Report for a Survey on the Sustainability of Nanotechnology Workforce Education Programs in the United States

Prepared by the Subcommittee on Program Sustainability of the
Nanotechnology Applications and Career Knowledge Network

Ray Tsui
Arizona State University

Robert Ehrmann
Pennsylvania State University

Rogerio Furlan
University of Puerto Rico, Humacao

Trevor Thornton
Arizona State University

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NACK NETWORK
Building College-University
Partnerships for Nanotechnology
Workforce Development

Executive Summary

Nanotechnology provides numerous opportunities for advancing the economic value and impact of new U.S. technologies and products in a variety of business sectors. To train students that can enter the nanotechnology workforce as technicians, an increasing number of education programs have been set up in community or technical colleges around the country, in many cases with financial support from federal and state agencies.

Reliance on federal and/or state funding is not a viable long-term approach to sustain nanotechnology workforce education at the undergraduate level. In 2014, the Nanotechnology Applications and Career Knowledge (NACK) Network, a national center for nanotechnology workforce development funded by the Advanced Technological Education (ATE) Program of the National Science Foundation, surveyed the different financial approaches schools are currently using to sustain their education programs. The survey also asked for what approaches are planned for future program sustainability, particularly if any government funding being relied upon were to go away, and what are the specific areas in which schools have or anticipate having challenges.

The survey was sent to 26 schools across the U.S. The 15 schools that responded come from 10 states as well as Puerto Rico, and have programs with ages that cover a 12-year span, with the earliest dating back to 2002. Some of the key survey findings are listed below.

- 7 out of the 15 schools have programs that are currently sustainable financially. However all receive either state or federal funding.
- For the 8 programs yet to achieve sustainability, a lower percentage of them have state or federal funding support. Tuition and lab fees are not sufficient to cover the difference.
- If government funding goes away, half of the responding schools intend to rely on tuition and 20% plan on using some combination of increased tuition and lab fees to make programs sustainable. However, several schools mentioned that enrollment numbers would have to go up for this to work.
- Key challenges include the recruitment of students (including those from under-represented populations), gaining more industry support, and development of institutional partnerships.

This sampling of nanotechnology education programs around the country shows that they are still heavily dependent on government funding to be economically sustainable, even for the well-established ones. And given the regional differences, it is also clear that a multi-prong approach is necessary to achieve full sustainability that is independent of government funding.

Of the key challenges mentioned by over 65% of the schools, student recruitment and industry engagement are actually closely related. A comprehensive marketing effort that targets both students and industry, coordinated between a national ATE center and regional community colleges, can pay great dividends in these two areas. Other findings of this survey, such as the need to further develop distance learning and help in establishing institutional partnerships, also point to areas where additional efforts should be considered.

Such efforts are essential since nanotechnology is a key skill for an advanced workforce in the 21st Century and beyond, and achieving total self-sustainability in education programs to develop technicians for such a workforce will be a key ingredient for long-term economic success.

1. Introduction

Since the turn of the 21st Century, an increasing number of programs aimed at nanotechnology education at the undergraduate level have been set up in the United States. Most of these programs were established with the help of federal and state funding, with a main objective of producing graduates that can enter the nanotechnology workforce as technicians or engineering assistants. Consequently, the educational institutions involved are predominantly community or technical colleges that grant 2-year Associate degrees of Science (AS) or Applied Science (AAS). Some 4-year colleges and research universities are also involved. The 4-year schools often offer Associate degrees as well as Bachelor's degrees in various technical fields with a concentration in nanotechnology. Research universities usually perform the role of a partner in which their extensive equipment and facility capabilities are leveraged for hands-on training.

The reliance on federal and/or state funding is not a long-term approach to achieve a self-sustainable base for nanotechnology workforce education at the undergraduate level. The Nanotechnology Applications and Career Knowledge (NACK) Network, a national center for nanotechnology workforce development funded by the Advanced Technological Education (ATE) Program of the National Science Foundation, has taken on the task to survey the different financial approaches schools are currently using to sustain their education programs. The survey will also ask for what approaches are planned for future program sustainability, particularly if any government funding being relied upon were to go away. The survey developed for this study by the NACK Network is shown in Appendix 1. It also asks for information pertaining to program formats and challenging areas that have or are anticipated to have a bearing on program sustainability. The survey was sent to 26 schools from various regions of the U.S., from which 15 responses were returned. The names of the responding schools are listed in Appendix 2.

