Project Title: Upgrading Surface Analysis Capabilities for Materials Science Education and Research at WWU

Department/Organization: AMSEC and Chemistry Department

Project Applicant(s):

Principal Contact
Name: Mark Bussell  MS 9150  Email: mark.bussell@wwu.edu
Phone: 3145

Others
Name: David Rider  MS 9150  Email: david.rider@wwu.edu
Phone: 4352

Name: Kyle Mikkelsen  MS 9076  Email: kyle.mikkelsen@wwu.edu
Phone: 4280

Amount Requested for Project

Proposed Budget:
1. Equipment total  $ 39,058
2. Plus site preparation (not STF funded)  +  $ 0
3. Total Project Cost (spreadsheet total from part IV of this form, Total Project Budget)  =  $ 39,058
   4. Less organization’s contribution  −  $ 17,200
   5. Less site preparation  −  $ 0
   6. **STF Grant Request**  =  $ 21,858

**IMPORTANT NOTE**

1. THE STF Committee will accept only **complete** proposals by the announced deadline. Every section (I–IX) and all items of this proposal format must be addressed.

I. Executive Summary (800 words max)

Provide a summary of the project and the benefits to be derived. Explain what the students would gain from the project, and how the acquisition would meet the Student Technology Fee mission.

**STF Mission:**
The Student Technology Fee provides Western students with adequate and innovative technology experiences by:

- Broadening/enhancing the **quality** of the academic experience
- Providing additional student **access** to technology
- Increasing **integration** of technology into the curriculum
Materials science addresses the challenges of creating and using new materials for a wide range of applications from cutting-edge technology to everyday products. These materials include metals and alloys, ceramics, semiconductors, polymers and composites. Materials science is the study of these materials, their properties and uses. At WWU, the focal point for materials science is the Advanced Materials Science and Engineering Center (AMSEC), which brings together faculty and students from Biology, Chemistry, Engineering, Geology, Math and Physics for interdisciplinary education and research on materials. Underpinning the investigation of materials is the use of sophisticated instrumentation that enables detailed characterization of their chemical, physical and engineering properties. This proposal addresses upgrading of instrumentation that probes the topmost surface layers of a wide range materials using a technique called X-ray photoelectron spectroscopy (XPS).

In 2012, WWU had the good fortune of receiving a donation of two XPS instruments from Oklahoma State University upon the retirement of Dr. Peter Sherwood to Bellingham. Dr. Sherwood, an internationally recognized expert in surface analysis, was a Dean at Oklahoma State and he is now actively engaged in research with faculty and students at WWU as an affiliate faculty member in AMSEC. The two instruments, a SAGE 100 XPS system located in the Chemistry Building (CB 420) and a Surface Science Instruments (SSI) XPS system located in the Communications Facility (CF 14) are valued at approximately $250,000 each (with a new replacement value over $1M). Following the cross-country move of the instruments to Bellingham, the Chemistry Department has spent approximately $7,500 on computer and hardware upgrades on the SAGE 100 instrument and it is has been in hands-on use by students for teaching and research for 18 months. As noted below, further upgrades are needed to the SAGE 100 XPS system in order to increase student throughput for teaching and research. AMSEC has spent approximately $6,200 for some necessary repairs on the SSI XPS instrument and we are excited to have this instrument approaching its first measurements at WWU, which we expect to happen in spring or summer 2015.

The SAGE 100 XPS instrument is already in limited use in teaching (Chem 436, 465) and research (Chem 301/401, MSCI 491/492) and we propose increased use if funding is secured for upgrading the SAGE and SSI instruments. The courses, experiment titles and numbers of students that would be affected are listed in Table 1.

