iPDC: Integrating Parallel and Distributed Computing in Introductory Programming

Workshop Report
A National Science Foundation Supported Workshop
Held June 20-21, 2016 in Cookeville Tennessee

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Preface

This report summarizes the organization and executions, as well as the observations made during those executions, of the National Science Foundation (NSF) sponsored workshop, “Integrating Parallel and Distributed Computing in Introductory Programming Courses” (iPDC).

The workshop was held June 20-21, 2016 at Tennessee Tech University (TTU) in Cookeville, TN. It was attended by 15 participants, from 2 and 4-year colleges and universities, as well as a total of five organizing committee members from Tennessee Tech University, Calvin College, and DePauw University. The workshop consisted of presentations, tutorials, breakout sessions, and an open discussion session focused on integrating parallel and distributed computing topics into introductory Computer Science courses.

The goal of the workshop was to inform and train the participants with teaching techniques, provide teaching materials to aid the participants when integrating PDC topics in their courses, to share ideas on challenges and solutions to introducing PDC topics into those courses, and to build collaboration among the participants so that the participants would share techniques, materials, and experiences to enrich the PDC teaching community.

Workshop Organizing Committee

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SECTION 1 Executive Summary

The widespread deployments of multicore and GPU based systems in recent years have changed the computing landscape. However, most undergraduate computer science (CS) programs exclusively train CS undergraduates to think and program sequentially, and do not teach parallel computing concepts. The gap is widening rapidly between the emerging highly parallel computer architectures and the sequential programming approach taught in traditional CS undergraduate curriculums. Undergraduate programs should train the CS students to think parallel and code parallel from the beginning. The curriculum should enable students to design and develop applications that can take advantage of the emerging multicore and GPU based parallel computers and to meet the current and future PDC challenges. A few CS programs offer a parallel computing class as an upper division elective, but hardly any CS programs introduce Parallel and Distributed Computing (PDC) in the introductory programming courses (CS1 and CS2). Unfortunately, the challenges of teaching PDC topics in introductory courses are significant. CS1 and CS2 instructors are typically not trained in PDC, the instructors lack teaching resources, and CS classes are over-loaded with course material.

The overall goal of this project is to prepare CS under-graduate students for their future careers in light of the technological shifts towards parallelism through parallel hardware architectures and the corresponding software environments by incorporating PDC topics of the TCPP curriculum in CS1 and CS2 courses. Specifically, this project conducted a hands-on workshop on PDC concepts and programming tools to train CS1 and CS2 instructors from two and four year colleges and provided them PDC modules that can be easily integrated into CS1 and CS2 courses.

The strategic objectives of the workshop were to create a friendly environment where educators could meet and share ideas about how to integrated PDC topics and discuss impediments to integrating PDC as well as the solutions, provide easy to integrate materials for existing courses so that the educators' teaching workflow was interrupt as little as possible, and educate the educators with basic knowledge of PDC so that they are prepared to instruct their students.

Our strategy for meeting our objectives consisted of hosting a hands-on training workshop for undergraduate CS instructors with the following salient features:

- An introduction to parallel and distributed computing topics appropriate for introductory programming classes.
- An introduction to parallel programming tools and libraries. The tools and libraries were OpenMP, Java threads, and Python's multiprocessing library. We choses these tools and libraries because they are easy to use and are components of commonly used programming languages in CS1 and CS2.
- Hands-on exercises on parallel programming using OpenMP in C/C++, Java Threads, and Python multiprocessing.
- An introduction to readily usable PDC modules for introductory programming classes.
- Hand on exercises with the CS1 and CS2 PDC modules.
- A panel session with open discussion of impediments to introducing PDC topics in introductory CS courses and the solutions to those impediments.

The 2016 iPDC workshop was held June 20-21, 2016 at Tennessee Tech University (TTU) in Cookeville, TN. It was attended by a diverse group of 13 participants from 2 and 4-year colleges and universities. Post workshop survey data is encouraging in that it indicates that the workshop objectives were met.

SECTION 2 Workshop Organization and Execution

The workshop organizing committee held its meetings and planning sessions via Skype conference calls, e-mails, and face-to-face gatherings. Given that the organizing committee was spread over three different universities, initial meetings occurred via email and Skype. The first face-to-face meeting of the committee occurred in Memphis, TN during SIGCSE as all committee member attended that conference. Subsequent meetings via email and Skype continued until the workshop date.

The agenda was reviewed, modified, and ratified by committee members via email, and it was then posted on the web site. The organizing committee discussed and then ratified the topics of the keynote, presentations, tutorials, and breakout sessions, as well as the discussion panel. The organizing committee also assigned presenters for the tutorials, breakout session leaders, and the members of the discussion panel.

