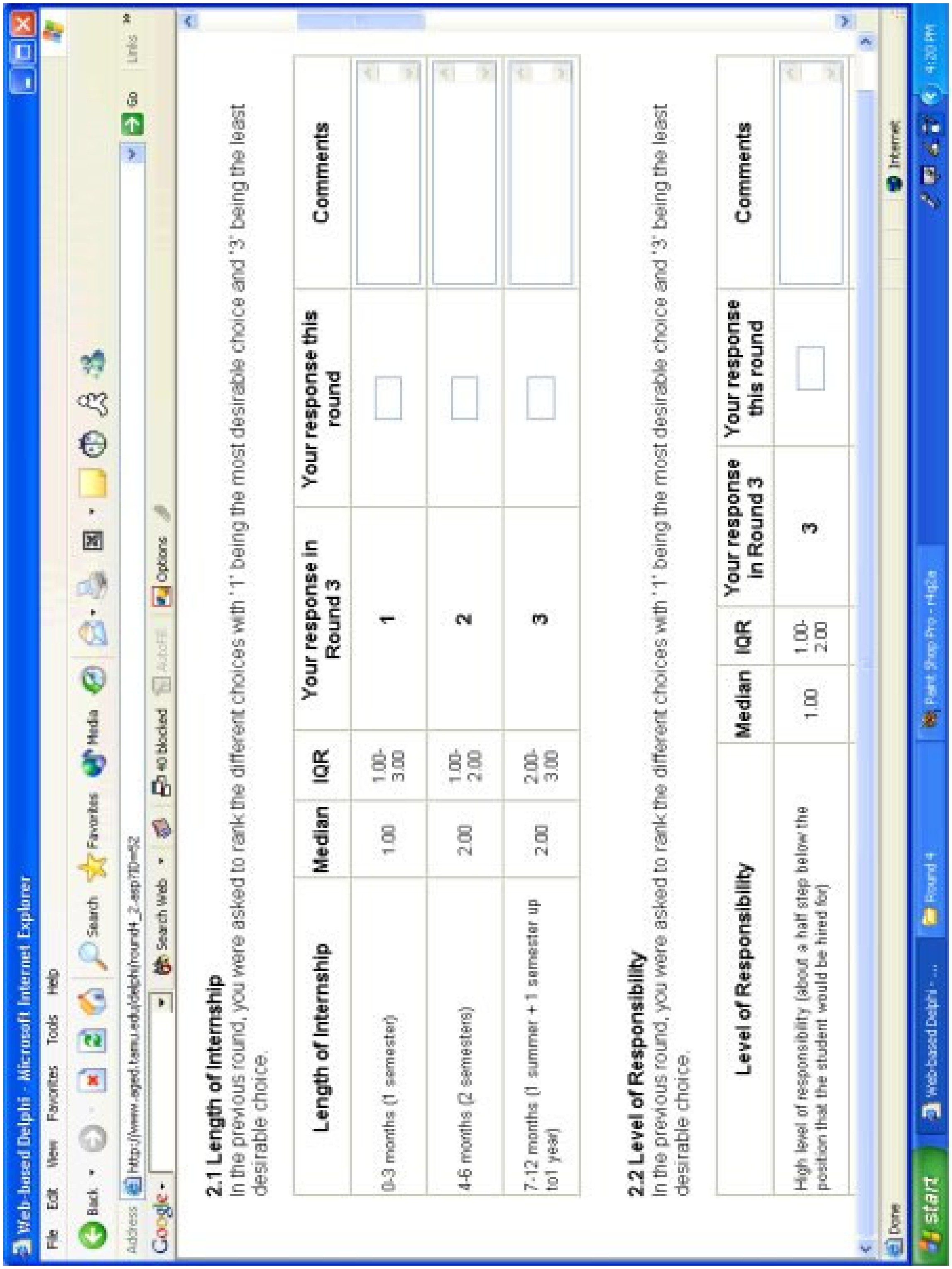
- The median for all responses.
- The interquartile range (that range within which 50% of responses falls-IQR) of all responses.
- Your response from the previous round.
- Comments from the previous round.

In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:

Agree strongly **1**	**2**	**3**	**4**	Disagree strongly **5**

2.1 Length of Internship
In the previous round, you were asked to rank the different choices with '1' being the most desirable choice and '3' being the least desirable choice.

Length of Internship	Median	IQR	Your response in Round 3	Your response this round	Comments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Go Links
2.1 Length of Internship
In the previous round, you were asked to rank the different choices with '1' being the most desirable choice and '3' being the least desirable choice.
Length of Internship
Median
IQR
Your response in Round 3
Your response this round
Comments
0-3 months (1 semester) 1.00 1.00-3.00 1
4-6 months (2 semesters) 2.00 1.00-2.00 2
7-12 months (1 summer + 1 semester up to1 year) 2.00 2.00-3.00 3
2.2 Level of Responsibility
In the previous round, you were asked to rank the different choices with '1' being the most desirable choice and '3' being the least desirable choice.
Level of Responsibility
Median
IQR
Your response in Round 3
Your response this round
Comments
High level of responsibility (about a half step below the position that the student would be hired for) 1.00 1.00-2.00 3
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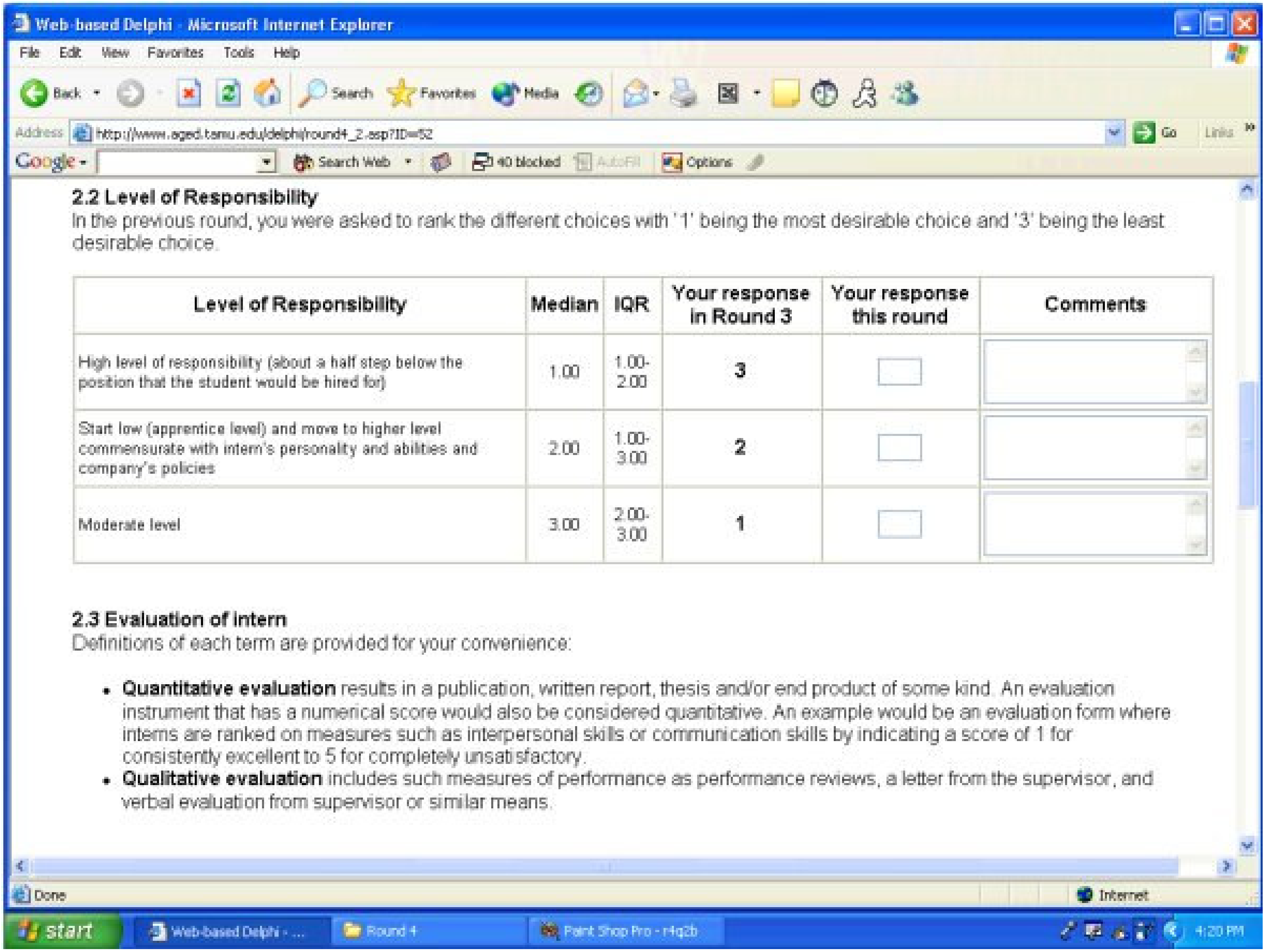

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2.2 Level of Responsibility

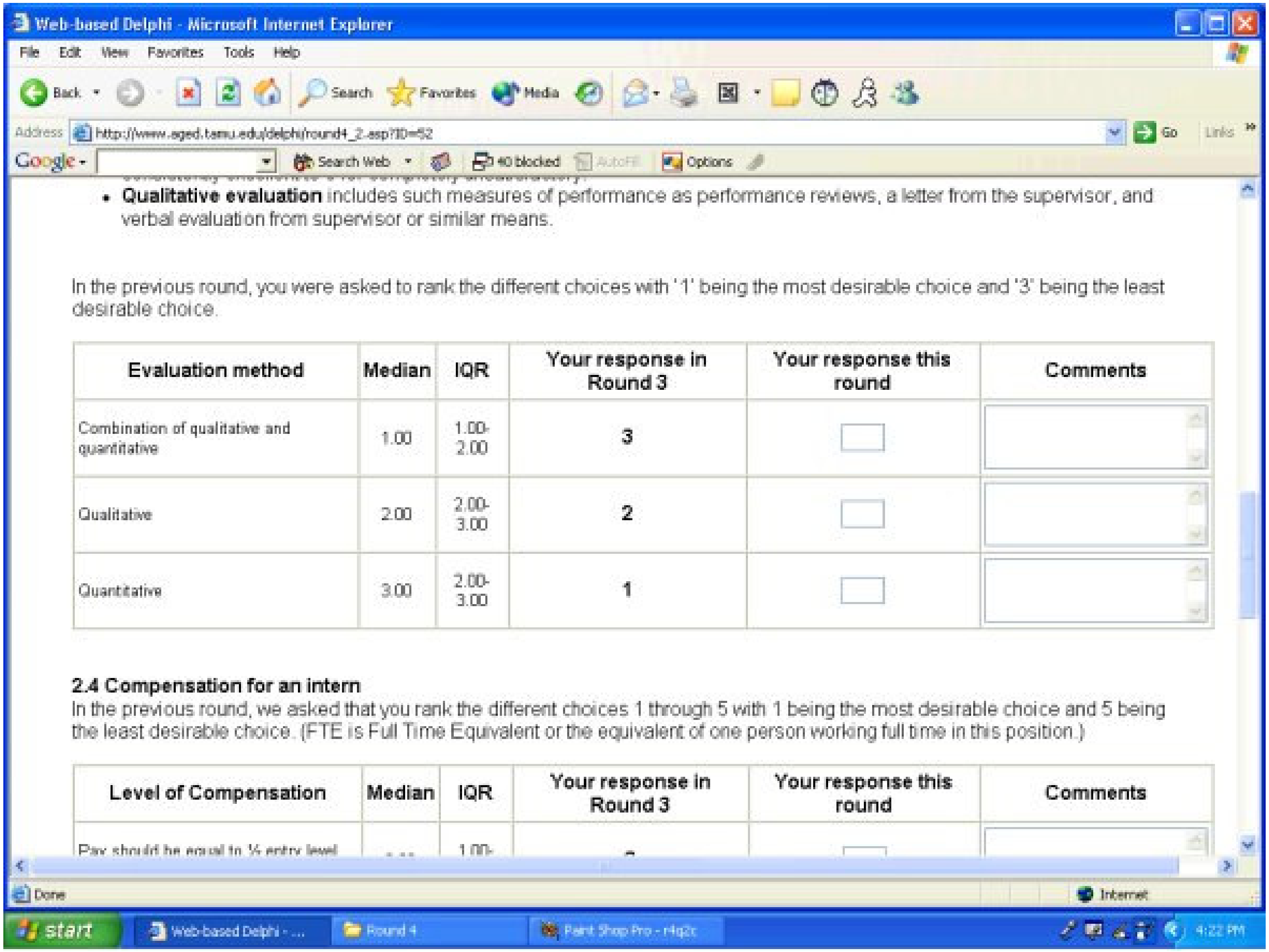
In the previous round, you were asked to rank the different choices with '1' being the most desirable choice and '3' being the least desirable choice.