### Table 1: X-ray Photoelectron Spectroscopy Instrument Usage in Classes and Research

<table>
<thead>
<tr>
<th>Course</th>
<th>Lab Experiment Title</th>
<th>Number of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCI 410</td>
<td>Preparation and Characterization of Modified Copper and Steel</td>
<td>16</td>
</tr>
<tr>
<td>CHEM 436</td>
<td>Characterization of Metal Alloys by X-Ray Photoelectron Spectroscopy</td>
<td>50</td>
</tr>
<tr>
<td>CHEM 465</td>
<td>Characterization and Identification of a Faujasite-type Zeolite Material</td>
<td>32</td>
</tr>
<tr>
<td>PHYS 391</td>
<td>XPS Investigation of Oxide Layer Growth on Aluminum</td>
<td>10</td>
</tr>
<tr>
<td>Research</td>
<td>Undergraduate and M.S. research in Materials Science</td>
<td>25</td>
</tr>
</tbody>
</table>

In this proposal, funding is requested for a new backing pump, X-ray anode and multiplier for the SAGE 100 instrument and new pumping system, computer and software upgrade for the SSI instrument. The hardware and software targeted for replacement are functioning well past their life expectancy, but now require replacement.
Students in at least three STEM programs (Chemistry, Physics, Materials Science) would be positively affected through funding of this proposal from the STF Program by addressing three program objectives:

- **Enhance the quality of the academic experience**: The requested upgrades will improve instrument performance by increasing XPS signal-to-noise and data analysis capabilities. The two instruments will complement each other, with the SAGE 100 instrument providing high throughput analysis and the SSI instrument featuring a higher-level of performance for more detailed analyses. Following implementation of the upgrades, the students in the courses listed in Table 1 will more actively and successfully participate in the XPS characterization of their synthesized materials and will best experience this powerful technique.

- **Additional student access to technology**: The requested upgrades will result in improved pumping efficiency and XPS signal-to-noise, increasing student throughput for laboratory courses and research activities. Current use of the instruments is hampered by slow pump-down following sample insertion into the instruments, long data acquisition times, and outdated computer hardware and software (on the SSI instrument). Once the upgrades are implemented, the active instrument time per student will increase significantly and, therefore, will result in a richer learning experience for the students who use the XPS instruments in classes and research.

- **Increased integration of technology into the curriculum**: XPS is a cutting-edge technology in materials science education and research and WWU would be the first institution in the Pacific Northwest to integrate its use into its undergraduate and M.S. curricula. Providing hands-on experience with XPS instrumentation will give WWU students a competitive edge when applying to graduate school or to regional employers such as Boeing, Zodiac Aerospace and PACCAR.
II. Relationship to STF Objectives / Impact on Current Academic Programs

The STF Committee will use as its primary assessment criteria the three objectives—quality, access, and integration—defined in the STF mission (above). Given this criteria, describe your proposed project in detail.

1. Tell us—focusing on what the students will gain from the project—how the project would provide positive benefits to specific courses or instructional programs. Specifically, answer at least one of a, b, and c below:

   a. How would this project provide additional student access to technological resources?

   Current use of the SAGE 100 and SSI XPS instruments is hampered by slow pump-down following sample insertion into the instruments, long data acquisition times, and outdated computer hardware and software (on the SSI instrument). Approximately 60 students are using the SAGE 100 XPS spectrometer each academic year in two upper division chemistry laboratory courses (CHEM 436 and 465) as well as in materials science research (MSCI 491/492 and CHEM 301/401). The requested upgrades for the SAGE 100 will result in improved pumping efficiency and XPS signal-to-noise, enabling increased student throughput for laboratory courses and research activities. We estimate that 100 students will use the SAGE 100 instrument following implementation of the upgrades. Importantly, the active instrument time per student will increase significantly as a result of the upgrades and, therefore, will result in a richer learning experience for the students who use the XPS instruments in classes and research.

   The SSI XPS instrument has not yet been used in courses or faculty-student research, but we are excited to have this instrument approaching its first measurements at WWU (expected to happen in either spring or summer 2015). Kyle Mikkelsen (AMSEC technical staff) and Max Knittel (Physics technical staff) are currently working with Dr. Peter Sherwood on repairs to the instrument. The requested upgrades, combined with improvements already under way, will enable students and faculty to begin using the SSI XPS instrument in Fall 2015. Our current estimate is that this instrument will be used in two courses (PHYS 391, MSCI 410 - 26 students total) and in student research projects (10 students total)

   b. How would this project broaden or enhance the quality of the student’s academic experience through the proposed technology?