The organizing committee invited the Dean of the College of Engineering at TTU and the Chair of the Computer Science department at TTU to give welcome speeches, and Sushil Prasad from NSF agreed to give the keynote. Joel Adams of Calvin College conducted the introductory session on parallel and distributed computing concepts and terminology.

SECTION 2.1 Rational for Forming the organizing committee

The organizing committee consisted of individuals that had experience teaching undergraduate courses, classroom experience in integrating PDC topics in undergraduate courses, and experience in researching integrating PDC topics into CS courses, evidence by their peer reviewed publications.

SECTION 2.2 Advertisement

The workshop was advertised via its Web site and emails. The emails consisted of a call to participate to universities, colleges, and two year institutions in 12 states. So that the two-day workshop would be within driving distance of the participants, the emails were sent to institutions that were relatively close in proximity to TTU, which was the site of the workshop. The targeted institutions included universities and colleges lack in teaching and research resources for PDC. Institutions that primarily served under-represented group were also targeted.

The call consisted of a questionnaire to aid the organization committee when choosing appropriate participants.

SECTION 2.3 Participants

The organizing committee received thirty-two responses, of which 13 were chosen according to the criteria in the questionnaire and the budget for the workshop.

The thirteen participants came from the following Universities and colleges: Lipscomb University, University of Cincinnati, Georgia College, Marshall University, Austin Peay State University, Lander University, East Carolina University, Tennessee State University, Mississippi Valley State University, and The Citadel.

Two of the members of the organizing committee came from Tennessee Tech University. One member of the organizing committee came from Calvin College, and the other member came from DePauw University. A full list of participants and their contact information is found the appendix of the report in Table 3.

SECTION 2.4 Selection Criteria

The preferred criteria, gleaned from the survey in the call to participate, for accepted participants included:

- The participant will be teaching introductory courses in CS.
- The participant should have some desire to include PDC topics in their introductory courses
- The participant teaches using a language that will be used in the workshop.
- The participant teaches at an organization that serves under-represented groups.
- The participant is open to further collaboration with other workshop participants and the organizers.

The full questionnaire from which these criteria were gleaned is shown in ***Figure 1***.

	Question Text	Type	Choices
Q1	**First Name**	Freeform	
Q2	**Last Name**	Freeform	
Q3	**Middle Initial**	Freeform	
Q4	**What is your contact phone number?**	Freeform	
Q5	**What is your contact email address?**	Freeform	
Q6	**What institution do you teach at?**	Freeform	
Q7	**In what state does your institution reside?**	Multiple choice and freeform	State abbreviations
Q8	**What position do you hold at your current institution?**	Multiple choice and freeform	Instructor Assistant Professor Associate Professor Professor Other (please specify)
Q9	**Are you:**	Multiple choice and freeform	Tenure track? Non-Tenure track? Tenured? Other (please specify)
Q10	**In what discipline did you earn highest degree?**	Multiple choice and freeform	Computer Science Computer Engineering Information Systems Other (please specify)
Q11	**What is your underrepresented status (optional)?**	Multiple choice	Women Persons with disabilities African Americans Hispanics American Indians Alaska Natives

			Native Hawaiians Pacific Islanders
Q12	**What courses do you typically teach? (Please provide answers separated by commas. If it is a graduate course, please write (G) after the course name)**	Freeform	
Q13	**Have you taught introductory programming sequence courses (CS0-Introduction to Computer Science, CS1-Introduction to Programming, CS2-Data Structures, etc) in the past?**	Multiple choice and freeform	Yes No If yes, please provide answers separated by commas
Q14	**Are you scheduled to teach any introductory programming sequence classes in the 2016-2017 academic year?**	Multiple choice and freeform	No Yes If yes, please provide answers separated by commas
Q15	**Which of these UNDERGRADUATE courses do you expect to teach in the upcoming academic year?** 1. **CS 1-Introduction to programming** 2. **CS 2-Data Structures** 3. **CS 0-Introduction to Computer Science**	Multiple choice	Fall 2016 Spring 2017
Q16	**What language is used for the following classes in your institution?** 1. **CS 1-Introduction to programming** 2. **CS 2-Data Structures** 3. **CS 0-Introduction to Computer Science**	Multiple choice	C/C++ Java Python Other
Q17	**In a few lines, please tell us about your interest in attending the iPDC workshop.**	Freeform	
Q18	**The project aims to enable faculty without prior parallel and distributed computing expertise to incorporate PDC topics into traditional introductory programming sequence classes. By participating in this project, you are committing to adopt the workshop material in your classes. if you agree to do so, please type the initials of your name in the text box. Thanks for your interest and participation.**	Freeform	
Q19	**By submitting this form you are declaring that the information submitted by you is correct to the best of your knowledge.** **By submitting this form you are declaring that the information submitted by you is correct to the best of your knowledge.** **By submitting this form you are acknowledging that the information will**	Multiple choice	I agree I disagree

	be handled as part of the iPDC project National Science Foundation grant ACI-1549812.		