2. General Program Information

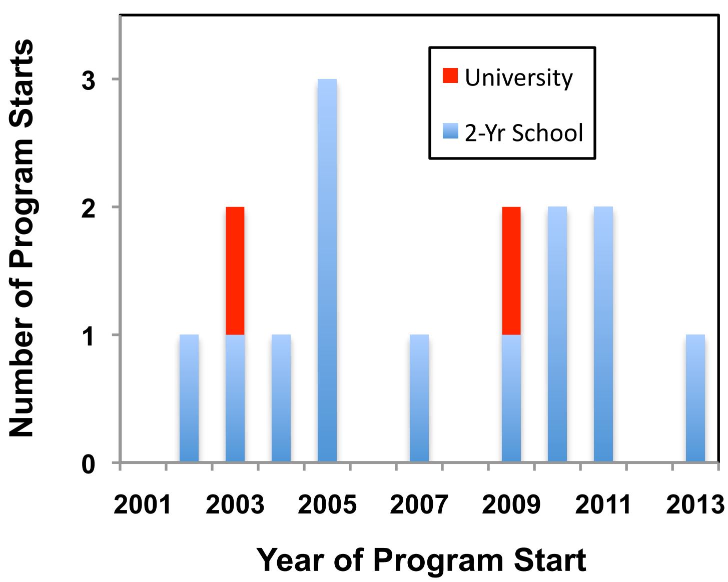

Figure 1. Column chart showing year in which the education program was established at each of the 15 schools that responded to the survey.

The schools that responded have programs with ages that cover a 12-year span, with the earliest dating back to 2002 while the most recent one began in 2013. More details are given in Figure 1, and they show a good distribution of schools with well-established as well as relatively new programs. The schools are also well distributed in location, covering 10 states as well as Puerto Rico (see Appendix 2). 3 out of the 15 schools are located in Pennsylvania (PA). This relatively high proportion is in part because PA has more than 30 schools actively involved in nanotechnology workforce education at the undergraduate level since they can leverage a long-established partnering opportunity with Pennsylvania State University (PSU) partially funded by the state government.

Since the schools surveyed are predominantly 2-year institutions, it is not surprising that 86.7% of the responding schools offer an Associate degree (AS or AAS) for their education programs. And 53.3% of them offer a Certificate upon successful completion of their programs, with 7 of the 15 schools offering both options. Details are shown in Table 1.

Nanotechnology Degree/Certificate/Courses Offered at the 15 Schools Reponding to the Sustainability Survey	Number of schools with this program	Percentage of schools with this program
AAS degree	9	60.0%
AS degree	4	26.7%
Certificate	8	53.3%
Exploratory or introductory course(s)	2	13.3%
Concentration within another technical program	1	6.7%
Course(s) to support another technical program	2	13.3%

Table 1. Summary of the different education programs offered at the 15 schools that responded to the survey. The percentages add up to more than 100% because 8 of the schools offer more 2 or more options.