   The requested upgrades will improve instrument performance by increasing XPS signal-to-noise and data analysis capabilities. The two instruments will complement each other, with the SAGE 100 instrument providing high throughput analysis and the SSI instrument featuring a higher-level of performance for more detailed analyses. While the SAGE 100 instrument is currently in heavy use, the outdated X-ray anode, photoelectron detector and pumping system slow down instrument operation. As a result, students in courses that use the instrument currently carry out fairly modest analyses ("survey" scans) as more detailed, "high resolution" scans require dramatically longer data acquisition times.

   c. How would this project increase integration of technology into coursework?

   X-ray photoelectron spectroscopy is a cutting-edge technology in materials science education and research and WWU would be the first institution in the Pacific Northwest to integrate its use into its undergraduate and M.S. curricula. Providing hands-on experience with XPS instrumentation will give WWU students a competitive
edge when applying to graduate school or to regional employers such as Boeing, Zodiac Aerospace and PACCAR.

2. Would other departments be involved with this project?

   No ☐   Yes ☒ If yes, describe.

   While the primary users will be students and faculty that come from two departments that participate in AMSEC (Chemistry and Physics), students in other AMSEC departments who enroll in the materials science minor (e.g. Engineering & Design - Plastics and Composites Engineering Program) will also utilize the instruments in the required MSCI 410 course.

3. Has any part of this project previously been funded by the Student Technology Fee?

   No ☒   Yes ☐ If yes, describe.

4. Is the proposed project a pilot project?

   No ☐   Yes ☒

III. Utilization

List the anticipated number of times and duration per each use—per quarter or per academic year—that students would use the proposed technology. The committee is looking for total student hours and total number of unique students who would use the technology in that time period. Explain how you arrived at this utilization.

SAGE 100 XPS Instrument Usage (per academic year)

   CHEM 436   50 students   6 hours per student pair   150 hours total (includes pump down)
   CHEM 465   32 students   8 hours per student pair   128 hours total (includes pump down)
   RESEARCH   16 students   100 hours per student    1600 hours total (includes pump down)

SSI XPS Instrument Usage (per academic year)

   MSCI 410   16 students   10 hours per student pair   80 hours total (includes pump down)
   PHYS 391   10 students   12 hours per student pair   60 hours total (includes pump down)
   RESEARCH   8 students    120 hours per student    960 hours total (includes pump down)

The estimated student usage of the SAGE 100 XPS instrument after the requested upgrades is based upon extrapolation from current usage in CHEM 436 and 465, and in student research projects. The estimated student usage of the SSI XPS instrument is more uncertain, but is predicted based on the two experiments that will be done in MSCI 410 and PHYS 391, and in student research projects.

IV. Total Project Budget

This section details the estimated total cost of the project. Include costs that would be covered—by your department or another source—for ongoing costs such as personnel or operating expenses.

1. For assistance in preparing your budget, please consult with relevant campus support departments (ATUS, Purchasing, Space Administration, etc.).
2. For more information about these contacts and helpful tools/links: from the STF website home page (http://www.wwu.edu/stf), choose “STF Tech Initiatives” on sidebar, then section “II. Tech Initiatives Forms and Instructions.”