Figure 1 Workshop call to participate

SECTION 3 Workshop Format

The intent of the workshop was that participants would experience a collegial atmosphere where they would receive instruction in basic concepts of parallel and distributed computing and hands-on exercises in the form of tutorials. Additionally, the participants would participate in open discussions on impediments to integrating PDC and how to overcome those impediments. Therefore, on day one, the format of the workshop consisted of a welcome introduction by the Dean of the College of Engineering at TTU and the Computer Science department's acting chair that was followed by a keynote address by Dr. Sushil Prasad representing the National Science Foundation. After the keynote, Dr. Joel Adams and Dr. Sheikh Ghafoor presented a tutorial on PDC concepts. Then the participants divided into groups to participate in break-out sessions that incorporated hands-on exercises in OpenMP, Java thread programming, and Python thread programming. The break-out session were conducted by Dr. Mike Rogers, Dr. Sheikh Ghafoor, Dr. Mark Boshart, and Dr. Steven Bogaerts. After the break-out sessions, a panel session was held. The topic of the panel session was *impediments to integrating PDC topics in introductory courses*. The panel session was conducted by members of the organizing committee, but the workshop participants engaged in the discussion. The day closed with dinner at a local restaurant.

The format of day two consisted of more break-out sessions, a common session where the break-out session leaders gave some examples in each of the programming languages used in the break-out sessions, and a final debriefing. In the debriefing, the organizing committee encouraged the participants to give feedback and evaluate the workshop. The full iPDC Workshop agenda in shown in Figure 1.

	Time	Location	Description
June 20			
8:30-9:00	8:30-9:00	Bruner 206	Registration and Breakfast
9:00 – 9:15	9:00 – 9:15	Bruner 206	Welcome (Joseph Rencis, Dean, College of Engineering, Ken Wiant, Chair, CS Department)
9:15 – 9:45	9:15 – 9:45	Bruner 206	Keynote (Sushil Prasad, NSF)
9:45 – 10:45	9:45 – 10:45	Bruner 206	Parallel Distributed Computing concept and terminology (Part 1) Joel Adams, Calvin College
10:45 – 11:00	10:45 – 11:00	Bruner 206	Coffee Break
11:00 – 12:00	11:00 – 12:00	Bruner 206	Parallel Distributed Computing concept and terminology (part 2) Sheikh Ghafoor, Tennessee Tech
12:00 – 1:00	12:00 – 1:00	Bruner 206	Lunch
1:00 – 2:00 Break out session	1:00 – 2:00 Break out session	Bruner 420	Introduction to OpenMP Sheikh Ghafoor/Mike Rogers, Tennessee Tech
		Bruner 206	Java thread programming Mark Boshart, Tennessee Tech.
		Bruner 404	Python thread programming Steven Bogaerts, DePauw University
2:00 – 3:00 Break out session	2:00 – 3:00 Break out session	Bruner 420	Hands on exercise in OpenMP
		Bruner 206	Hands on exercise in Java
		Bruner 404	Hands on exercise in Python
3:00 – 3:15	3:00 – 3:15	Bruner 414A	Coffee Break
3:15 – 4:15 Break out session	3:15 – 4:15 Break out session	Bruner 420	Hands on exercise in OpenMP
		Bruner 405	Hands on exercise in Java
		Bruner 404	Hands on exercise in Python
4:15 – 5:15	4:15 – 5:15	Bruner 420	Panel Session, Joel Adams, Sheikh Ghafoor, Steven Bogaerts
6:30 -	6:30 -		Dinner at a local restaurant (Car pool from hotel)
June 21			
8:30 – 9:00	8:30 – 9:00	Bruner 206	Breakfast
9:00 – 10:00 break out session	9:00 – 10:00 break out session	Bruner 420, 404, 405	Hands on exercise on CS1/CS2 PDC modules
10:00 – 10:15	10:00 – 10:15	Bruner 414 A	Coffee Break

10:15 – 12:15 Break out session	10:15 – 12:15 Break out session	Bruner 206, 420, 404	Hands on exercise on CS1/CS2 PDC modules
12:15 – 1:15	12:15 – 1:15	Bruner 206	Lunch
1:15 – 2:15 Common Session	1:15 – 2:15 Common Session	Bruner 206	Presentation of OpenMP, Java, and Python modules
2:15 – 3:00	2:15 – 3:00	Bruner 206	Debriefing, discussion, feedback and workshop evaluation, Joel Adams, Sheikh Ghafoor, Mike Rogers, Steven Bogaerts

Figure 1 iPDC Workshop agenda.