3. Funding Information

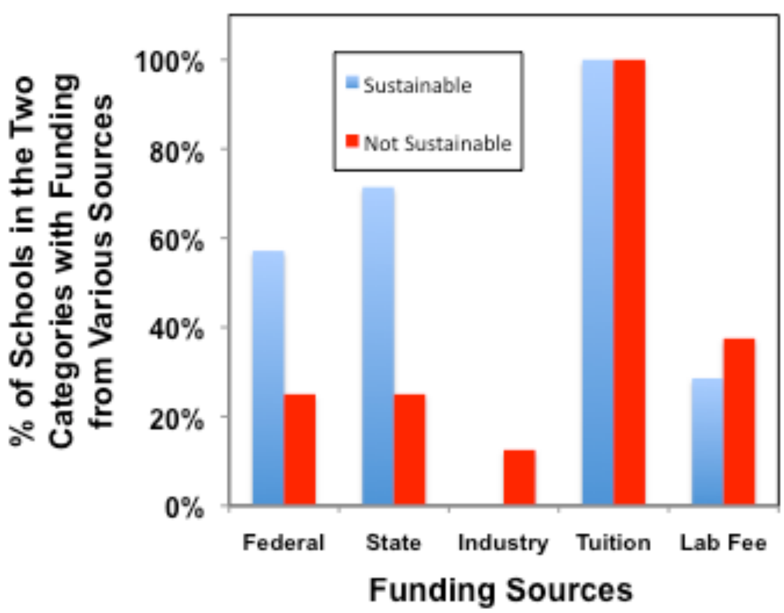

Figure 2. Column chart showing the percentages of schools in each of the 2 categories (with programs that are sustainable and non-sustainable) receiving funding from various sources.

Out of the 15 schools that responded, 7 have programs that are currently sustainable with the support of either state or federal funding (and with both types in 2 cases) to supplement the revenue generated from tuition and fees (see Figure 2). Note that all PA schools are considered to be receiving state funding, even though that may be in an indirect manner. That is because all PA schools send their students to PSU for a Capstone semester of nanotechnology-focused courses, and that cost is partially covered by the state.

In the other 8 schools, program sustainability is not achieved as yet even with support from government funding (see Figure 2). In this latter group of schools, tuition and lab fees are not sufficient to cover the shortfall because enrollment numbers are not high enough to generate sufficient revenue. However, Figure 2 also shows that for schools with non-sustainable programs a smaller percentage of them receive federal and/or state support, and this probably exacerbate the funding problem.

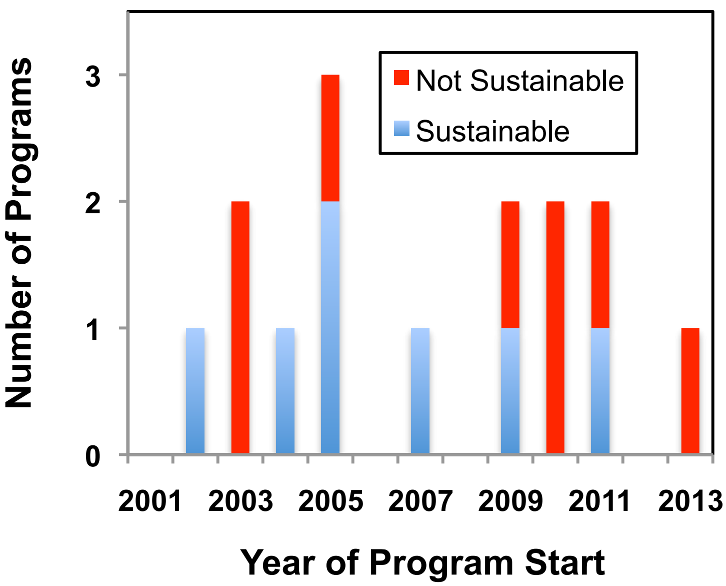

Figure 3. Correlation of the sustainability of a program with its age.

For sustainability with respect to the age of the program, the data shown in Figure 3 may suggest programs that have been in existence for 5 or more years have a higher likelihood to be economically sustainable. For this particular survey, that means education programs started prior to 2009. It seems like a reasonable outcome since such programs have had more time to get established. However, given the size of the current data set and the influence of other factors, the status of additional programs will need to be collected to more accurately conclude whether there is indeed a correlation between the sustainability of a program and its age.

As for the relationship of sustainability with the existence of an Industrial Advisory Board (IAB) for a program, a cursory review of the collected data shows a stronger correlation. Of the 4 programs that have no IAB, none are currently sustainable (i.e., 0%). On the other hand, 7 out of the 11 programs that can be associated with IABs are currently sustainable (63.6%). However, it should be noted that the 3 PA schools (of which 2 have sustainable programs) actually rely on PSU's IAB and other resources to serve that advisory function. If the PA schools are reclassified as having no IABs, the 2 percentages mentioned above change to 28.6% (2 out of 7) and 62.5% (5 out of 8), respectively.