Attach an Excel spreadsheet if you have additional details.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Item Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSI Instrument - vacuum system upgrades</td>
<td>1</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>SSI Instrument - Computer hardware and software</td>
<td>1</td>
<td>2,000</td>
<td>2,000</td>
</tr>
<tr>
<td>SSI Instrument - Data acquisition computer interface</td>
<td>1</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>SSI Instrument - On-site installation and testing</td>
<td>1</td>
<td>6,000</td>
<td>6,000</td>
</tr>
<tr>
<td>SAGE 100 Instrument - X-ray source anode</td>
<td>1</td>
<td>2,900</td>
<td>2,900</td>
</tr>
<tr>
<td>SAGE 100 Instrument - Photoelectron detector multiplier</td>
<td>1</td>
<td>2,500</td>
<td>2,500</td>
</tr>
<tr>
<td>SAGE 100 Instrument - Oil-free vacuum pump</td>
<td>1</td>
<td>4,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Subtotal</td>
<td></td>
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<tr>
<td>Allowance for price increases (3% of subtotal)</td>
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<tr>
<td>Shipping (taxable)</td>
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<tr>
<td>Tax (8.7%)</td>
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<td></td>
<td>3,126</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>39,058</td>
</tr>
</tbody>
</table>

*This budget total (or your attached spreadsheet total) should match the projected budget figure on page 1 of this proposal. (See box on page 1, line 3.)*

Important Notes from the STF Committee:

- We recognize your proposed budget as an estimate. Final funding for successful projects will be established after thorough technical review; some costs may need adjusting due to price changes.

- We recommend that you include a 3 percent cushion to allow for price increases.

- We may impose special conditions on a proposal before approval. See STF Proposal Guidelines.

- Funding is not provided directly to departments for purchases. All purchasing is done via the Office of the VPIT/CIO and savings are retained in the STF fund.

3. What funding or contributions are available from your department or other sources?

   **Note:** “Contribution” is defined as a monetary contribution. A vendor discount, for example, is not considered a contribution.

   Budget contributions totaling $17,200 have been obtained to support this project: AMSEC - $5,200, Chemistry Department - $5,000, Physics Department - $1,000, College of Science and Engineering - $6,000. Please see the attached spreadsheet for an itemized list of the matching contributions.

4. Could this project be divided into discrete elements that could be funded separately?
Note: A “no” response to this question creates an “all or nothing” proposal. That is, if the STF Committee decides against funding your entire proposal, it will not consider any elements for partial funding. If elements could be funded separately, the applicant is responsible for prioritizing them before submitting the proposal.

No ☐ Yes ☒ If yes, summarize and prioritize project elements with cost estimate for each.

The project elements are prioritized in the attached spreadsheet. The budget items for the two instruments are prioritized separately (1a, 2a, 3a, 4a, 5a and 1b, 2b, 3b), which would allow funding of upgrades on one system, but not the other, or selected items for each instrument. However, the desired outcome is full funding of both XPS instruments, which would take full advantage of the leveraged funds (i.e. matching contributions) from the participating departments and the College of Science and Engineering.

5. Are course or lab fees charged for any of the courses that will use this equipment?

No ☐ Yes ☒ If yes, describe. Please note: The total funding requested from the Student Technology Fee must reflect the amount collected from course fees for equipment replacement and/or equipment acquisition.

Yes, lab fees are collected for four of the courses that will use the two XPS instruments: MSCI 410, CHEM 436, CHEM 465, and PHYS 391. Lab fees for these courses are used to purchase consumables in lab experiments, to pay for instrument repair, and to fund instrument replacement. Many different instruments are used in these lab courses and the lab fees are used to support all of the different instruments. Each participating department (AMSEC, Chemistry, Physics) is committing some lab fee funds as budget contributions to support this proposal.

V. Impact on Existing Resources

Your proposal must address the project’s potential impact on existing resources. Give special attention to the impact on data transmission networks (e.g., sources accessed, networking equipment, etc.), and personnel (e.g., staffing, administrative support, faculty support, etc.).

1. Describe how existing equipment is used. Contrast this to projected use if your project were funded.

The SAGE 100 XPS instrument is heavily used currently, but this use is inefficient because of the slow pump-down following sample insertion and the long data acquisition times. Following the requested upgrades, our expectation is that pump-down times will be cut in half, and data acquisition times would be 2-3 times faster. As a result, we expect to double the amount of student use of the instrument. We do not foresee any negative impact on infrastructure or personnel.

