



Inter-institutional Resource Sharing in Undergraduate HPC Education : Interviews with University Administrators

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ABSTRACT

High performance computing (HPC), typically used only in research until recently, is being integrated more into undergraduate curricula across disciplines. HPC resources are expensive but lend themselves easily to sharing among institutions. However, in the context of undergraduate education, inter-institutional sharing of such resources is still relatively rare. The authors hold the belief that generating administrator support early in system-wide initiatives for sharing resources is crucial for long term success.

Taking the case of a specific HPC cluster at the University of Wisconsin-Eau Claire, part of the University of Wisconsin System (UW-System) of higher educational institutions, the authors asked 15 administrators from the system about the barriers as well as the path forward for better cluster sharing in undergraduate education. The responses to the interview questions were analyzed qualitatively for themes and sentiments.

Five themes arose from this analysis, related to awareness of and access to HPC, cost-sharing structures, industry needs, institutional factors, and variations in benefits depending on the field. The sentiments were overwhelmingly positive, but with variations depending on the questions asked and approaches taken by the interviewees.

Overall, the responses indicated a positive attitude and willingness to incorporate HPC in undergraduate education as well as the importance of awareness of such resources. They also indicate that cost-sharing structures and institutional factors are both the

biggest barriers and the keys to better sharing practices and industry partnerships. At the end, the authors make recommendations for anyone looking to establish a framework to share HPC resources across institutions.

CCS CONCEPTS

• **Social and professional topics** → **Computing / technology policy; Computing education.**

KEYWORDS

high performance computing, HPC education, HPC cluster sharing, resource sharing, computing policy

ACM Reference Format:

Abhimanyu Ghosh, William Kunkel, Anthony Varghese, Ying Ma, Rahul Gomes, Sudeep Bhattacharyya, Molly Mohr, Isabella Doss, and Jordan Hebert. 2023. Inter-institutional Resource Sharing in Undergraduate HPC Education : Interviews with University Administrators. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE 2023)*, March 15–18, 2023, Toronto, ON, Canada. ACM, New York, NY, USA, 6 pages. <https://doi.org/10.1145/3545945.3569784>

1 INTRODUCTION

Over the years, computation, as a tool for discovery, has expanded into all undergraduate curricula, including physics [4], chemistry [11], engineering [17], business [14], and social sciences [8]. High performance computing (HPC) is a general term that refers to a host of hardware and software technologies, usually working together in a “cluster” of compute nodes, that solve complex problems requiring massive processing power. HPC has been used in scientific research for decades now but in recent years, its application has become more prevalent in industry, especially emerging fields. Along with the expansion of computing in different fields of higher education, this makes it an apt time to introduce more undergraduate students to HPC.

There have been many recent attempts to integrate HPC education in undergraduate programs. Banchelli and Mantovani [1] discuss the lessons learned from a student cluster competition, in

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SIGCSE '23, March 15–18, 2023, Toronto, ON, Canada.

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ACM ISBN 978-1-4503-9431-4/23/03...\$15.00

<https://doi.org/10.1145/3545945.3569784>

terms of industry readiness of computer science undergraduates. Chen et al.[6] present the effects of immersing computing and engineering undergraduates in HPC curricula. Fernandez et al.[19] studied existing literature on supercomputing/HPC education and proposed three major outcomes, focusing specifically on biotechnology education.

While HPC resources are expensive to start up and maintain, they are conducive to sharing among institutions since they do not need physical presence of the end user. Shared HPC resources can be utilized by multiple universities, especially those that are part of a single system, which can help integrate more HPC in undergraduate curricula.

2 RESEARCH QUESTIONS

Why then, are HPC resources still underutilized and not widely shared among institutions in the context of undergraduate education? What are the barriers, and possible solutions to mitigate those barriers, to allow for sharing of HPC resources among institutions that are otherwise closely aligned, like those within a single system?

We took the specific case of the Blugold HPC cluster at the University of Wisconsin-Eau Claire (UW-EC), part of the UW-System, and asked administrators in various parts of the UW-System about the barriers as well as the path forward for better cluster sharing in undergraduate education. This project is part of a larger study utilizing various other tools but, in this paper, we only present the findings from interviews with administrators (or their representatives) from various campuses and offices in this specific system of universities. Thematic and sentiment analysis of their responses are utilized to answer two key research questions:

- 1 What are some common themes arising out of responses from university administrators in the UW-System, regarding HPC use in undergraduate education?
- 2 What can other systems and groups of universities learn from the administrators' responses, to enhance sharing of HPC resources?