4. Future Plans for Sustainability

One of the key questions asked in the survey is: "If you were to loose your Federal, State, or both sources of funding, how do you envisage sustaining your program?" 46.7% of the responding schools intend to rely on tuition and 20% of them plan on using some combination of increased tuition and lab fees. However, several schools mentioned that enrollment numbers would have to go up for programs to be sustainable. It would seem that will be a common requirement. Since the tuition at community colleges is traditionally low compared to 4-year schools and universities, there is a need for significant student numbers to make up for the loss in external funding. A similar situation probably exists for lab fees. At least one school is fee-free, and others that charge lab fees will have constraints on how high they can be. Note that one school has been successful in boosting enrollment in its nanotechnology courses by having a multi-track program with majors in 3 different engineering technology areas.

There are also additional approaches that some schools are planning to use. These approaches are listed below.

- Rethink and/or reengineer the curriculum.
- Develop community, general or continuous education alternatives.
- Look for federal funding with high school and college partners.
- Secure grants.
- Offer all courses online.
- Increase enrollment by making credits for nanotechnology courses transferable to 4-year schools.
- Establish industry partnerships as well as endowed scholarships and faculty appointments.

It is quite possible that achieving and maintaining program sustainability will require a combination of approaches that vary from school to school. Local conditions will have to be taken into consideration, and programs may have to evolve to adapt accordingly.

5. Challenging Areas

The survey also asked for more information related to specific areas in which schools have or anticipate having challenges. The collected information is summarized in Figure 4 below.

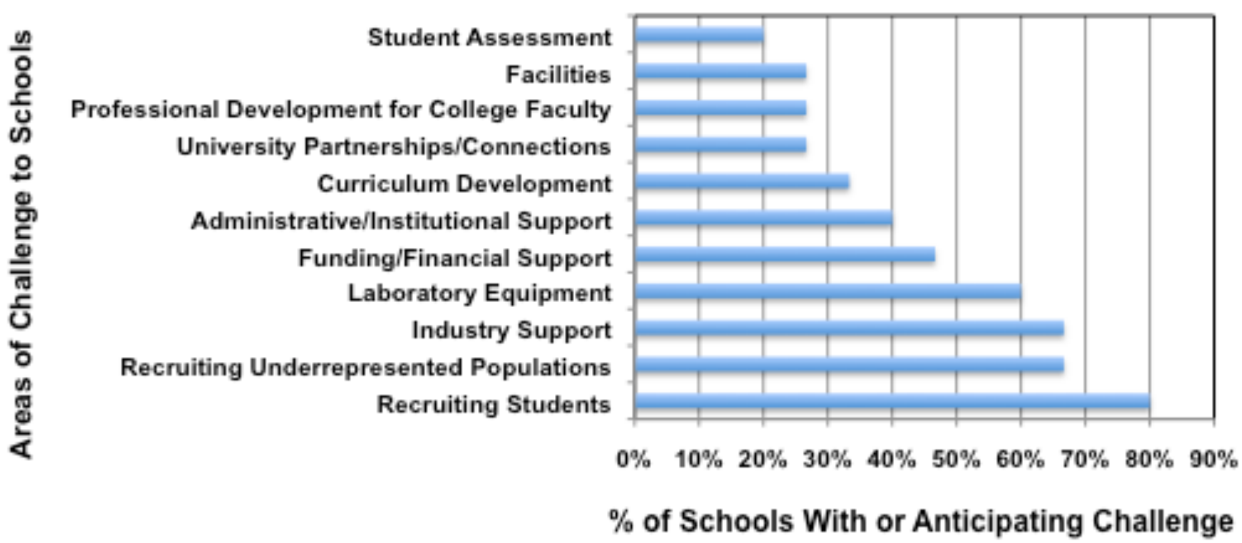

Figure 4. Bar chart showing percentages of schools that find specific areas to be challenging or expect them to be.