The SSI XPS instrument is currently being worked on by technical staff members Kyle Mikkelsen (AMSEC) and Max Knittel (Physics) along with Dr. Peter Sherwood, but is not yet fully operational. With continued work and the requested upgrades, the instrument will be operational in time for fall quarter 2015. During the 2015-16 academic year, the instrument will be used in two courses (MSCI 410, PHYS 391) and a number of student research projects. We do not foresee any negative impact on infrastructure or personnel.

2. Is similar equipment or technology available elsewhere on campus—such as the Student Technology Center, Classroom Services, Video Services, Western Libraries, a college lab?

No ☒ Yes ☐ If yes, describe why the existing equipment does not meet the needs outlined in this proposal.
3. If this project involves the replacement of equipment, including computers:

   a. Describe the “before and after” configuration changes. (A spreadsheet reflecting these changes may be attached.) Or, write “N/A.”

   The SSI XPS instrument is currently equipped with an out-dated, home-built personal computer running Windows 2000 and ESCA Capture 2000 software (the latter is for instrument control). The requested computer (running Windows 7), instrument control software and data acquisition hardware will provide updated instrument control, data acquisition and network connectivity for data storage and back-up. The vacuum system upgrades will permit the replacement of pump components that are functioning beyond their expected lifetimes and will allow for more rapid cycle time from sample insertion into the instrument to XPS spectral acquisition.

   The SAGE 100 XPS instrument is currently in heavy use by students and faculty, but its operation is hampered by slow pump-down following sample insertion and lengthy data acquisition times. The requested upgrades will address both issues as the replacement pump will enable more rapid pump-down following sample insertion, and the replacement X-ray anode and photoelectron multiplier will allow faster data acquisition.

   b. Describe the costs and benefits of replacing vs. upgrading. Or, write “N/A.”

   The high cost of replacing the two XPS instruments (~$1 million) would be prohibitive, but, fortunately, the relatively low-cost upgrades requested in this proposal will substantially improve instrument performance.

4. Would this equipment be available to students outside of your department?

   No ☐   Yes ☒   If the proposed technology would be used by students outside of your department, describe how they would gain access, how equipment availability would be publicized, the hours/week when equipment would be available, and any costs that would apply.

   Students in any of the departments that participate in AMSEC (Biology, Chemistry, Engineering, Geology, Math, Physics) would be able to the SSI XPS instrument following training by the AMSEC Lab Manager (Kyle Mikkelsen). The hours of instrument availability and on-line scheduling of instrument time are accessed on the AMSEC webpage. There will be no charge for instrument time for student users (with the exception of when large amounts of consummables are needed). The SAGE 100 XPS system will be available to non-chemistry students on a case-by-case basis determined primarily by the availability of instrument time.

5. Does this project involve the check-out of equipment to students?

   No ☐   Yes ☒   If yes, discuss whether or not the Student Technology Center/ATUS Loan Pool could be assigned this task.

6. Does the department have adequate operating funds to provide ongoing maintenance and support?

   No ☐   Yes ☒   If yes, describe.
AMSEC and Chemistry have the necessary operating funds to provide for ongoing maintenance and support of the SSI and SAGE 100 XPS instruments.

7. Does the department have adequate personnel funds to provide ongoing staff support for the project?
   No ☐ Yes ☒ If yes, describe.

AMSEC and Chemistry have adequate technical staff to support the maintenance, operation and training of student and faculty users of the SSI and SAGE 100 XPS instruments.

VI. Space and Site Information

This section addresses any space alteration or site preparation necessary for the proposed project. Site alterations include painting, holes in walls, security systems, carpeting, construction, lighting changes, or conversion of a lab or office.

Special Note: If this project would require any site preparation, or if this project would use any space not currently under your department’s control:

   a. You must submit a draft proposal to Space Administration by March 13, 2015.
   b. Space Administration and Facilities Management will then conduct a site survey and respond to you by March 20, 2015 about project feasibility, cost, and schedule.
   c. You must include the site survey response with your final proposal.