3 METHODS

University administrators were asked six questions designed to provide answers to our research questions. Interview question 1 sought to identify their perceptions of the importance of HPC in undergraduate education and question 2 helped establish their awareness of their institutions' current status with respect to HPC-related needs. Questions 3 and 4 dealt with the barriers and best practices to overcome those barriers, respectively. Question 5 asked about the role of industry in popularizing the use of HPC in undergraduate education. Question 6 was a courtesy allowing the interviewees to ask any questions they may have had about the project.

Contact information (email addresses) for administrators was gathered by searching their respective institutions' public websites. Potential interviewees were sent emails containing a brief introduction to the project, a list of the questions that would be asked, and an informed consent form. If an interviewee responded to the e-mail, giving consent to be interviewed, a virtual meeting through Microsoft Teams™ was set up.

Questions 1 through 5, used in the current analysis, are shown in Table 1. All interviewees were asked the same set of questions, one at a time and allowed to respond freely, without interruption. During the interviewee's response, researchers took notes on what was said and compiled all notes after each interview.

3.1 Thematic Analysis

Qualitative analysis of semi-structured interviews is a prevalent and widely accepted research tool in the social sciences [9]. More generally, qualitative methods are commonly used in pedagogical research [13], with thematic analysis being a prominent one. Thematic analysis in this work was largely informed by the publications of Braun and Clarke in 2006[2] and again, in 2012[3].

In the first step, interviews were conducted and all researchers participating in the interview took notes on the responses. Then, in the second step, all responses were compiled, organized by question and individual interviewee, simultaneously helping the authors become familiar with the data. Next, in the third step, the authors worked together to manually code the interview responses, each response being considered a data extract. The importance of group coding is described by Weston [18] and is done to engender rigor throughout the coding process.

This process was done by a sub-group of the authors jointly, meeting together, and an expansive approach was adopted. When they came up with different codes and could not agree on dropping one, both codes were assigned to the comment. This biases the overall data set toward a higher count for every theme. However, with both authors assigning codes jointly, there was less chance of personal prejudice creeping into the assignment of codes.

The fourth step involved a frequency analysis on the initial codes to inform the fifth step i.e. the emergence of 11 sub themes from the data. The sixth and final step consisted of reviewing and combining the sub themes generated in step five to finally get the five themes, listed in Table 2. Javadi Zarea [12] provides a detailed account on how theme combinations can be made in a meaningful way.

3.2 Sentiment Analysis

Sentiment analysis utilized the auto code feature in NVivo 12 as described by Gupta [10], Pudaruth[16], and Chivers[7]. Data extracts (individual responses to a question) were imported into NVivo software and analyzed. NVivo assigned sentiments of very positive, moderately positive, undetermined sentiment, moderately negative, and very negative to each extract. Once the sentiment of each data extract was determined, all initial codes derived from that data extract were assigned the same sentiment, much like the methods described by Celepkolu et al.[5] and Olangoju[15].

All codes were then processed first by theme and then, question, to derive a numerical sentiment score. A sentiment value was first applied to each code, depending on the sentiment of the data extract which the code came from. The value system used +2(very positive), +1 (moderately positive), 0 (undetermined), -1 (moderately negative), and -2 (very negative) for the various sentiments. Then, all values within each question/theme were summed up and reported as sentiment scores in figures 2 and 3, respectively.

E.g. if a theme contained 13 initial codes, each code had a specific value (-2 to 2) depending on the data extract that they came from.

Table 1: List of questions asked in the interviews

Question Number	Interview Question
1	High-performance computing (HPC) has become increasingly important in virtually all branches of science. What is your view on the importance of HPC in undergraduate education?
2	What is the current status of HPC education and research at your institution?
3	Maintaining HPC resources requires substantial expertise and resources, and not every higher education institution in Wisconsin has access to HPC resources. We are hoping to develop a model to share existing HPC resources among public institutions within your system. In your view, what are the difficulties to share existing HPC resources among, for example, campuses within your system?
4	A follow up of the above question, what are the best practices to overcome the difficulties and promote sharing of resources?
5	HPC also plays an important role in driving innovation in industry. What is your view on a public-private partnership involving higher education and local industries in the state that could benefit the economic growth of the state?