Level of Responsibility	Median	IQR	Your response in Round 3	Your response this round	Comments
High level of responsibility (about a half step below the position that the student would be hired for)	1.00	1.00-2.00	3		
Start low (apprentice level) and move to higher level commensurate with intern's personality and abilities and company's policies	2.00	1.00-3.00	2		
Moderate level	3.00	2.00-3.00	1		

2.3 Evaluation of intern

Definitions of each term are provided for your convenience:

- **Quantitative evaluation** results in a publication, written report, thesis and/or end product of some kind. An evaluation instrument that has a numerical score would also be considered quantitative. An example would be an evaluation form where interns are ranked on measures such as interpersonal skills or communication skills by indicating a score of 1 for consistently excellent to 5 for completely unsatisfactory.
- **Qualitative evaluation** includes such measures of performance as performance reviews, a letter from the supervisor, and verbal evaluation from supervisor or similar means.



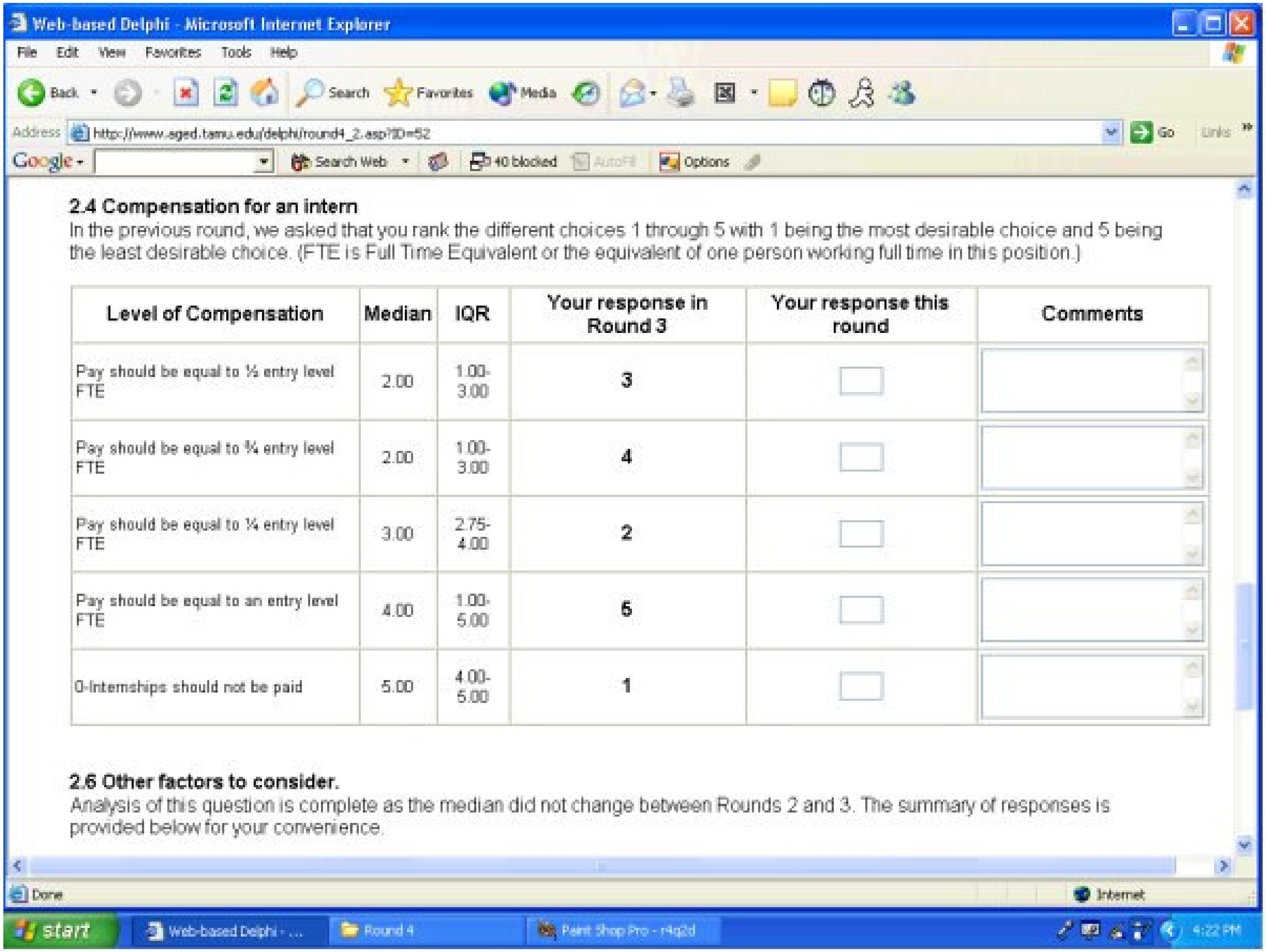
- **Qualitative evaluation** includes such measures of performance as performance reviews, a letter from the supervisor, and verbal evaluation from supervisor or similar means.

In the previous round, you were asked to rank the different choices with '1' being the most desirable choice and '3' being the least desirable choice.

Evaluation method	Median	IQR	Your response in Round 3	Your response this round	Comments
Combination of qualitative and quantitative	1.00	1.00-2.00	3		
Qualitative	2.00	2.00-3.00	2		
Quantitative	3.00	2.00-3.00	1		

2.4 Compensation for an intern
In the previous round, we asked that you rank the different choices 1 through 5 with 1 being the most desirable choice and 5 being the least desirable choice. (FTE is Full Time Equivalent or the equivalent of one person working full time in this position.)

Level of Compensation	Median	IQR	Your response in Round 3	Your response this round	Comments
Pay should be equal to ½ entry level	[illegible]	1.00-	[illegible]		



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2.4 Compensation for an intern

In the previous round, we asked that you rank the different choices 1 through 5 with 1 being the most desirable choice and 5 being the least desirable choice. (FTE is Full Time Equivalent or the equivalent of one person working full time in this position.)

Level of Compensation	Median	IQR	Your response in Round 3	Your response this round	Comments
Pay should be equal to ½ entry level FTE	2.00	1.00-3.00	3		
Pay should be equal to ¾ entry level FTE	2.00	1.00-3.00	4		
Pay should be equal to ¼ entry level FTE	3.00	2.75-4.00	2		
Pay should be equal to an entry level FTE	4.00	1.00-5.00	5		
0-Internships should not be paid	5.00	4.00-5.00	1		

2.6 Other factors to consider.

Analysis of this question is complete as the median did not change between Rounds 2 and 3. The summary of responses is provided below for your convenience.

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2.6 Other factors to consider.

Analysis of this question is complete as the median did not change between Rounds 2 and 3. The summary of responses is provided below for your convenience.

In this question, the scale you were given was:

1. Not Important,
2. Important but not necessary, and
3. Important and necessary.

Other Factors to Consider	Median Round 3	IQR Round 3	Comments from Round 3
Good supervision provided by the company.	3.00	3.00	
The student and the school should evaluate the position each time to be sure it should be continued within the program.	3.00	2.00-3.00	See comments to factor 1. We dont want the students to be subjected to a poor experience, so the internship should be evaluated for the experience level provided to the student by the company.
Working with a company that is familiar with the science master's curriculum and goals.	2.00	2.00	I'm not sure this would ever happen as the internships are usually set up by the program. However, I wonder if I thought this question meant that the student did not have to do an internship within the realm of their own future goals. Anyway, the important focus is that the student get some "in company" experience no matter what the company does, and no matter what their familiarity is with the MS program.
Both individual and team experiences should be provide during the internship.	2.00	2.00-2.75	