It is reasonable to expect some of these challenges are related to program sustainability, particularly those that are identified by a large percentage of the schools. Not surprisingly, student recruitment ranks the highest among the various areas since this topic is intimately connected to the issue of student enrollment number discussed above. Other challenging areas mentioned include the following:

- Generating program interest at a community college.
- Providing professional development for STEM faculty at local high schools and colleges.
- Setting up the entire suite of nanotechnology courses on campus instead of having them taught at a partnering research university.
- Supporting other 2-year schools to regionalize nanotechnology education.
- Expanding the IAB.

6. Services and Resources Desired from the NACK Network

Finally, the survey asked what services and resources would the schools like the NACK Network to provide. The collected information is summarized in Figure 5.

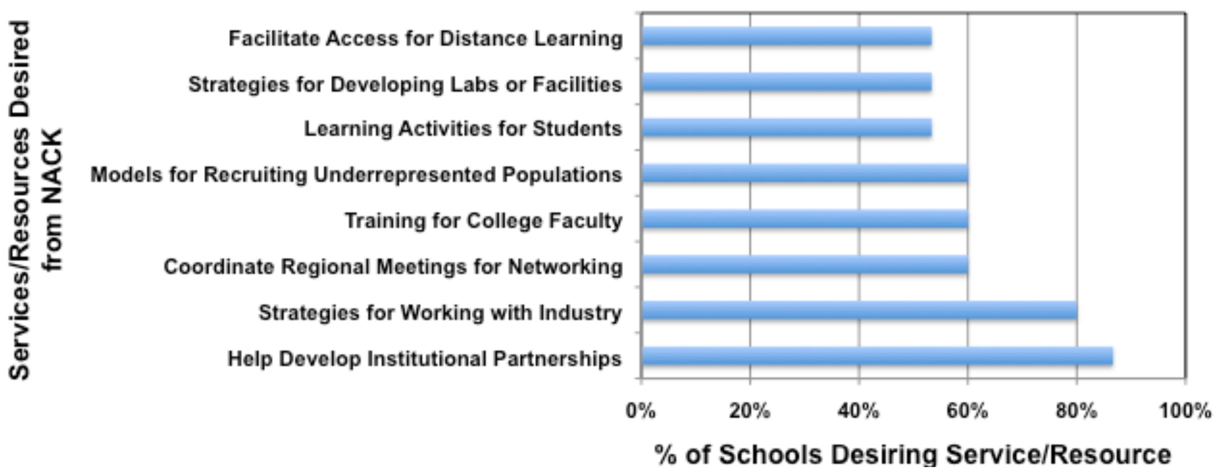

Figure 5. Bar chart showing percentages of schools that would like to have certain services or resources provided by the NACK Network.

As to be expected, some of the most commonly requested services or resources are very well aligned with areas that programs are finding to be a challenge, such as working with industry and recruiting underrepresented populations. Other services or resources requested on an individual basis include the following:

- Assistance in making all courses available online.
- Assistance in creating lecture material to introduce nanotechnology during survey courses (e.g., Introduction to Chemistry, Biological Concepts, etc.) for non-science majors.
- Assistance in setting up meetings with regional community colleges.
- Assistance in leveraging ATE grant to pursue other future funding possibilities.

7. Additional Inputs from Various Programs

Respondents of the survey also made the following comments and suggestions.

- In some areas, it is still hard to convince local businesses and industry of the importance of nanotechnology since they do not see the direct relevance of this field to their profitability margins and bottom line.
- Do a survey on other technical programs at community colleges that are sustainable. For example, the nursing programs at most schools are clearly so. What allows them to operate this way?
- Learn from directors of the ATE program which of their previously funded centers have achieved sustainability and how they did it.

8. Discussions

From this sampling of nanotechnology education programs around the country, it appears that these programs are still heavily dependent on government funding to be economically sustainable, even for the well-established ones. Revenue from tuition and fees are generally insufficient to cover school expenses. This is particularly so when taking into account the costs to purchase and maintain equipment for hands-on training or, in some cases, to utilize such equipment in laboratory facilities at the campuses of research university partners.