Table 2: List of themes arising out of interview responses

Theme number	Theme
1	Awareness and access to HPC resources
2	Cost sharing models and structures
3	Industry needs
4	Institutional and management factors
5	Variations in benefits depending on field and users

All values were summed up to get the overall sentiment score for this theme. This process was repeated for every theme, and then, for every question.

4 RESULTS

Five themes emerged from the thematic analysis, as listed in Table 2. Figure 1 shows the frequency of responses by question, contained in each theme. Theme 1 comes up most frequently in responses to questions 2 and 3, dealing with the status of HPC at their institutions and the difficulties of sharing resources. Themes 2 and 4 appear most often with responses to questions 3, 4, and 5, asking about difficulties and best practices for better sharing of HPC resources and the role of industry-academia partnerships. Theme 3 is most prevalent in responses to question 5, as can be expected, but is also present often in responses to questions 1 and 2. Theme 5, identifying how benefits vary between different groups of users, is most commonly present in responses to question 1.

As a whole, the sentiment analysis of all responses to a given question shows that interviewees had a net positive sentiment when responding to every one of them. This can be seen in figures 2 and 3, with sentiments grouped by interview questions and themes, respectively. Questions 1 and 5 showed the strongest positive sentiment, while questions 2, 3, and 4 show a weakly-positive score, almost neutral.

The sentiment of the question is also strongly reflected in the sentiment of a given theme. Certain questions and themes were supposed to evoke more positive or more negative responses. However,

the format of a semi-structured interview allows the interviewee to control their perspective when responding to questions. Some interviewees took a possibilities approach, leading to more positive responses, whereas others took on a problem identification approach, leading to more negative responses. Examples of these two approaches separated by question are given below.

4.1 Response Excerpts

In question 1, a positive response fitting into theme 5, focused on opportunities for students, would be:

“Want our students to have applied learning experiences. Important that they have access to opportunities to really learn about high performance computing.”

On the other hand, an example of a negative response to question 1, coded in theme 3 and identifying the issue of required skill level, would be:

“Most new tech is good, and exposure is good, big issue is understand the barrier to entry. Students would also need employable level skills”

In question 2, an example of a positive possibilities-oriented response, coded into theme 4, is

“Utilizing in classes, working on doing more, lots of opportunity to use it more, other campus is getting on board, continuing to build momentum. Big part is marketing, how can we advertise the use, how can we get undergrad interested”.

To contrast,

“Many staff here have no experience with HPC Until faculty experience and understands how to use it in their research and teaching, it will be difficult to fuse it in undergraduate research.”

is an example of a problem-identification response, that represents theme 1. Even though the interviewee appears to be in favor of incorporating HPC into undergraduate education this response was determined to have negative sentiment, as the issue of limited faculty experience was identified.