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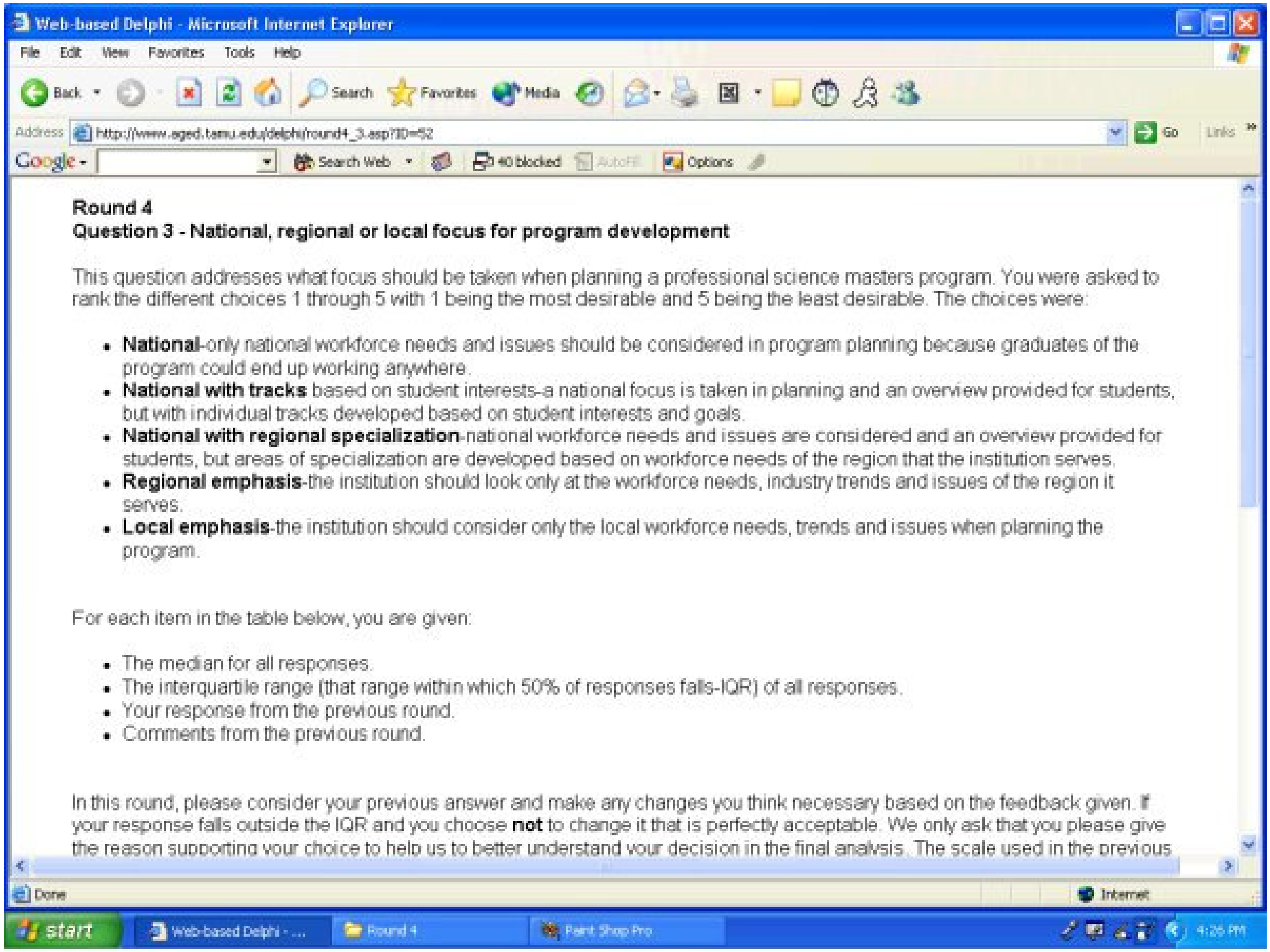
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Round 4
Question 3 - National, regional or local focus for program development
This question addresses what focus should be taken when planning a professional science masters program. You were asked to rank the different choices 1 through 5 with 1 being the most desirable and 5 being the least desirable. The choices were:
National-only national workforce needs and issues should be considered in program planning because graduates of the program could end up working anywhere.
National with tracks based on student interests-a national focus is taken in planning and an overview provided for students, but with individual tracks developed based on student interests and goals.
National with regional specialization-national workforce needs and issues are considered and an overview provided for students, but areas of specialization are developed based on workforce needs of the region that the institution serves.
Regional emphasis-the institution should look only at the workforce needs, industry trends and issues of the region it serves.
Local emphasis-the institution should consider only the local workforce needs, trends and issues when planning the program.
For each item in the table below, you are given:
The median for all responses.
The interquartile range (that range within which 50% of responses falls-IQR) of all responses.
Your response from the previous round.
Comments from the previous round.
In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose not to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous
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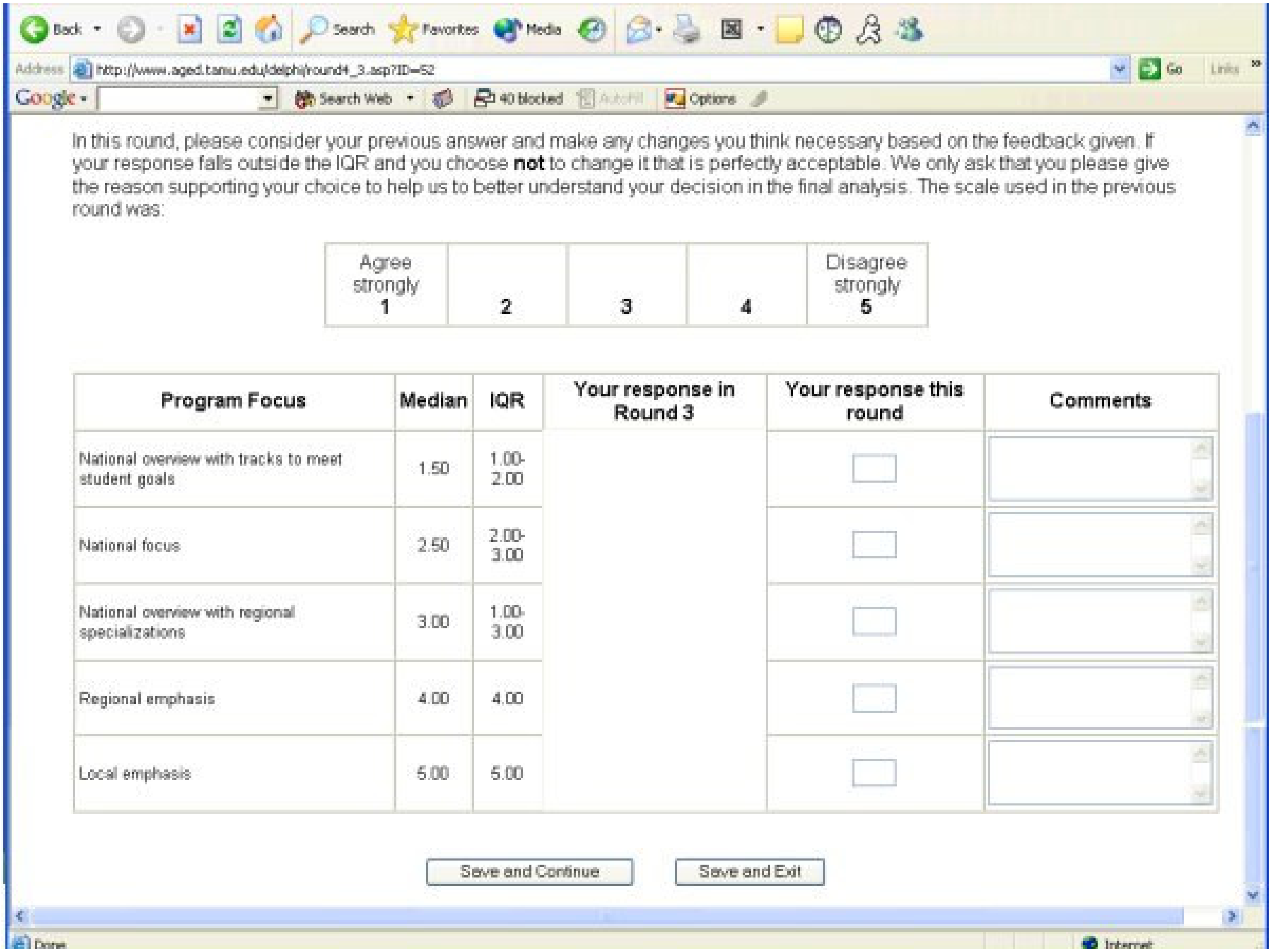
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In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:
Agree strongly 1
2
3
4
Disagree strongly 5
Program Focus
Median
IQR
Your response in Round 3
Your response this round
Comments
National overview with tracks to meet student goals
1.50
1.00-2.00
National focus
2.50
2.00-3.00
National overview with regional specializations
3.00
1.00-3.00
Regional emphasis
4.00
4.00
Local emphasis
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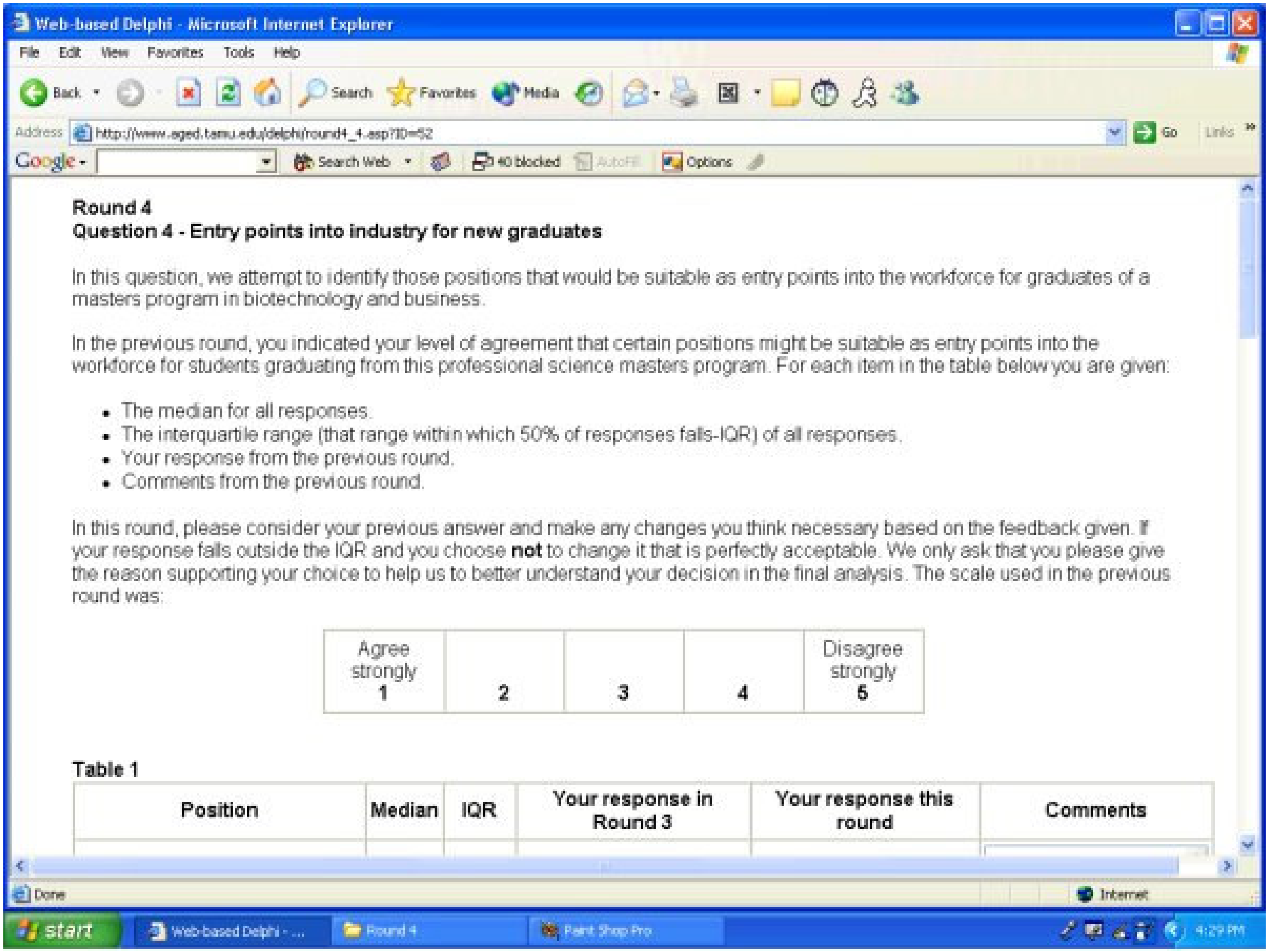
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Round 4
Question 4 - Entry points into industry for new graduates
In this question, we attempt to identify those positions that would be suitable as entry points into the workforce for graduates of a masters program in biotechnology and business.
In the previous round, you indicated your level of agreement that certain positions might be suitable as entry points into the workforce for students graduating from this professional science masters program. For each item in the table below you are given:
The median for all responses.
The interquartile range (that range within which 50% of responses falls-IQR) of all responses.
Your response from the previous round.
Comments from the previous round.
In this round, please consider your previous answer and make any changes you think necessary based on the feedback given. If your response falls outside the IQR and you choose not to change it that is perfectly acceptable. We only ask that you please give the reason supporting your choice to help us to better understand your decision in the final analysis. The scale used in the previous round was:
Agree strongly 1
2
3
4
Disagree strongly 5
Table 1
Position
Median
IQR
Your response in Round 3
Your response this round
Comments
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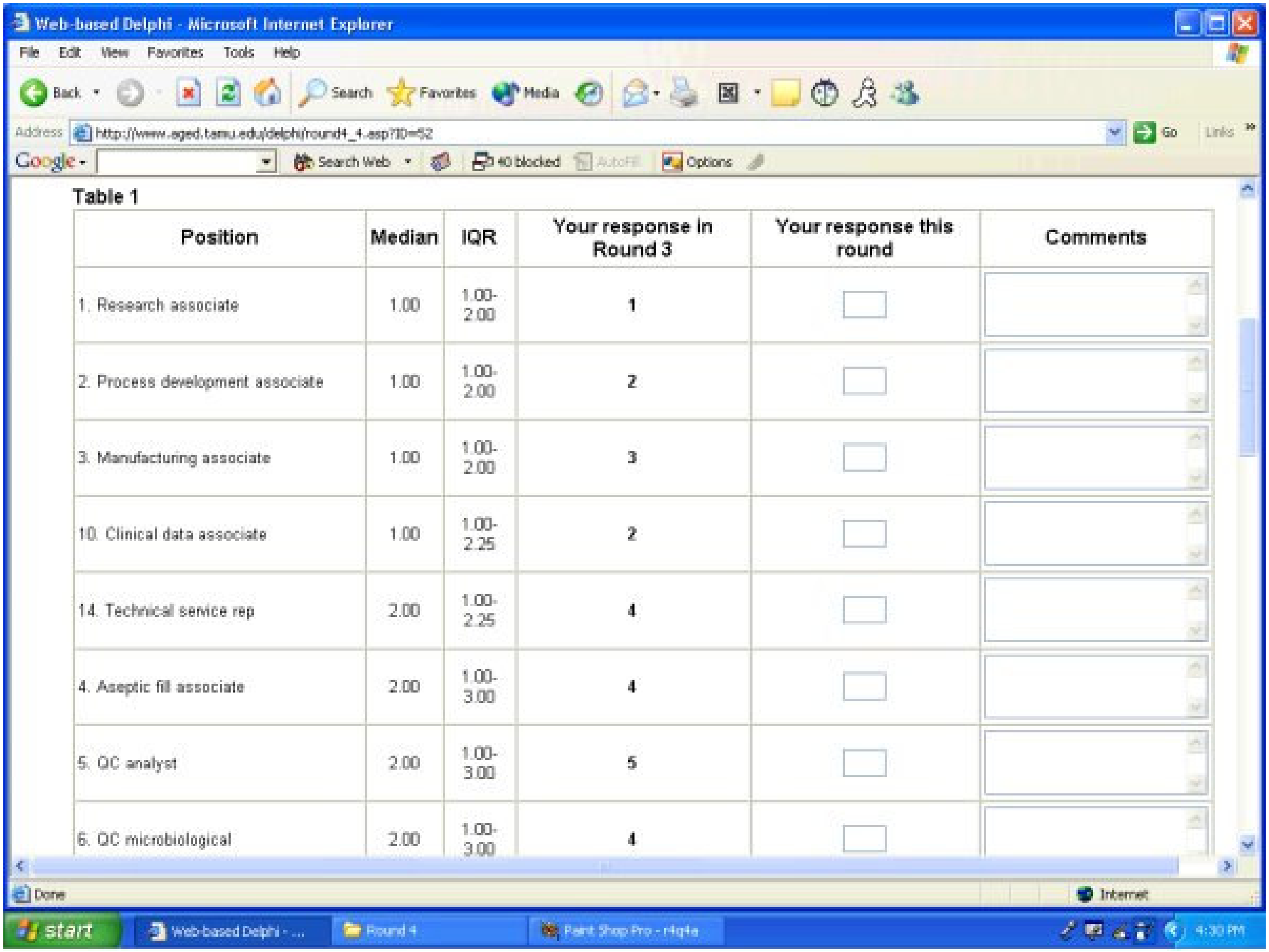
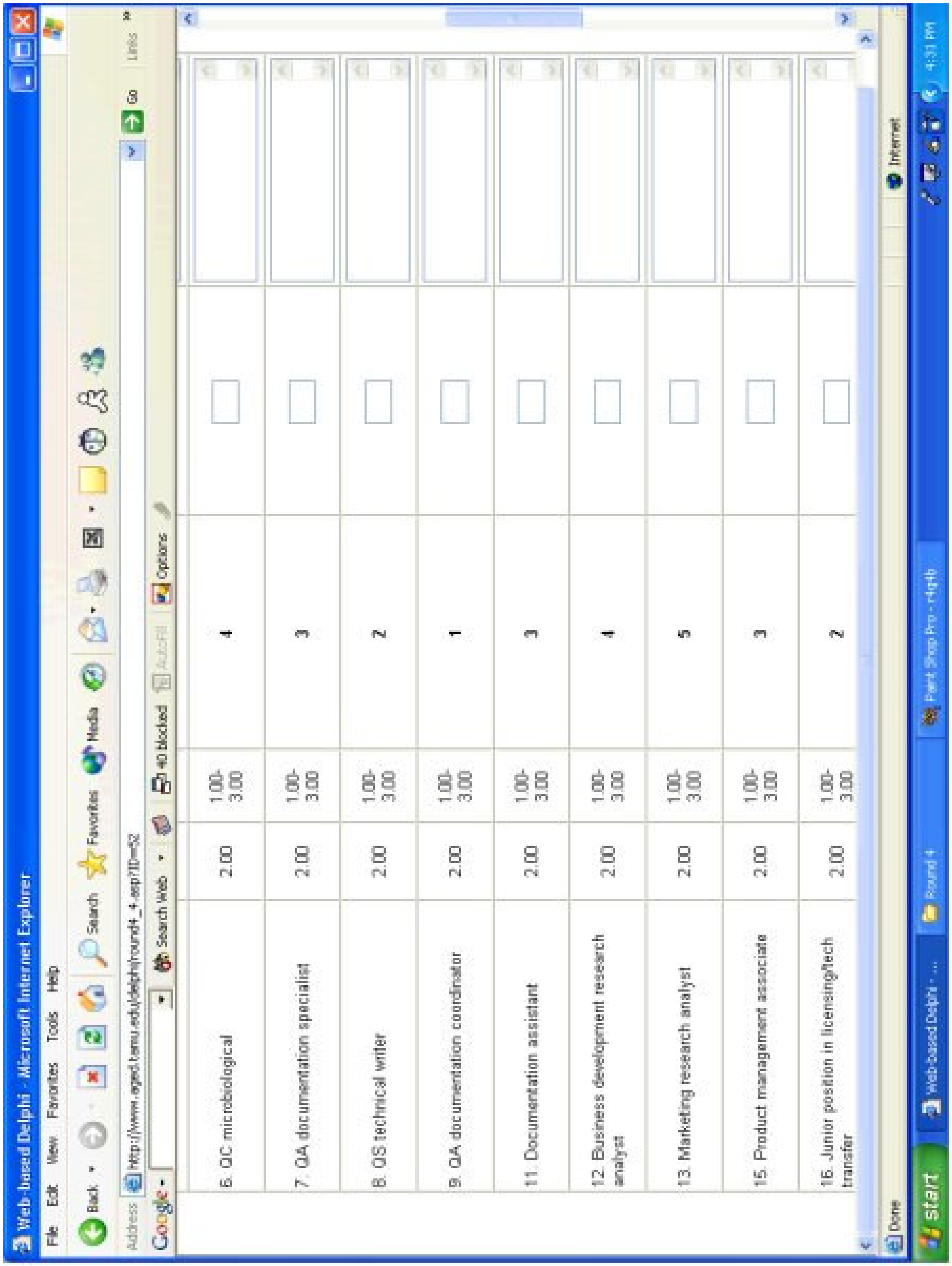