This situation raises the question of whether there is a need to re-assess how program sustainability is defined. If there is a research university partner involved, a point worth considering is whether it is realistic to expect the full cost of using its facilities and equipment for hands-on training to be covered. For almost all university laboratories in which nanoscale fabrication and characterization is conducted, the facilities are not in use during a substantial part of a workday but are still incurring operational expenses nonetheless. Making these facilities available for the training or laboratory experience of community college students enrolled in nanotechnology education programs has the potential of generating additional revenue in the form of lab fees. This extra revenue, even though if it does not totally cover the operational costs during the training period, is still helpful in partially defraying the overall costs incurred by the university. Such training can strengthen the local community college system, increase the potential pool of transfer students, and build up the talent at the local high-tech industries (by helping in the education of their employees). If the university can consider all these as benefits, then perhaps the cost calculation can be changed and sustainability can be more readily achieved.

Regardless of whether the research university partners will reconsider the cost calculation as described above, it is also clear there is no single action that can be the solution and a multi-prong approach is needed to address the sustainability challenge. There are regional differences, and steps taken by one education program may not be applicable for another. However, the survey results indicate several items are key, which include increasing student enrollment and obtaining greater industry support.

Student recruitment and industry engagement are actually closely related. Besides getting students interested in nanotechnology during recruitment, it is important for them to know that there are ample employment opportunities upon graduation. Industry can provide internships for on-the-job training as well as full-time jobs, but only if employers are aware of the education programs and believe graduates will have the appropriate skill set that can benefit their businesses. Industry is also a good source for financial support and surplus equipment. It appears that a comprehensive marketing effort that targets both students (including those from underrepresented populations) and industry, coordinated between a national ATE center and regional community colleges, can pay great dividends in these two areas. The further engagement of IABs by the individual programs should also help significantly.

Another potentially useful role that a national ATE center can play is to evaluate how economical sustainability has been achieved in programs for other technological areas funded by the ATE, and see if some of the approaches taken there are applicable to nanotechnology education. Some of the other findings of this survey, such as the need to further develop distance learning and help in establishing institutional partnerships, also point to areas where additional efforts should be considered.

For nanotechnology education, it is clear that important work remains to be done for the nation's education programs to become economical sustainable without relying on long-term government funding. This is essential work since nanotechnology is a key skill for an advanced workforce in the 21^{st} Century and beyond. Hopefully, following through on some of the findings in the present survey will contribute towards the successful accomplishment of this effort.

9. Acknowledgements

The Subcommittee on Program Sustainability of the NACK Network would like to thank the ATE program of the NSF for its support. We also wish to express our appreciation to the representatives of the schools that responded to the survey, as well as to Al Schwabenbauer and Len Sterry (external evaluators for the NACK Network) for their valuable inputs to the survey and its findings.

Appendix 1

Nanotechnology Education Sustainability Survey
Nanotechnology Applications and Career Knowledge Network
December 2013

1. Program Information

Type of institution:
___ Community and/or Technical College
___ University
___ Combination, we do both

1.1 When was your nanotechnology educational program started?

1.2 What Degree/Certificate/Course(s) are offered? (Check all that apply)
___ AAS degree program
___ AS degree program
___ Diploma program
___ Certificate program
___ Concentration, possibly within another technical program
___ Nanotechnology courses to support other technical programs
___ Nanotechnology concepts infused into science and technical courses
___ Exploratory or introductory courses
___ Specialization, concentration, degree, or graduate study at the university level
___ None. We are interested but do not currently offer nanotechnology education

1.3 Does your nanotechnology program recognize advanced placement (AP) and/or dual credit courses from area high schools?
___ Yes, ___ No, ___ Plan to in the future

1.4 Does your nanotechnology program have articulation agreements with other colleges and/or universities?
___ Yes, ___ No, ___ Plan to in the future

1.5 If teamed with a University, please provide names of the institution and collaborator:

1.6 Does your program have an Industry Advisory Board? If yes, please provide details such as meeting schedule, duties of the IAB, and other information you consider relevant:

2. Program Format

2.1 (a) If you partner with a university, how is the part of the curriculum taught at the 2-year school handled:
* Lectures only?

* Lectures plus some labs?

(b) And what is the part of the curriculum taught at the university partner:
* Labs only?

* Labs plus some lectures?