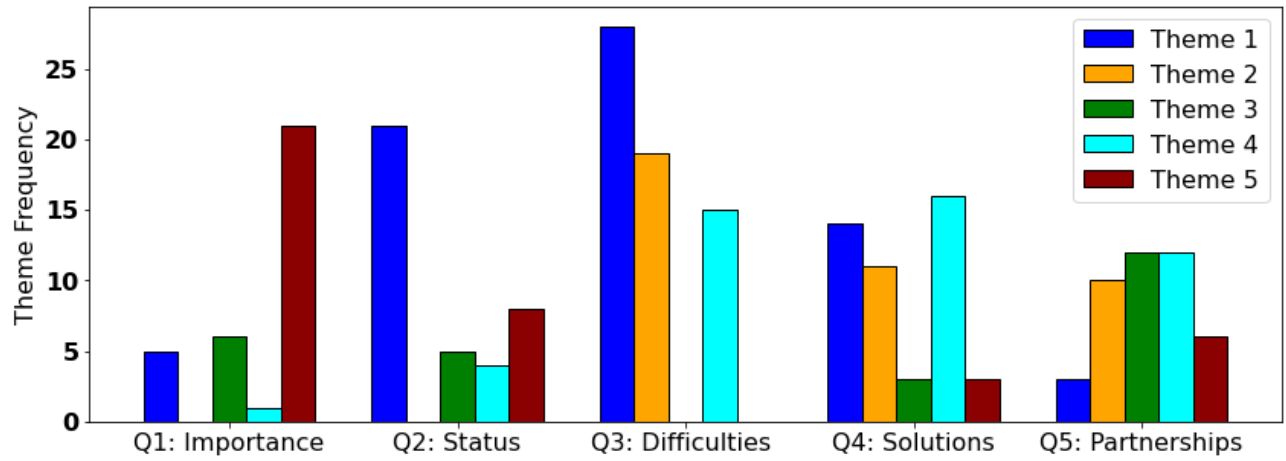


Figure 1: Frequency of emergence of each theme in every question

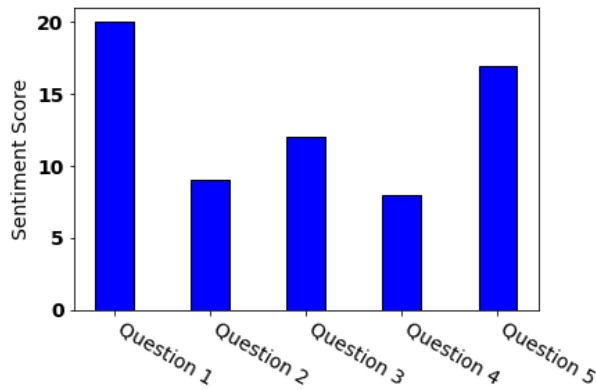


Figure 2: Sentiment scores by question. To give context, questions 1 through 5 had 33, 31, 53, 43, 36 initial codes derived from them, respectively. Thus, for example, a score of 20 in question 1 out of 33 codes demonstrates that the sentiments overwhelmingly inclined positive while a score of 12 in question 3 out of 53 codes demonstrates a smaller positive tilt.

Consider question 3 in which, even when discussing barriers, some participants took a possibilities-oriented approach, coded into theme 4:

“Should be no barriers, every school has a specialty and they can help others, free or low cost ... Every campus has some expertise, and they share it with other campuses. Even without system involvement, multiple campuses have agreements amongst themselves”

In contrast, many interviewees took a problem-identification approach when responding to question 3, such as below (theme 1):

“Cost can be an issue; resources need to generate revenue to maintain them however other universities should not try to “get rich” by sharing resources, so maybe make them available at cost...”

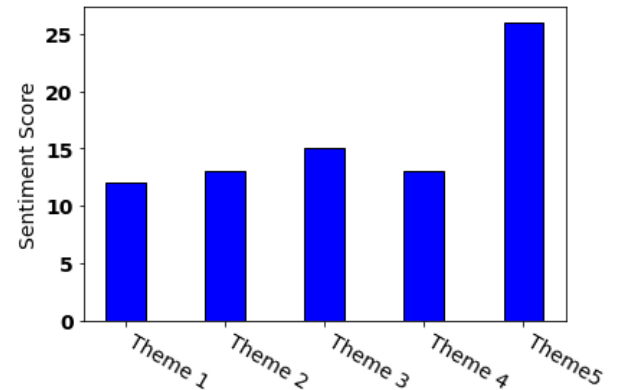


Figure 3: Sentiment scores by theme. To give context, themes 1 through 5 had 71, 40, 27, 48, 38 initial codes derived from them, respectively. Note that the number of codes in figure 3 is often higher than in figure 2, as some codes were placed in multiple themes.

A positive response coded in theme 4, in question 4, is

“Generating funding from industry partnerships. Leadership from the university system to say that sharing of resources is a priority within the system. Need a widely known resource inventory list for systems campus to help with awareness of available resources. Research administrators are good contact people for sharing of resources and funding acquisition.”

Alternatively, a negative response that was coded into theme 2 is,

“First: Overcome personal resistance. Second: Do nominal exchanges of funds among comprehensive schools. It is difficult to come up with a way to charge others for use of an HPC.”