Table 1

Position	Median	IQR	Your response in Round 3	Your response this round	Comments
1. Research associate	1.00	1.00-2.00	1		
2. Process development associate	1.00	1.00-2.00	2		
3. Manufacturing associate	1.00	1.00-2.00	3		
10. Clinical data associate	1.00	1.00-2.25	2		
14. Technical service rep	2.00	1.00-2.25	4		
4. Aseptic fill associate	2.00	1.00-3.00	4		
5. QC analyst	2.00	1.00-3.00	5		
6. QC microbiological	2.00	1.00-3.00	4		



6. QC microbiological	2.00	1.00-3.00	4	
7. QA documentation specialist	2.00	1.00-3.00	3	
8. QS technical writer	2.00	1.00-3.00	2	
9. QA documentation coordinator	2.00	1.00-3.00	1	
11. Documentation assistant	2.00	1.00-3.00	3	
12. Business development research analyst	2.00	1.00-3.00	4	
13. Marketing research analyst	2.00	1.00-3.00	5	
15. Product management associate	2.00	1.00-3.00	3	
16. Junior position in licensing/tech transfer	2.00	1.00-3.00	2	

Web-based Delphi - Microsoft Internet Explorer

Address: http://www.aged.tamu.edu/delphi/round4_4.asp?ID=52

16. Junior position in licensing/tech transfer	2.00	1.00-3.00	2		

Positions added in previous round

In the previous round, you were asked to indicate whether you think the positions in Table 2 were appropriate as entry-points for new graduates with a simple YES or NO. In this round, frequencies for Yes/No are provided and the items are ranked in order by the difference between Y and N (Y minus N). Please indicate your level of agreement that each position listed under "Position Titles" is an appropriate entry point for graduates of a professional science masters program combining biotechnology and business. For example, "Strongly Agree" if the position is, in your mind, definitely an appropriate entry-point position and "Strongly Disagree" if you think the position is definitely not appropriate.

Some people believe that one or more of these positions are essentially the same as positions already listed and that information is summarized and provided in the table below, but you are not expected to take action on it. For your information, the equivalent titles suggested for a position are provided with frequencies provided in parenthesis.

Table 2

	Frequencies				Strongly Agree				Strongly Disagree
Position Titles	**Yes**	**No**	**Y-N**	**Equivalent to (Frequencies)**	**1**	**2**	**3**	**4**	**5**
18. Clinical research associate I	12	2	10	Research associate (2) Clinical data assoc (4) Marketing research analyst (1)	◉	○	○	○	○
17. Associate product manager	11	3	8	Marketing research analyst (1) Product management associate (5)	○	◉	○	○	○

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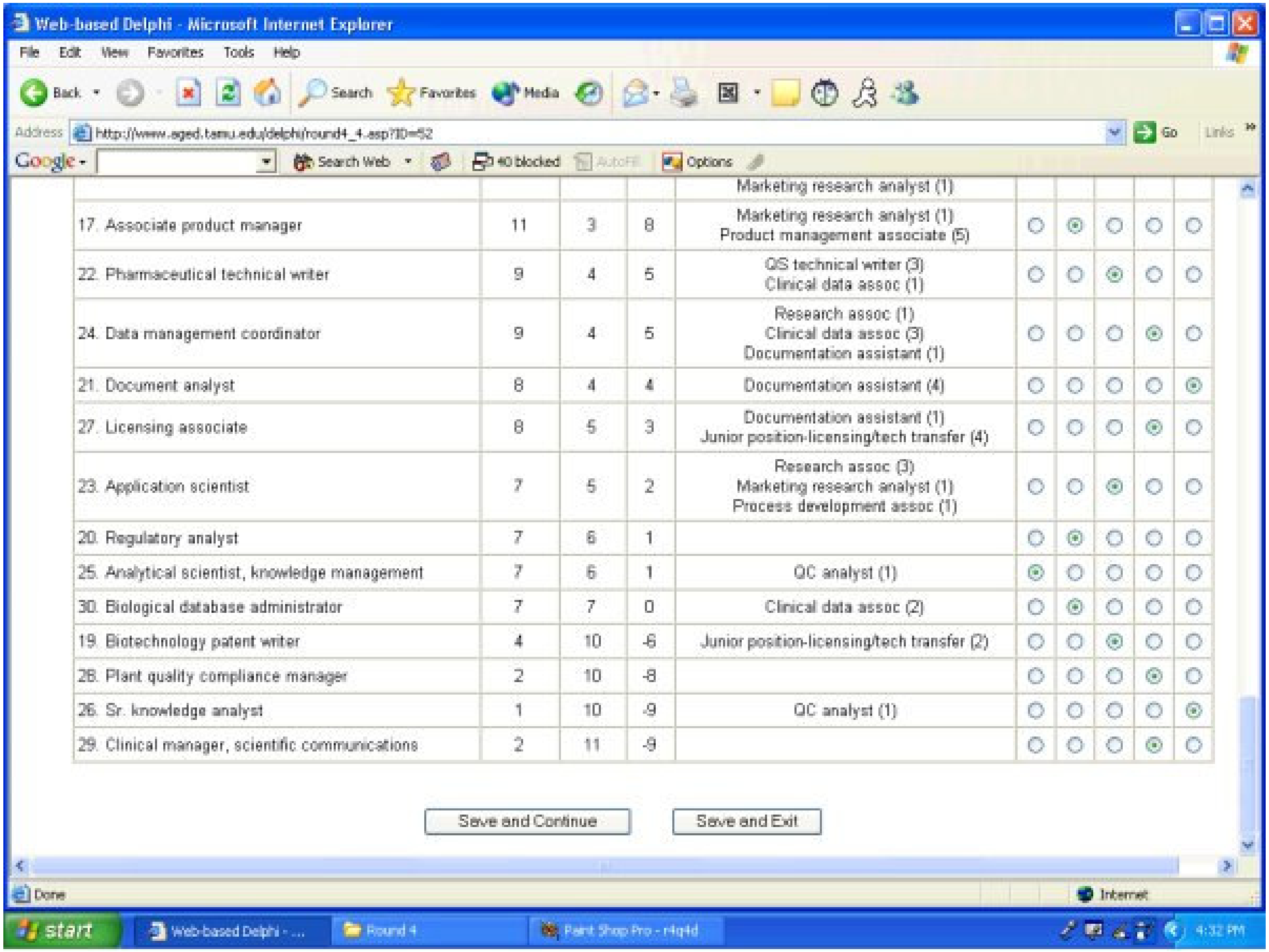
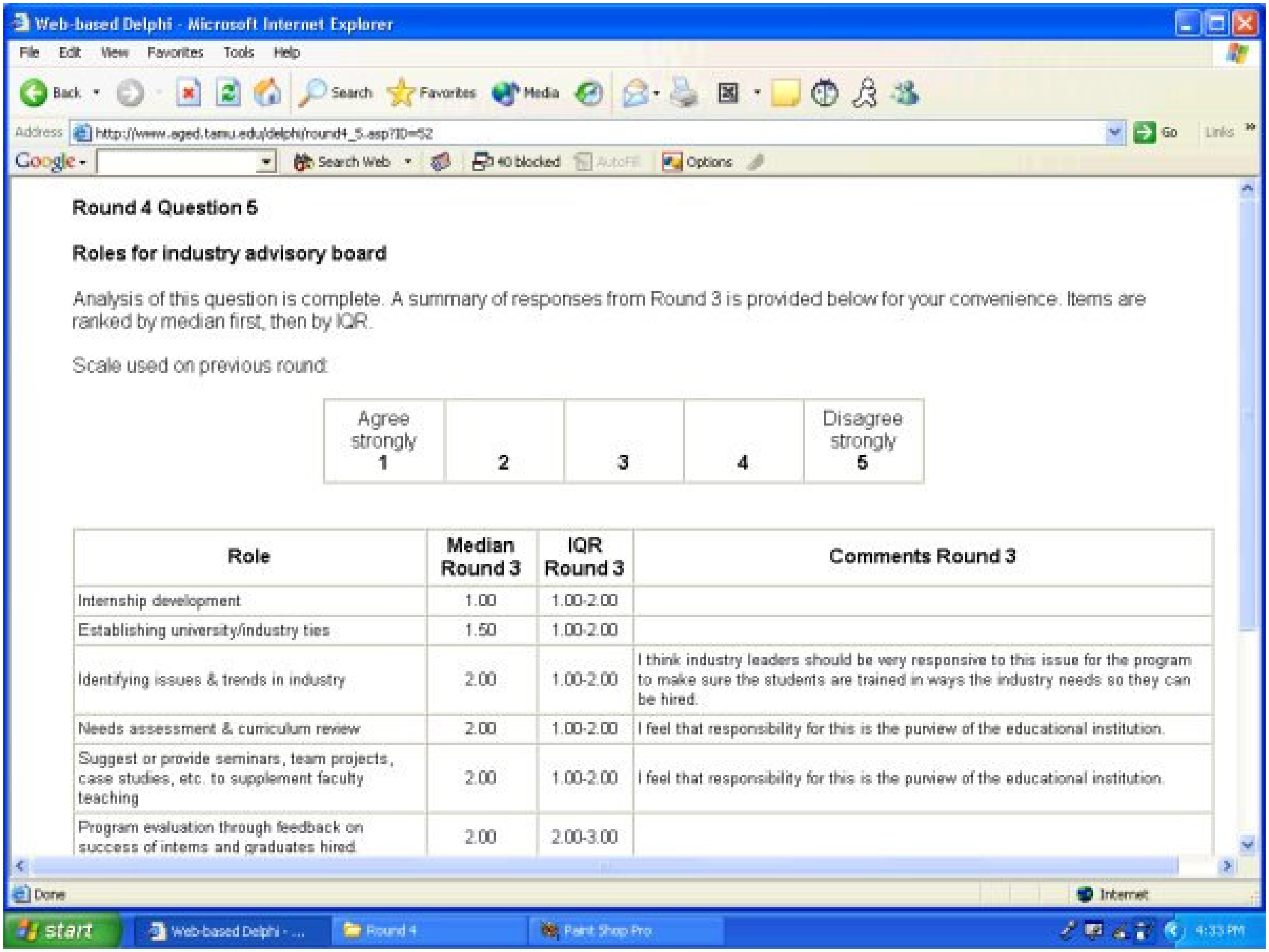