1. Location for installation of equipment or technology:
   SAGE 100 XPS instrument - CB 420; SSI XPS Instrument - CF 14

2. Would site modification be required?
   No ☒ Yes ☐ If yes, describe the modifications (e.g., electrical, air, painting, lighting, security, network access, etc.).

3. Would this project use space not currently assigned to your department or area?
   No ☐ Yes ☒ If yes, describe.

VII. Project Schedule

Describe your overall implementation schedule. (Remember that project awards are announced during spring quarter, and that projects are to be substantially completed by the end of the calendar year.) If any site preparation is involved (see section VI above), align your project schedule with the schedule provided by Space Administration and Facilities Management.

The proposed upgrades of the SAGE 100 XPS instrument are relatively minor and will take place over 2-3 days during summer quarter 2015 or the inter-session in Sept. 2015. The proposed upgrades of the SSI XPS instrument are more substantial and would occur over a 2-3 week time period in summer 2015 or during the inter-session in Sept. 2015.

VIII. Constraints
List or describe any external or internal factors/constraints that could affect your project schedule, project objectives, or the project budget (e.g., if external approval is required for curricular changes, or if funding must be received by a certain date).

The only constraint that we foresee could affect the project timeline is scheduling the on-site installation and testing of the new hardware and software for the SSI XPS instrument by the vendor, Service Physics. Based on our discussions with Service Physics, which is located in Bend, OR, we do not expect any delay if we are able to contact them in mid-to-late May to set an installation date.

IX. Submitting the Proposal

1. Make sure your proposal does not exceed 12 pages (not including Tech Initiatives Summary Sheet).

2. Complete a 2015 Tech Initiatives Summary Sheet for the front of the proposal.

3. Submit the proposal and summary sheet electronically for prioritizing (PDF preferred, or Word document):
   a. Faculty and staff: Submit by internal due date, which must be before proposal due date of April 2.
   b. Students: Submit by March 31 to AS VP for Academic Affairs at ASVPforAcademicAffairs@wwu.edu.

4. Submit prioritized proposals:
   a. Organization reps and AS VP for Academic Affairs: Submit to Student Technology Fee (STF) Committee by 12:00 noon on April 2.
   b. For each proposal, email one electronic version (PDF preferred, or Word document) of both the proposal and the summary sheet to diane.bateman@wwu.edu (the STF Committee secretary).

Note: Paper copies of proposals are no longer required; please do not send.
<table>
<thead>
<tr>
<th>Priority</th>
<th>Item</th>
<th>Cost</th>
<th>AMSEC</th>
<th>CHEM</th>
<th>PHYS</th>
<th>CSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Vacuum system upgrades</td>
<td>$12,000</td>
<td>$2,000</td>
<td>$1,000</td>
<td>$3,000</td>
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</tr>
<tr>
<td>2a</td>
<td>On-site installation and testing</td>
<td>$6,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>XPS software upgrade (to Windows 7)</td>
<td>$500</td>
<td>$250</td>
<td></td>
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<tr>
<td>4a</td>
<td>Data acquisition computer interface</td>
<td>$5,000</td>
<td>$1,500</td>
<td>$1,000</td>
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<tr>
<td>5a</td>
<td>Desktop computer workstation</td>
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<table>
<thead>
<tr>
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<th>Item</th>
<th>Cost</th>
<th>AMSEC</th>
<th>CHEM</th>
<th>PHYS</th>
<th>CSE</th>
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</thead>
<tbody>
<tr>
<td>1b</td>
<td>X-ray source - replacement anode</td>
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<tr>
<td>2b</td>
<td>Photoelectron detector - replacement multiplier</td>
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<tr>
<td>3b</td>
<td>Oil-free vacuum pump</td>
<td>$4,000</td>
<td>$700</td>
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</tr>
</tbody>
</table>

**Subtotal:** $34,400

Allowance for price increases (3%): $1,032

Shipping: $500

Sales tax (8.7%): $3,126

**Total cost:** $39,058

**Total match:** $17,200

**Student Technology Fee request:** $21,858