Consider a response to question 5:

“We are always trying to find ways to bring business into ways of thinking how to be innovative... apprenticeships or internships are an option...students can promote HPC and be a liaison between universities and industry...”

This represents a positive, possibilities-oriented response, which was coded into theme 3. An example of a negative, problem-identification response, coded into theme 2, is:

“Companies are money strapped...will shy away from a tech because the risk is too great...”

As demonstrated in this section, the sentiment behind a response may be positive or negative, regardless of the question asked, due to the different approaches taken by interviewees. The excerpts include the theme into which each of the displayed responses was coded, to provide some qualitative background on how the process of thematic analysis worked.

5 DISCUSSION AND RECOMMENDATIONS

Two major findings emerged from the analysis presented. Questions 1 and 5 show the strongest sentiment, as can be seen in figure 2. This indicates a positive attitude and willingness to incorporate HPC in undergraduate education, through best practices and industry-academia partnerships.

Themes 1, 3, and 4 show up frequently in response to questions 3, 4, and 5, as shown in figure 1. This indicates that cost-sharing structures and institutional factors are not only the biggest difficulties for resource-sharing, but they also seem to hold the keys to better sharing practices and partnerships with industry, according to the administrators.

The authors take the position that system-wide initiatives to share resources take both time and money to be successful, as every organization is unique and needs to tailor their policies to fit their needs. For this reason, generating administrator support early in the project is crucial for long term success. Initial support from administrators can also help prevent opposition to new initiatives.

Based on the interviews, we recommend everyone looking to establish a framework to share resources, especially computing resources, to consider the following:

- 1 Identify the financial capabilities of anticipated users so equitable cost sharing models can be implemented
- 2 Create policies and procedures focused on generating awareness of available resources and easing access to them
- 3 Incentivize overcoming institutional barriers related to industry-academia or inter campus partnerships

ACKNOWLEDGMENTS

This work was made possible through a faculty research grant from the Tommy G. Thompson Center on Public Leadership, as part of a larger project to understand barriers and generate policy recommendations for better sharing of HPC resources in undergraduate education among universities in the UW-System, as part of a push to make higher education more resilient in the face of disruptions such as the Covid-19 pandemic.

In addition, the authors would like to thank the people at the research and finance offices of their respective universities, who helped immensely with managing the budget. The authors would also like to thank the Institutional Review Boards at each university for their speedy review and thorough supervision of the project.