				Marketing research analyst (1)					
17. Associate product manager	11	3	8	Marketing research analyst (1) Product management associate (5)	○	●	○	○	○
22. Pharmaceutical technical writer	9	4	5	QS technical writer (3) Clinical data assoc (1)	○	○	●	○	○
24. Data management coordinator	9	4	5	Research assoc (1) Clinical data assoc (3) Documentation assistant (1)	○	○	○	●	○
21. Document analyst	8	4	4	Documentation assistant (4)	○	○	○	○	●
27. Licensing associate	8	5	3	Documentation assistant (1) Junior position-licensing/tech transfer (4)	○	○	○	●	○
23. Application scientist	7	5	2	Research assoc (3) Marketing research analyst (1) Process development assoc (1)	○	○	●	○	○
20. Regulatory analyst	7	6	1		○	●	○	○	○
25. Analytical scientist, knowledge management	7	6	1	QC analyst (1)	●	○	○	○	○
30. Biological database administrator	7	7	0	Clinical data assoc (2)	○	●	○	○	○
19. Biotechnology patent writer	4	10	-6	Junior position-licensing/tech transfer (2)	○	○	●	○	○
28. Plant quality compliance manager	2	10	-8		○	○	○	●	○
26. Sr. knowledge analyst	1	10	-9	QC analyst (1)	○	○	○	○	●
29. Clinical manager, scientific communications	2	11	-9		○	○	○	●	○



Round 4 Question 5

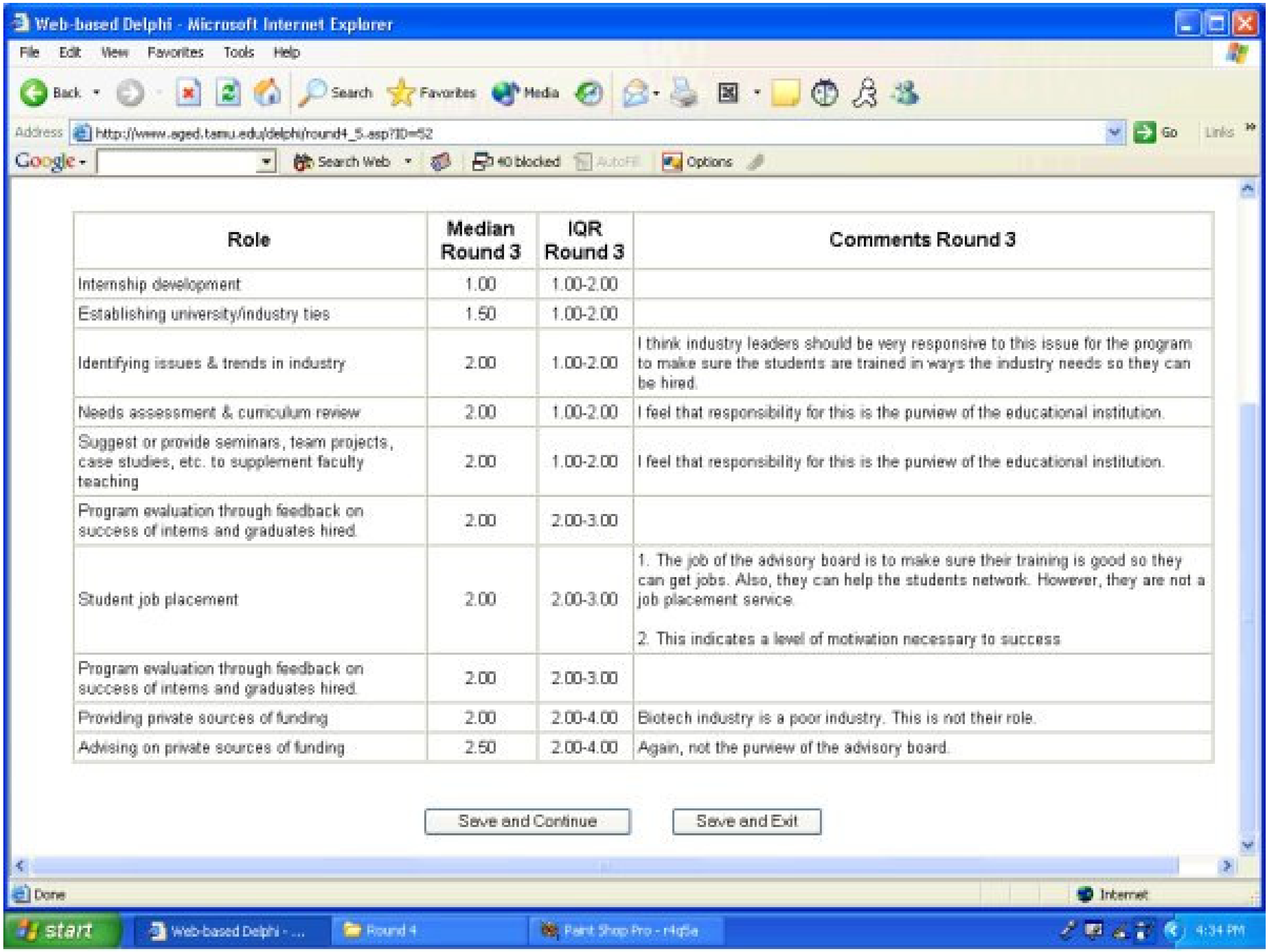
Roles for industry advisory board

Analysis of this question is complete. A summary of responses from Round 3 is provided below for your convenience. Items are ranked by median first, then by IQR.

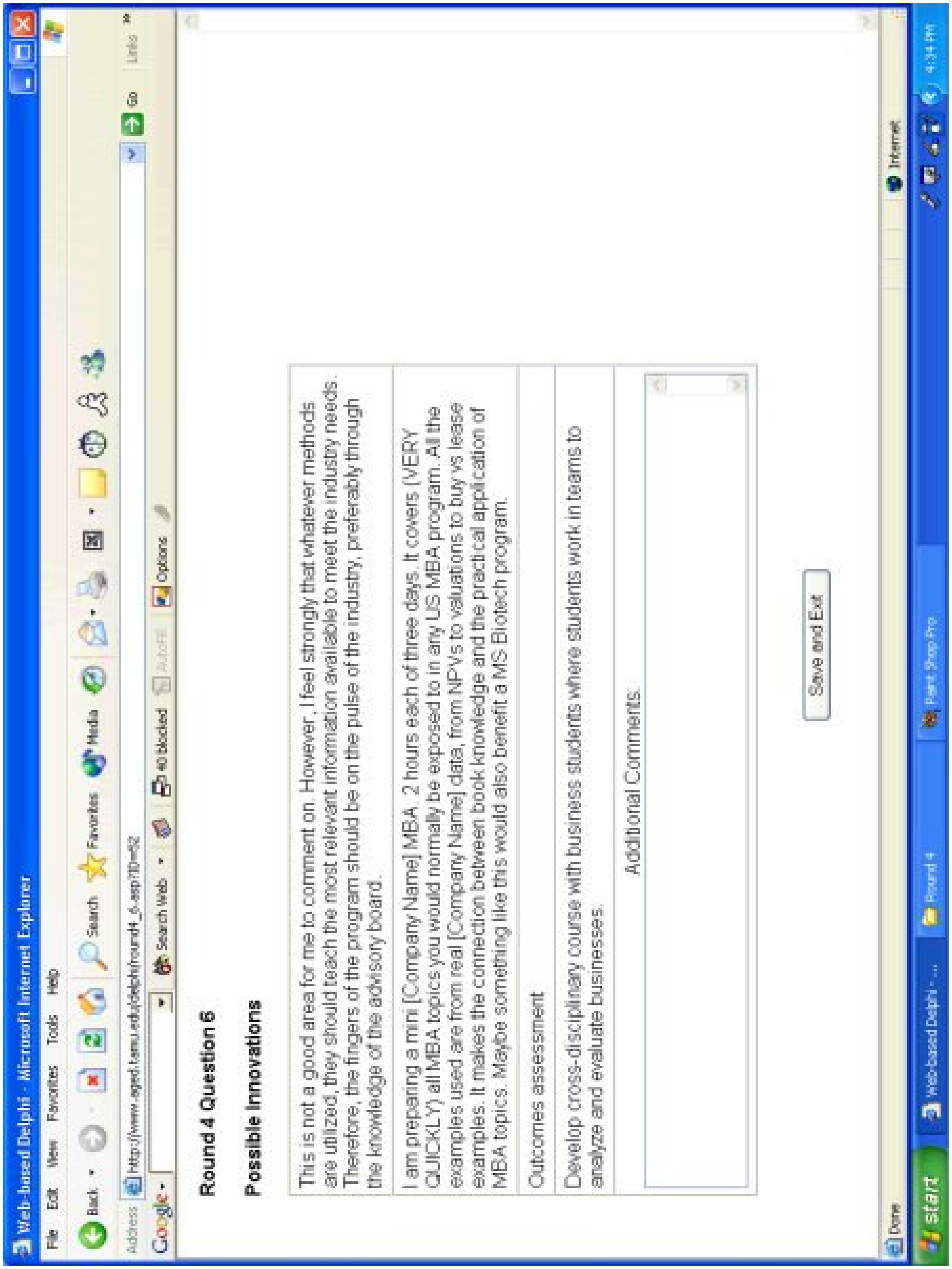
Scale used on previous round:

Agree strongly **1**	**2**	**3**	**4**	Disagree strongly **5**

Role	Median Round 3	IQR Round 3	Comments Round 3
Internship development	1.00	1.00-2.00	
Establishing university/industry ties	1.50	1.00-2.00	
Identifying issues & trends in industry	2.00	1.00-2.00	I think industry leaders should be very responsive to this issue for the program to make sure the students are trained in ways the industry needs so they can be hired.
Needs assessment & curriculum review	2.00	1.00-2.00	I feel that responsibility for this is the purview of the educational institution.
Suggest or provide seminars, team projects, case studies, etc. to supplement faculty teaching	2.00	1.00-2.00	I feel that responsibility for this is the purview of the educational institution.
Program evaluation through feedback on success of interns and graduates hired	2.00	2.00-3.00	