2.2 (a) As you developed and improved your nanotechnology educational program did you use any of the following curriculum resources? (Check all that apply)
___ NACK (http://www.nano4me.org), ___ NACK workshops,
___ Nano-Link (http://www.nano-link.org), ___ Other (please specify) _______________

(b) Did you find these materials to be helpful?
___ Yes, definitely helpful, ___ Somewhat helpful, ___ Not very helpful,
___ Did not know they were available

2.3 Do you utilize remote access to equipment? If yes, please list type and usage frequency:

2.4 What resources, if any, do you provide for K-12 outreach/education as part of your program?

2.5 What resources, if any, do you provide for industry as part of your program?

2.6 If your program uses a different format or have additional features, please list here:

2.7 In the future, does your institution intend to start or add any of the following nanotechnology educational opportunities? (Check all that apply)
___ AAS degree program
___ AS degree program
___ Diploma program
___ Certificate program
___ Concentration, possibly within another technical program
___ Nanotechnology courses to support other technical programs
___ Science and technical courses infused with nanotechnology concepts
___ Exploratory courses to help undeclared and other students on campus to consider nanotechnology as a career option
___ Specialization, concentration, degree, or graduate study at the university level

3. Funding Information (list by % the sources of your program funding):

* Federal _____
* State _____
* Industry _____
* Tuition _____
* Lab fee _____
* Other sources _____
* Is your program currently self-sustainable? ___ Yes, ___ No

4. **If you were to lose your Federal, State, or both sources of funding, how do you envisage sustaining your program?** (Check all that apply and list others not mentioned)
___ Through tuition, ___ Through lab fees,
___ Through some combination of increased tuition and lab fees,
___ Other (please specify) _______________

5. **Additional information regarding your program**

5.1 Identify the following areas in which you have or anticipate having challenges. (Check all that apply and list others not mentioned)
___ Industry support
___ Administrative/institutional support
___ Funding/financial support
___ Laboratory equipment
___ Facilities
___ Recruiting students
___ Recruiting underrepresented populations
___ Nanoscience curriculum development
___ Student assessment
___ University partnerships/connections
___ Professional development for college nanotech faculty
___ Professional development for area secondary and/or college STEM faculty
___ Other, please list ____

5.2 Are there institutions with which your school partners or might partner to offer cost-efficient nanotechnology education?
___ Yes, ___ No

5.3 Would you like the NACK Network to assist with developing institutional partnerships?
___ Yes, ___ No, ___ We are interested in exploring the possibility

5.4 Would you like the NACK Network to provide other services and resources to your institution? (Check all that apply and list others not mentioned)
___ Providing additional nanotechnology learning activities for students
___ Continue offering training for college nanotechnology faculty
___ Provide models for recruiting underrepresented populations
___ Suggest strategies for working with industry in areas of nanotechnology and emerging technologies
___ Suggest strategies for developing nanotechnology lab/facilities
___ Coordinate regional meetings to optimize networking opportunities for nanotechnology faculty
___ Facilitate students access to learning experiences from a distance, e.g., remote access
___ Other, please list _________________

5.5 Please provide any other comments you may have regarding program sustainability:

5.6 Our external National Science Foundation evaluator may like to ask some specific follow-up questions. If you would like to participate, please provide your preferred e-mail contact details: ____________

Thank you very much for your help and participation in this survey.

Please return completed survey to: Ray Tsui, Arizona State University
mailto:Raymond.Tsui@asu.edu

Appendix 2

List of Schools that Responded to the Survey

Foothills College
Los Altos Hills, CA

South Suburban College
South Holland, IL

Ivy Tech Community College
South Bend, IN

Dakota County Technical College
Rosemount, MN

Hudson Valley Community College
Troy, NY

Lock Haven University
Lock Haven, PA

Westmoreland County Community College
Youngblood, PA

Reading Area Community College
Reading, PA

University of Puerto Rico
Humacao, PR

Northwest Vista College
San Antonio, TX

Richland College
Dallas, TX

Northern Virginia Community College
Annandale, VA

North Seattle Community College
Seattle, WA

Chippewa Valley Technical College
Eau Claire, WI

North Central Technical College
Wausau, WI