REFERENCES

- [1] Fabio Banchelli and Filippo Mantovani. 2019. Filling the gap between education and industry: Evidence-based methods for introducing undergraduate students to HPC. *Proceedings of EduHPC 2018: Workshop on Education for High-Performance Computing, Held in conjunction with SC 2018: The International Conference for High Performance Computing, Networking, Storage and Analysis*, 41–50. <https://doi.org/10.1109/EduHPC.2018.00008>
- [2] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology* 3 (2006), 77–101. Issue 2. <https://doi.org/10.1191/1478088706qp0630a>
- [3] Virginia Braun and Victoria Clarke. 2012. Thematic analysis. , 57–71 pages. <https://doi.org/10.1037/13620-004>
- [4] Marcos D. Caballero, Norman Chonacky, Larry Engelhardt, Robert C. Hilborn, Marie Lopez del Puerto, and Kelly R. Roos. 2019. PICUP: A Community of Teachers Integrating Computation into Undergraduate Physics Courses. *The Physics Teacher* 57 (9 2019), 397–399. Issue 6. <https://doi.org/10.1119/1.5124281>
- [5] Mehmet Celepkolu and Kristy Elizabeth Boyer. 2018. Thematic analysis of students' reflections on pair programming in CS1. *SIGCSE 2018 - Proceedings of the 49th ACM Technical Symposium on Computer Science Education* 2018-January, 771–776. <https://doi.org/10.1145/3159450.3159516>
- [6] Juan Chen, John Impagliazzo, and Li Shen. 2020. High-Performance Computing and Engineering Educational Development and Practice. *Proceedings - Frontiers in Education Conference, FIE 2020-October*. <https://doi.org/10.1109/FIE44824.2020.9274100>
- [7] Bonnie R. Chivers, Rhonda M. Garad, Jacqueline A. Boyle, Helen Skouteris, Helena J. Teede, and Cheryce L. Harrison. 2020. Perinatal distress during COVID-19: Thematic analysis of an online parenting forum. *Journal of Medical Internet Research* 22 (9 2020), Issue 9. <https://doi.org/10.2196/22002>
- [8] Brian A. Eiler, Patrick C. Doyle, Rosemary L. Al-Kire, and Heidi A. Wayment. 2020. Teaching Computational Social Science Skills to Psychology Students: An Undergraduate Research Lab Case Study. *Scholarship and Practice of Undergraduate Research* 4 (11 2020), 5–14. Issue 1. <https://doi.org/10.18833/spur/4/1/5>
- [9] Ceryn Evans and Jamie Lewis. 2017. *Analysing Semi-Structured Interviews Using Thematic Analysis: Exploring Voluntary Civic Participation Among Adults*. SAGE Publications, Ltd. <https://doi.org/10.4135/9781526439284>
- [10] Sahil Gupta, Jyotsna Sharma, Muhammad Najm, and Siddharth Sharma. 2020. MEDIA EXAGGERATION AND INFORMATION CREDIBILITY: QUALITATIVE ANALYSIS OF FEAR GENERATION FOR COVID- 19 USING NVIVO. *Journal of Content, Community and Communication* 12 (12 2020), 14–20. <https://doi.org/10.31620/JCCC.12.20/03>
- [11] Sanchita Hati and Sudeep Bhattacharyya. 2016. Incorporating modeling and simulations in undergraduate biophysical chemistry course to promote understanding of structure-dynamics-function relationships in proteins. *Biochemistry and Molecular Biology Education* 44 (3 2016), 140–159. Issue 2. <https://doi.org/10.1002/bmb.20942>
- [12] M. Javadi and K. Zarea. 2016. Understanding Thematic Analysis and its Pitfall. *Journal of Client Care* 1 (2016). Issue 1. <https://doi.org/10.15412/j.jcc.02010107>
- [13] Moira Maguire and Brid Delahunt. 2017. Doing a Thematic Analysis: A Practical, Step-by-Step Guide for Learning and Teaching Scholars. *, 3351 pages. Issue 3. <http://ojs.aishe.org/index.php/aishe-j/article/view/335>
- [14] W. Brett McKenzie. 2013. Pragmatism and production: Introductory computing in an undergraduate business curriculum. *ACM International Conference Proceeding Series*. <https://doi.org/10.1145/2532333.2532336>
- [15] Tolulope Olagunju, Oladapo Oyeboode, and Rita Orji. 2020. Exploring Key Issues Affecting African Mobile eCommerce Applications Using Sentiment and Thematic Analysis. *IEEE Access* 8 (2020), 114475–114486. <https://doi.org/10.1109/ACCESS.2020.3000093>
- [16] Sameerchand Pudaruth, Sharmila Moheeputh, Narmeen Permessur, and Adeelah Chamroo. 2018. Sentiment Analysis from Facebook Comments using Automatic Coding in NVivo 11. *ADCAIJ: Advances in Distributed Computing and Artificial Intelligence Journal* 7 (2 2018), 41–48. Issue 1. <https://doi.org/10.14201/adcaij2018714148>
- [17] Claudia E. Vergara, Daina Briedis, Neeraj Buch, Abdol Hossein Esfahanian, Jon Sticklen, Mark Urban-Lurain, Louise Paquette, Cindee Dresen, and Kysha Frazier. 2012. Work in progress: Integrating computation across engineering curricula: Preliminary impact on students. *Proceedings - Frontiers in Education Conference, FIE*. <https://doi.org/10.1109/FIE.2012.6462286>
- [18] Cynthia Weston, Terry Gandell, Jacinthe Beauchamp, Lynn Mcalpine, Carol Wiseman, and Cathy Beauchamp. 2001. Analyzing Interview Data: The Development and Evolution of a Coding System. Issue 3.
- [19] Álvaro Fernández, Camino Fernández, José Ángel Miguel-Dávila, and Miguel Conde. 2021. Integrating supercomputing clusters into education: a case study in biotechnology. *Journal of Supercomputing* 77 (3 2021), 2302–2325. Issue 3. <https://doi.org/10.1007/s11227-020-03360-5>