Role	Median Round 3	IQR Round 3	Comments Round 3
Internship development	1.00	1.00-2.00	
Establishing university/industry ties	1.50	1.00-2.00	
Identifying issues & trends in industry	2.00	1.00-2.00	I think industry leaders should be very responsive to this issue for the program to make sure the students are trained in ways the industry needs so they can be hired.
Needs assessment & curriculum review	2.00	1.00-2.00	I feel that responsibility for this is the purview of the educational institution.
Suggest or provide seminars, team projects, case studies, etc. to supplement faculty teaching	2.00	1.00-2.00	I feel that responsibility for this is the purview of the educational institution.
Program evaluation through feedback on success of interns and graduates hired.	2.00	2.00-3.00	
Student job placement	2.00	2.00-3.00	1. The job of the advisory board is to make sure their training is good so they can get jobs. Also, they can help the students network. However, they are not a job placement service. 2. This indicates a level of motivation necessary to success
Program evaluation through feedback on success of interns and graduates hired.	2.00	2.00-3.00	
Providing private sources of funding	2.00	2.00-4.00	Biotech industry is a poor industry. This is not their role.
Advising on private sources of funding	2.50	2.00-4.00	Again, not the purview of the advisory board.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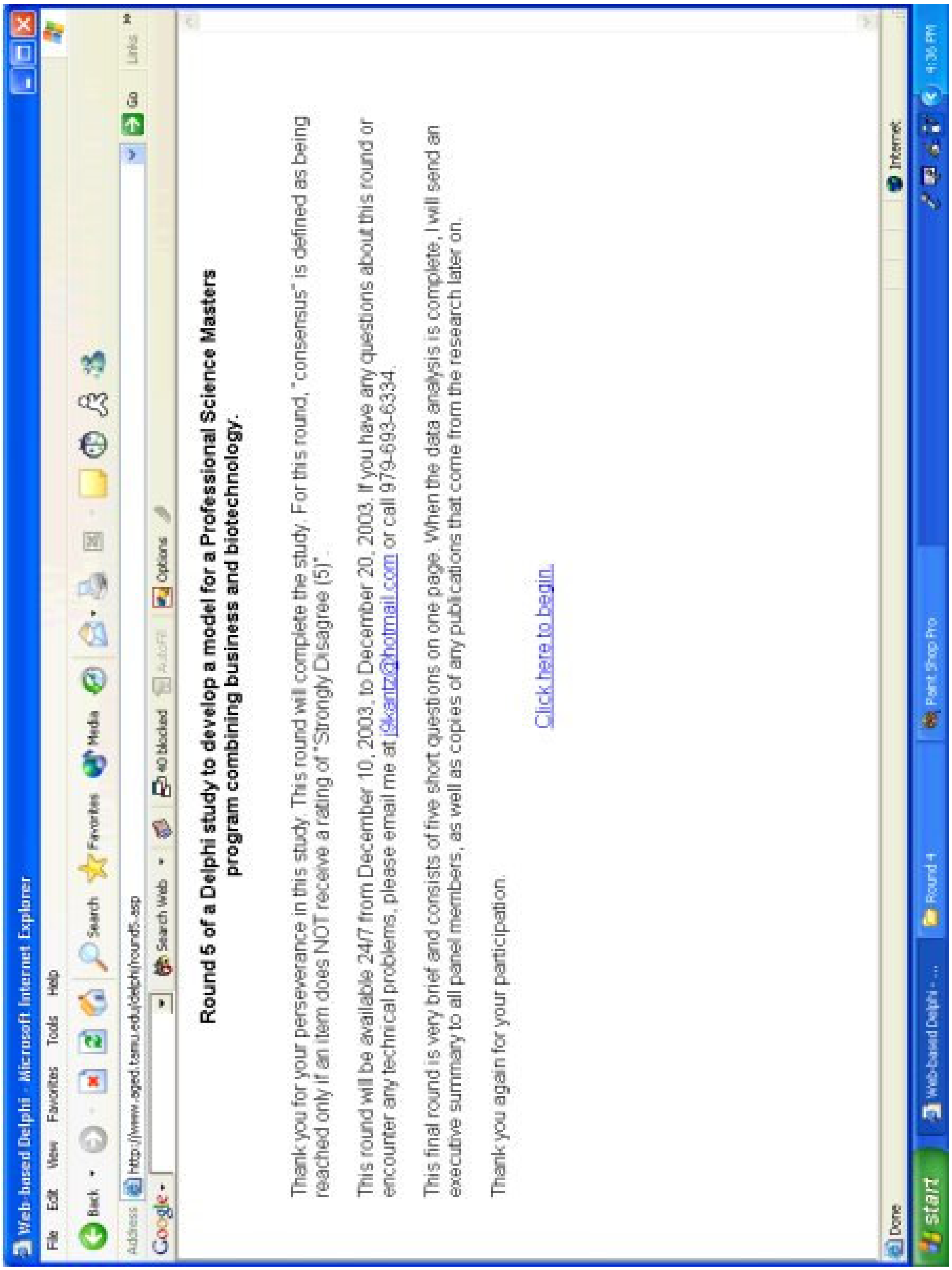
Round 4 Question 6
Possible Innovations
This is not a good area for me to comment on. However, I feel strongly that whatever methods are utilized, they should teach the most relevant information available to meet the industry needs. Therefore, the fingers of the program should be on the pulse of the industry, preferably through the knowledge of the advisory board.
I am preparing a mini [Company Name] MBA. 2 hours each of three days. It covers (VERY QUICKLY) all MBA topics you would normally be exposed to in any US MBA program. All the examples used are from real [Company Name] data, from NPVs to valuations to buy vs lease examples. It makes the connection between book knowledge and the practical application of MBA topics. Maybe something like this would also benefit a MS Biotech program.
Outcomes assessment
Develop cross-disciplinary course with business students where students work in teams to analyze and evaluate businesses.
Additional Comments
Save and Exit

APPENDIX H

ROUND 5 INSTRUMENT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http://www.aged.tamu.edu/delphi/round5.asp
Round 5 of a Delphi study to develop a model for a Professional Science Masters program combining business and biotechnology.
Thank you for your perseverance in this study. This round will complete the study. For this round, "consensus" is defined as being reached only if an item does NOT receive a rating of "Strongly Disagree (5)".
This round will be available 24/7 from December 10, 2003, to December 20, 2003. If you have any questions about this round or encounter any technical problems, please email me at j9kantz@hotmail.com or call 979-693-6334.
This final round is very brief and consists of five short questions on one page. When the data analysis is complete, I will send an executive summary to all panel members, as well as copies of any publications that come from the research later on.
Thank you again for your participation.
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Round 4
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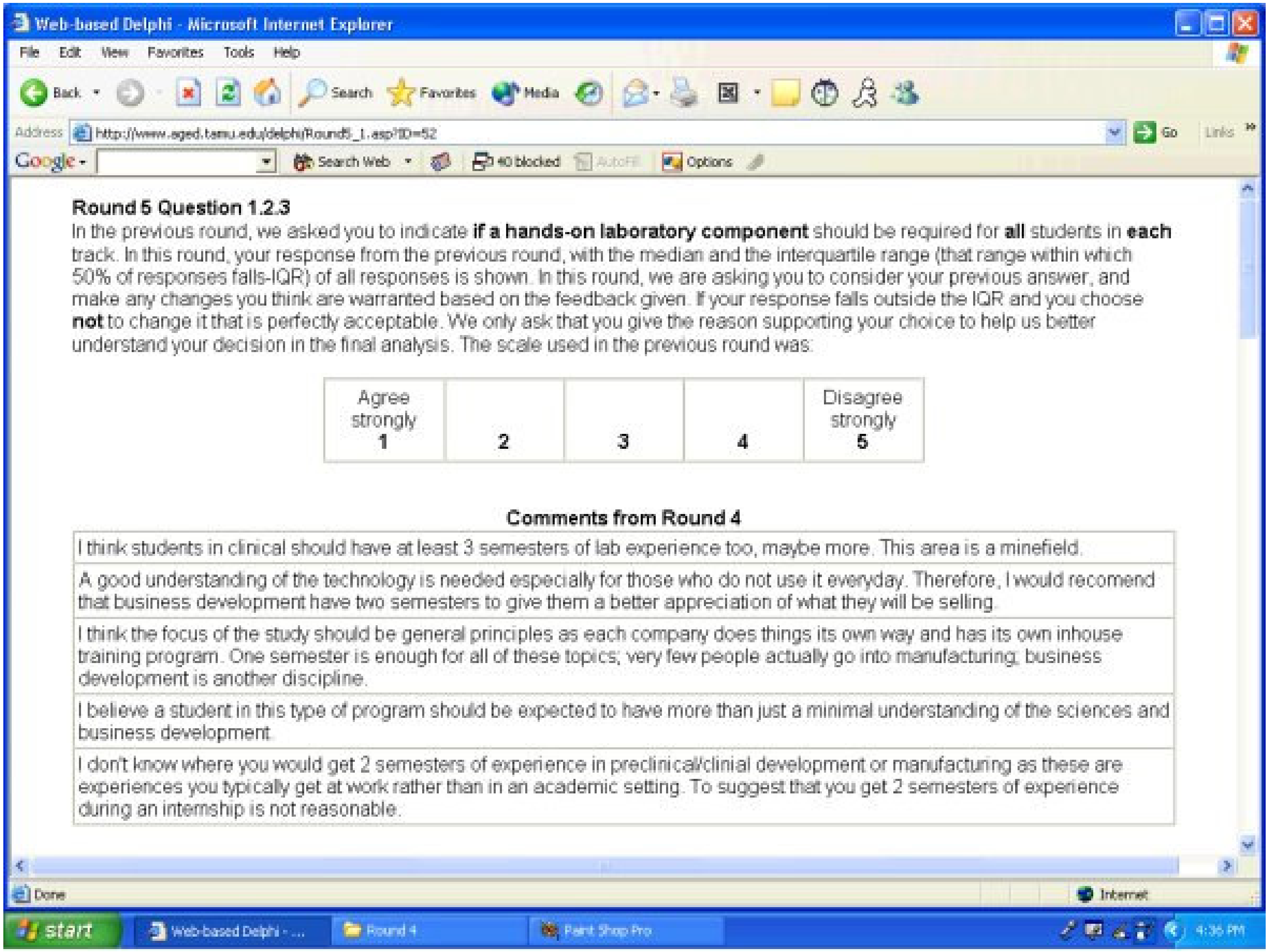


Web-based Delphi - Microsoft Internet Explorer

http://www.aged.tamu.edu/delphi/Round5_1.asp?ID=52

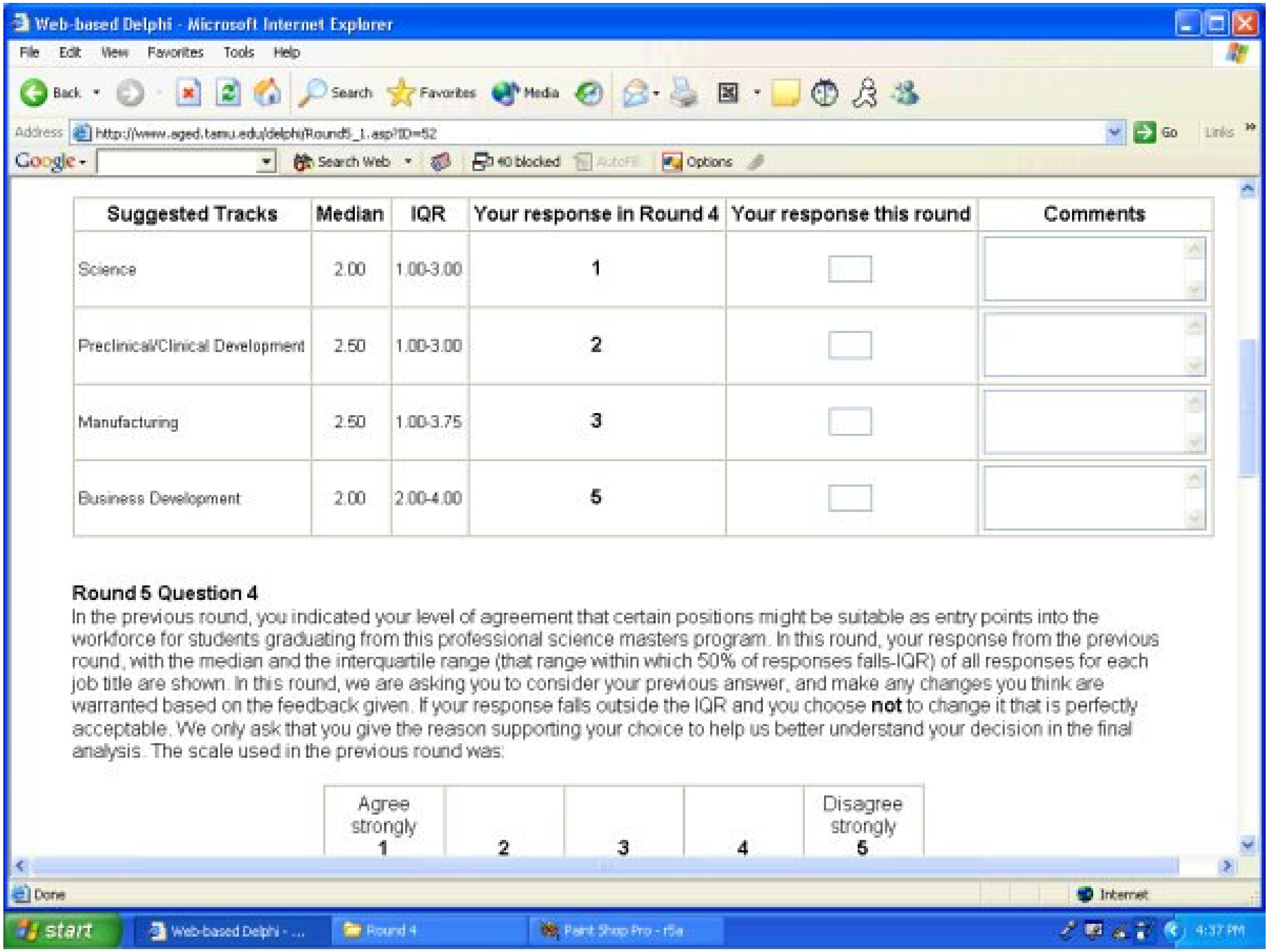
Round 5 Question 1.2.3

In the previous round, we asked you to indicate **if a hands-on laboratory component** should be required for **all** students in **each** track. In this round, your response from the previous round, with the median and the interquartile range (that range within which 50% of responses falls-IQR) of all responses is shown. In this round, we are asking you to consider your previous answer, and make any changes you think are warranted based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you give the reason supporting your choice to help us better understand your decision in the final analysis. The scale used in the previous round was:

Agree strongly **1**	**2**	**3**	**4**	Disagree strongly **5**

Comments from Round 4

I think students in clinical should have at least 3 semesters of lab experience too, maybe more. This area is a minefield.
A good understanding of the technology is needed especially for those who do not use it everyday. Therefore, I would recomend that business development have two semesters to give them a better appreciation of what they will be selling.
I think the focus of the study should be general principles as each company does things its own way and has its own inhouse training program. One semester is enough for all of these topics; very few people actually go into manufacturing; business development is another discipline.
I believe a student in this type of program should be expected to have more than just a minimal understanding of the sciences and business development.
I don't know where you would get 2 semesters of experience in preclinical/clinial development or manufacturing as these are experiences you typically get at work rather than in an academic setting. To suggest that you get 2 semesters of experience during an internship is not reasonable.

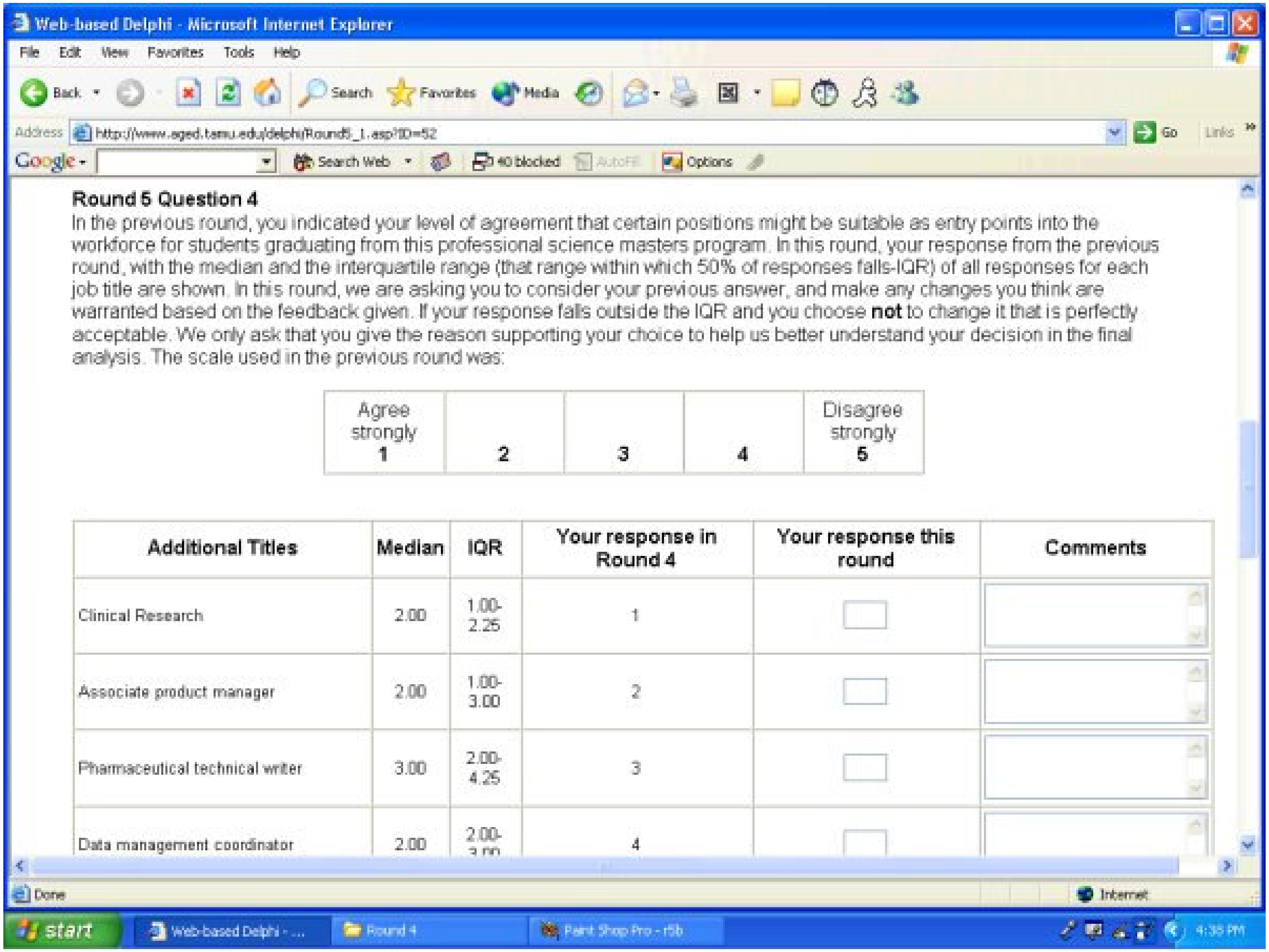


Suggested Tracks	Median	IQR	Your response in Round 4	Your response this round	Comments
Science	2.00	1.00-3.00	1		
Preclinical/Clinical Development	2.50	1.00-3.00	2		
Manufacturing	2.50	1.00-3.75	3		
Business Development	2.00	2.00-4.00	5		

Round 5 Question 4

In the previous round, you indicated your level of agreement that certain positions might be suitable as entry points into the workforce for students graduating from this professional science masters program. In this round, your response from the previous round, with the median and the interquartile range (that range within which 50% of responses falls-IQR) of all responses for each job title are shown. In this round, we are asking you to consider your previous answer, and make any changes you think are warranted based on the feedback given. If your response falls outside the IQR and you choose **not** to change it that is perfectly acceptable. We only ask that you give the reason supporting your choice to help us better understand your decision in the final analysis. The scale used in the previous round was:

Agree strongly 1	2	3	4	Disagree strongly 5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Round 5 Question 4
In the previous round, you indicated your level of agreement that certain positions might be suitable as entry points into the workforce for students graduating from this professional science masters program. In this round, your response from the previous round, with the median and the interquartile range (that range within which 50% of responses falls-IQR) of all responses for each job title are shown. In this round, we are asking you to consider your previous answer, and make any changes you think are warranted based on the feedback given. If your response falls outside the IQR and you choose not to change it that is perfectly acceptable. We only ask that you give the reason supporting your choice to help us better understand your decision in the final analysis. The scale used in the previous round was:
Agree strongly 1
2
3
4
Disagree strongly 5
Additional Titles
Median
IQR
Your response in Round 4
Your response this round
Comments
Clinical Research 2.00 1.00-2.25 1
Associate product manager 2.00 1.00-3.00 2
Pharmaceutical technical writer 3.00 2.00-4.25 3
Data management coordinator 2.00 2.00- 4
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Round 4
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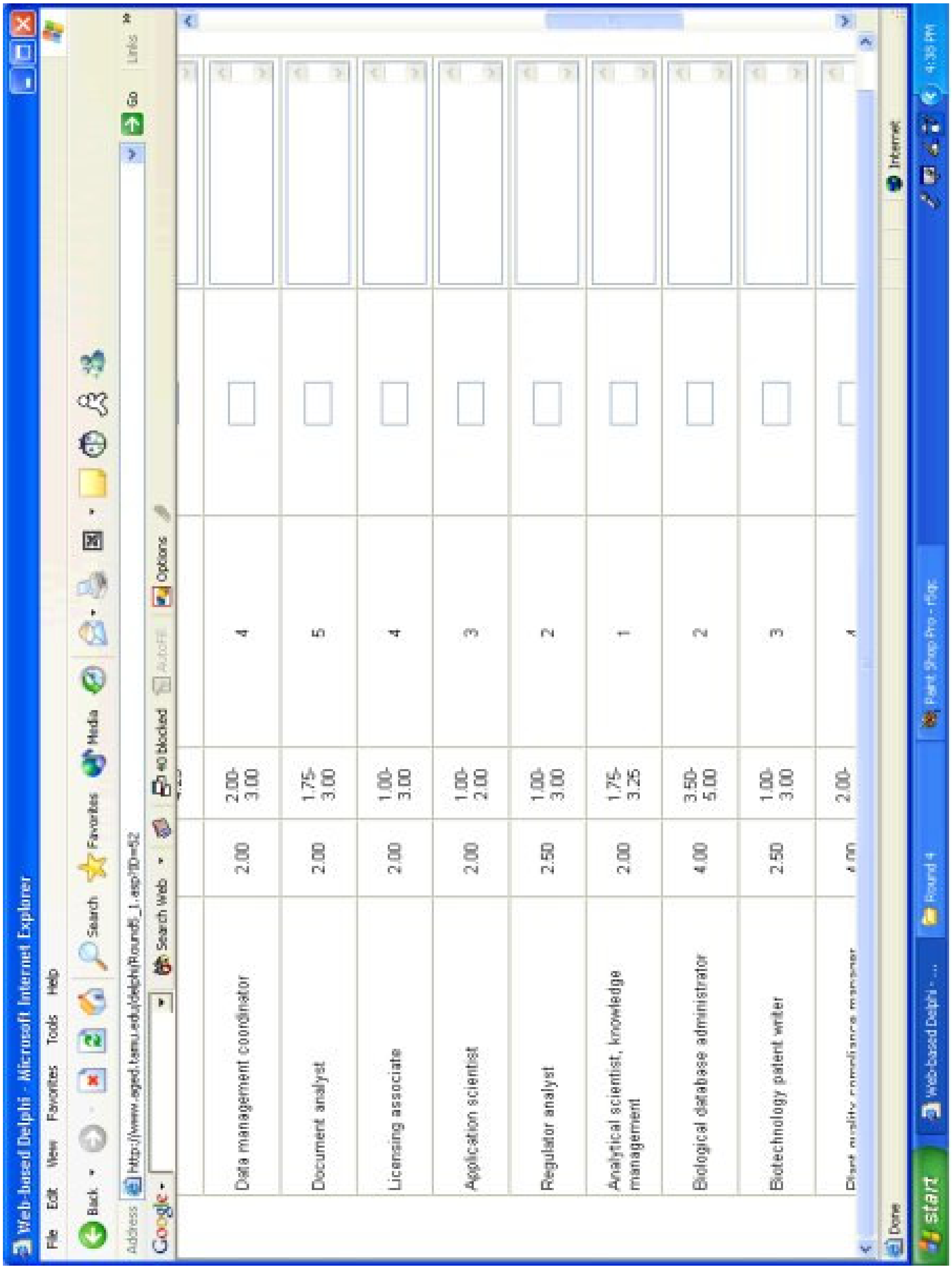
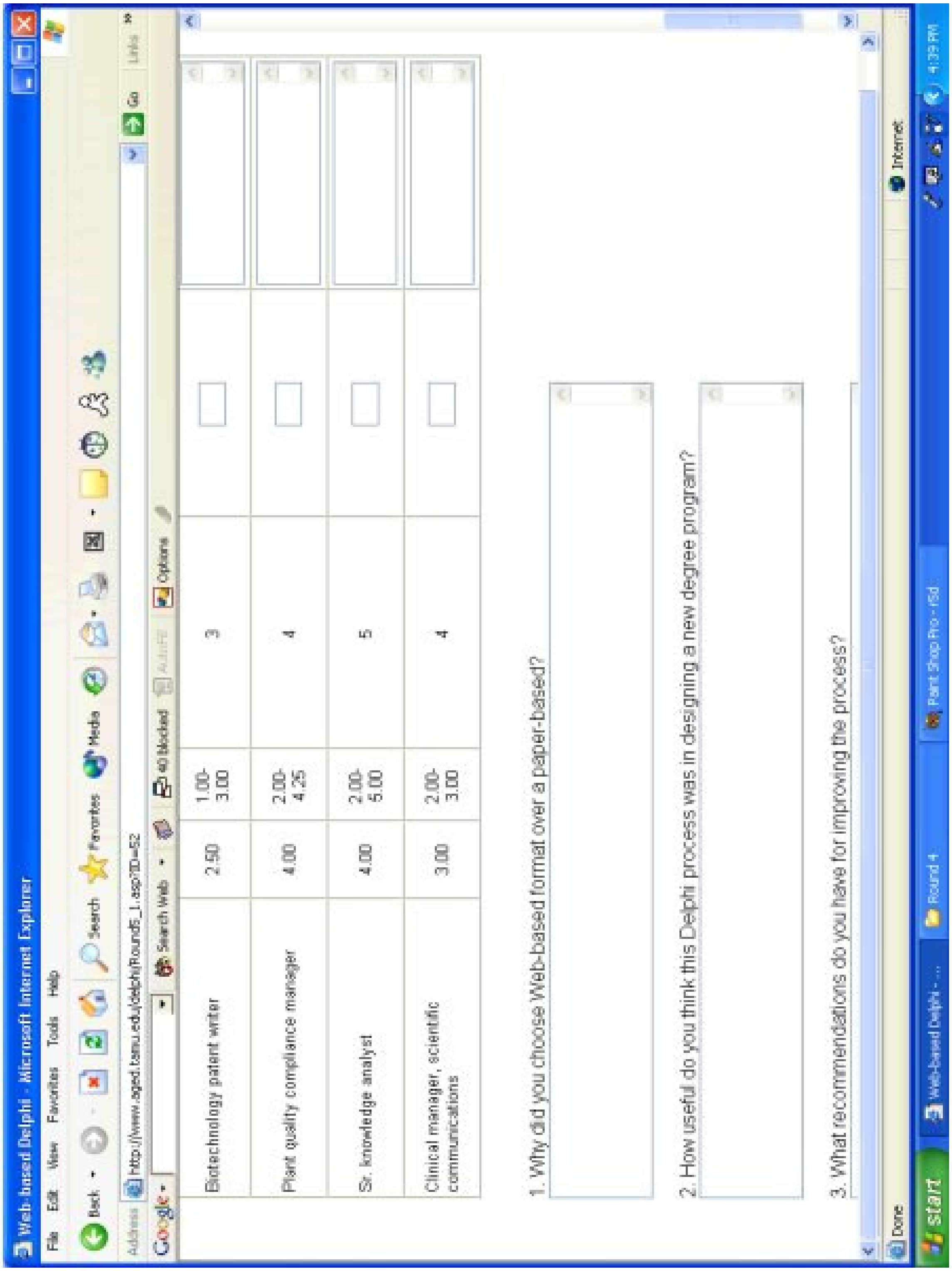


Data management coordinator	2.00	2.00-3.00	4
Document analyst	2.00	1.75-3.00	5
Licensing associate	2.00	1.00-3.00	4
Application scientist	2.00	1.00-2.00	3
Regulator analyst	2.50	1.00-3.00	2
Analytical scientist, knowledge management	2.00	1.75-3.25	1
Biological database administrator	4.00	3.50-5.00	2
Biotechnology patent writer	2.50	1.00-3.00	3
Plant quality compliance	4.00	2.00-	4



Web-based Delphi - Microsoft Internet Explorer

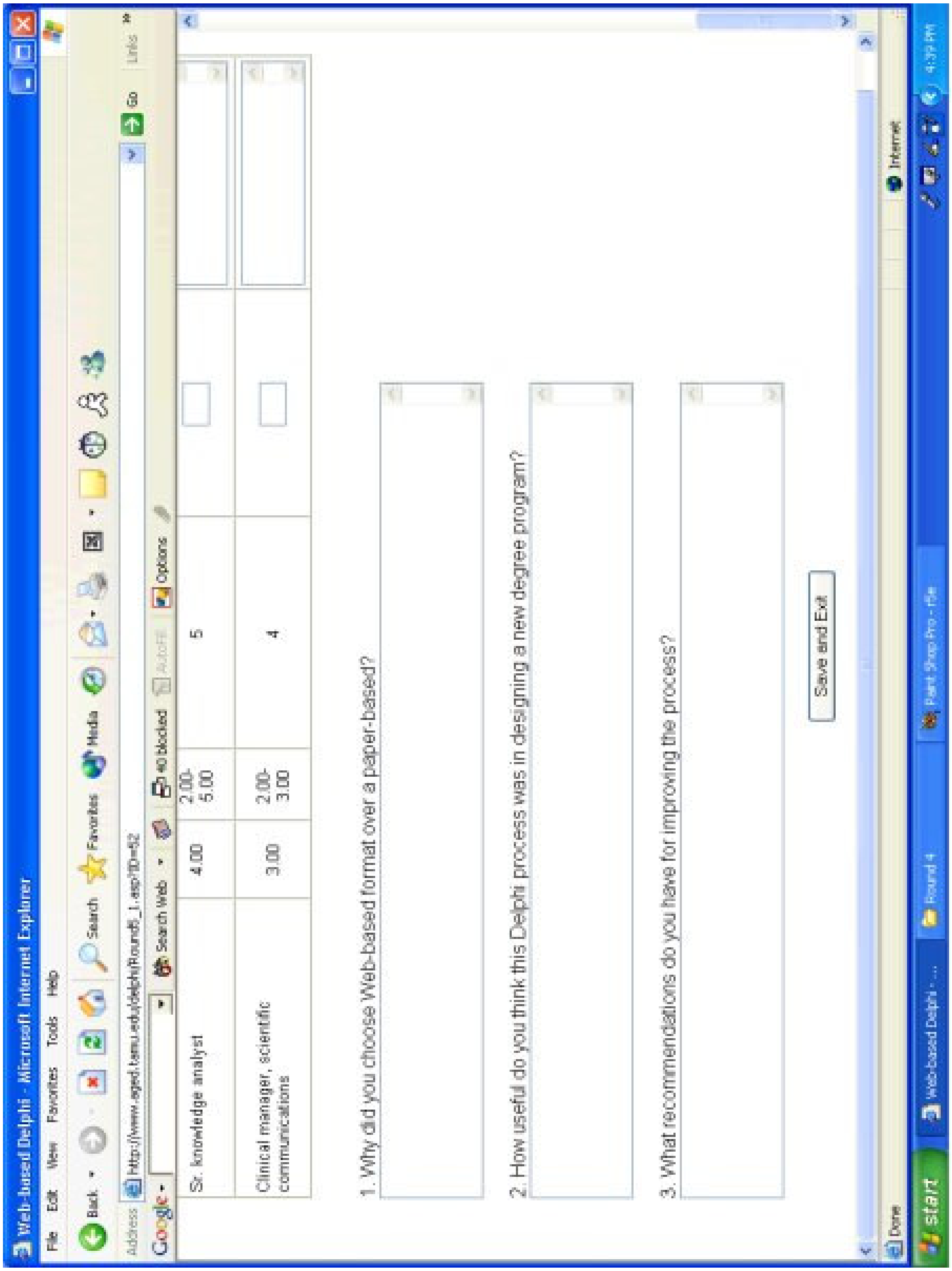
http://www.aged.tamu.edu/delphi/Round5_1.asp?ID=52

Biotechnology patent writer	2.50	1.00-3.00	3		
Plant quality compliance manager	4.00	2.00-4.25	4		
Sr. knowledge analyst	4.00	2.00-5.00	5		
Clinical manager, scientific communications	3.00	2.00-3.00	4		

1. Why did you choose Web-based format over a paper-based?

2. How useful do you think this Delphi process was in designing a new degree program?

3. What recommendations do you have for improving the process?


Web-based Delphi - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
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Search Web 40 blocked AutoFill Options
Sr. knowledge analyst 4.00 2.00-5.00 5
Clinical manager, scientific communications 3.00 2.00-3.00 4
1. Why did you choose Web-based format over a paper-based?
2. How useful do you think this Delphi process was in designing a new degree program?
3. What recommendations do you have for improving the process?
Save and Exit
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Web-based Delphi - ...
Round 4
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APPENDIX I

SKILLS IDENTIFIED AS APPROPRIATE FOR

CORE CURRICULUM OR SPECIALIZED TRACKS

Suggested Skills	Score R2	Frequency
Product development	Track	15
Sales skills	Track	15
Marketing	Track	13
Developing partnerships	Track	13
Conducting market research	Track	13
Acquiring funding for biotech companies	Track	13
Preclinical testing	Track	13
Human Factors testing	Track	13
Clinical testing	Track	13
Medical writing	Track	13
Contract law	Track	12
Poly(A) RNA isolation	Track	12
Transfection	Track	12
Good Clinical Practice (GCP)	Track	12
Good Tissue Practice (GTP)	Track	12
Know about current drugs under development	Track	12
Know about medical devices under development	Track	12
Facility design and engineering (*Basic understanding of HVAC, water systems, facility layout and design)	Track	12
Understanding venture capital process	Track	11
Microeconomics of a firm	Track	11
In vitro translation	Track	11
In-vitro transcription	Track	11
Site directed mutagenesis techniques	Track	11
Tissue and organ replacement	Track	11
Points to Consider documents	Track	11
ISO 9000	Track	11
Quality Assurance	Track	11
Experimental design	Track	10
Project management	Track	10
How to write a business plan	Track	10
Basic accounting principles	Track	10
Biostatistics	Track	10
Cell therapies	Track	10
In situ hybridization	Track	10
Microbial screening	Track	10
Non-isotopic labeling techniques	Track	10
Proteomics	Track	10
RNA amplification	Track	10
RNA isolation	Track	10
Transformation	Track	10
Use of bacteria	Track	10
21CFRx00	Track	10

Biotechnology market knowledge	Track	10
National and International Scope of Interest	Track	10
Risk management	Track	9
Bioinformatics	Track	9
cDNA library construction	Track	9
PCR-Real time	Track	9
Reverse transcription	Track	9
SDS-PAGE	Track	9
Viral and non-viral gene therapy	Track	9
Guidance documents	Track	9
Present findings with Powerpoint type presentation	Core	17
Critical thinking skills	Core	17
Time management	Core	17
Writing on, speaking about and presenting technical material to a variety of audiences with varying levels of knowledge in the field	Core	16
Problem solving skills	Core	16
Interpersonal skills-ability to work with diverse cross-section of people	Core	16
Ethics of research and business	Core	16
Teamwork in scientific investigation	Core	14
Working on teams with professionals who are not trained in biology or biotechnology	Core	14
Scientific and technical writing	Core	13
Writing brief trip reports	Core	13
Resume writing	Core	13
How biotechnology is used in different fields-agriculture, environmental, human health, etc.	Core	13
Intellectual property issues	Core	13
Understanding drug discovery & development	Core	13
Survey of biotechnology industry	Core	13
Understanding other people's research	Core	12
Work both as an individual and as a productive member of a research team	Core	12
Interviewing skills	Core	12
Laboratory safety	Core	12
Keeping laboratory notebooks	Core	12
Understand value and role of corporate culture	Core	12
Literature review skills	Core	11
Eagerness to adapt to new directions	Core	11
Awareness of history, current state and direction of the field	Core	11
Chemical safety	Core	11
Radiation safety	Core	11
Preparing an abstract for a meeting	Core	10
Proposal writing	Core	10
Interpretation of scientific literature	Core	10
Reading a balance statement	Core	10
Knowledge of gene expression	Core	10

Federal regulatory process	Core	10
Present a business plan for a biotechnology company	Core	9
Trouble shooting	Core	9
How to read a profit and loss statement	Core	9
Good Laboratory Practice (GLP)	Core	9
Good Manufacturing Practice (GMP)	Core	9
Basic Information Technology (IT) and MIS needs for biotech companies	Core	9
Knowledge of clinical trials process	Core	9
Basic finance principles	Tie	
Making posters	No Maj	
Budget preparation	No Maj	
Personnel management	No Maj	
Basic knowledge of stock options	No Maj	
Economics	No Maj	
Agarose Gel Electrophoresis	No Maj	
Apply basic principles to new situations in the use of computers and computer software, including writing algorithms	No Maj	
Automated sequencing	No Maj	
Awareness of differences that can occur with different lots of reagent	No Maj	
Northern blotting	No Maj	
Southern blotting	No Maj	
Western blotting	No Maj	
Cloning a gene	No Maj	
DNA isolation	No Maj	
DNA sequencing	No Maj	
Expression profiling (microarrays)	No Maj	
Making reagents	No Maj	
Polyacrylamide gel electrophoresis	No Maj	
PCR (Polymerase Chain Reaction)	No Maj	
Protein expression, isolation and characterization	No Maj	
Tissue culture	No Maj	
Use of molecular biology software	No Maj	
International Conference on Harmonization Guideline	No Maj	

APPENDIX J

DECISION SCENARIO FROM ROUND 2.1 GOALS QUESTION

Decision scenario

This program is in a Research I university, one of few with federal Land Grant, Sea Grant and Space Grant designation. The Colleges of Agriculture and Life Sciences, Science, Veterinary Medicine, Business and Liberal Arts are willing to support an interdisciplinary professional science master's program combining biotechnology and business. An interdisciplinary Faculty of Biotechnology, with membership representing the five colleges, has been formed to provide academic oversight for the program.

Rationale for the program is that numerous government, and other resources, have indicated a need for a new kind of science degree that prepares science professionals for the increasing opportunities in research and non-research positions in industry. The university has identified a need to provide an alternate choice for those students in the life sciences who are well-qualified academically, but who are seeking a career path other than that offered by traditional professional schools or doctoral programs. Some undergraduate majors emphasize undergraduate research experience, some do not, so the experience of the students who might enter the master's program is quite varied, ranging from a few students with several semesters experience to some with no experience beyond the laboratories associated with their biology and chemistry classes. The majority have no experience with independent research as undergraduates.

Resources identified to date:

- An almost endless number of science courses in numerous departments in the three science colleges;
- A certificate in business for non business majors (survey courses in management, marketing, accounting and finance);
- A certificate in entrepreneurship that emphasizes technology commercialization; and
- Experiential learning opportunities for students in a variety of environments-numerous laboratories, centers and institutes; technology licensing office; technology commercialization and market research in the university research park; agriculture communications office; and much more.
- Due to a recent focus on homeland security, opportunities in biosecurity are increasing.

Given this information, what objectives do you think the program should focus on? Please list no more than 5 objectives.

VITA

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College Station, TX

Education: Bachelor of Science, Biology (1976)
Tarleton State University
Stephenville, TX

Texas Teaching Certification (1986)
Secondary Composite Science
Howard Payne University
Brownwood, TX

Master of Science, Biology (1992)
Tarleton State University
Stephenville, TX

Doctor of Philosophy, Agricultural Education (2004)
Texas A&M University
College Station, TX

Experience: Assistant Director, Experiential Education
Texas A&M University Career Center
College Station, TX (January 2004-present)

Program Coordinator
Professional Program in Biotechnology
Texas A&M University
College Station, TX (August 1997-December 2003)

Program Coordinator
Texas Biotechnology Teacher Enhancement Project
Texas A&M University
College Station, TX (June 1994-August 1997)