SECTION 3.1 Summary of iPDC Panel Discussion

The topic of the panel session was *impediments to introducing PDC topics into introductory courses*. As the discussion continued, major themes organically arose. These major themes were *pedagogical issues*, *practical issues*, and *motivation*.

Pedagogical Issues

The panel session began with a discussion about when PDC topics should be introduced into the curriculum. Opinions as to how early differed. Overall, the opinion was to begin introducing PDC topics when teaching the topics becomes effective. Some participants introduce topics as early as CS0, while others argued that CS2 was most appropriate because students had obtained enough programming maturity to understand and implement applications that are more interesting. However, the participants seemed to agree that PDC topics should be introduces early-and-often.

In addition, participants indicated that PDC topics should be integrated into existing course material. For example, CS2 introduces many data structures that lend themselves to parallelism, and an instructor can discuss how operations on big sets of data contained in those data structures can be parallelized. Other topics where introducing parallelisms is natural are computer architecture, programming languages, operating systems, and software engineering. Many of these topics are cross-cutting, and the instructor can build on the material from previous courses and introduce PDC materials in the curriculum such that the students can experience the PDC materials in multiple, related contexts.

The participants also discussed the importance of visualization and real world examples. Visualization is important because it not only helps explain what a parallel program is doing, but also helps stimulate the student's interest. One panel discussion leader had implemented a formal experiment that showed better exam results for students when using visualization techniques. Real world examples are important in demonstrating to students that parallelism is not such an alien concept. For example, one participant described an exercise in his CS0 course. He asked his students to devise a plan for making many peanut butter sandwiches as fast as possible. The students automatically tried to solve the problem in parallel, without realizing that they were doing so.

Practical Issues

A primary concern of participants was that adding new material about PDC is difficult because classes are already loaded with existing topics. Therefore, integrating PDC where it fits naturally into the existing course material is not only important pedagogically, but it is also practical because doing so can save time. For example, while reviewing traditional concepts, such as statements and expressions, an instructor can discuss parallelism, such as how and when statements and parts of expressions could be executed in parallel.

Environmental setup is also of practical importance. Setting up the PDC environment can be time consuming and difficult for students. Therefore, hiding these details from the student is important, especially in early courses such as CS0 and CS1.

Having different expectations in CS0, CS1, and CS2 is also important. The instructor must determine what is feasible for the students given their level of CS maturity. Early in the curriculum, simple discussions with real-world examples of parallelism are helpful, such as describing the parallelism that occurs in the checkout counters in a grocery store.

Motivation

Participants agreed that both student and instructors needed motivation to see the importance of learning PDC. Students should give given course exercises that show the benefits of performance gains and of sharing information. However, participants expressed concerns about how to motivate faculty to teach PDC in introductory courses. Various methods were discussed, including monetary rewards. A panel discussion leader suggested that showing faculty that students are highly motivated would motivate the faculty.

SECTION 4 Workshop Evaluation

The iPDC organization committee created a post-workshop questionnaire and a follow-up email to evaluate the effectiveness of the workshop. Results of the questionnaire and email are in the following sections.

SECTION 4.1 Questionnaire

The questionnaire contained the questions shown in ***Table 2***. Of particular importance is question Q4. The purpose of this question was to measure the overall effectiveness of the workshop from the point of view of the participants.

	Question Text	Type	Choices
Q1	**Which of the following course(s) are you are scheduled to teach in the next academic year?**	Multiple choice and freeform	CS0 CS1 CS2/Data Structures Other (please specify)

Q2	**Which of the following course(s) are you planning to integrate PDC topics during next academic year? Check as many as appropriate.**	Multiple choice and freeform	CS0 CS1 CS2/Data Structure Other (please specify)
Q3	**Please rate the sessions in terms of usefulness.** 1. Keynote 2. Introduction to Parallel and Distributed Computing 3. Breakout sessions on Python, Java, or C/C++ OpenMP **4.** Panel and Discussion Sessions	Four level Likert Scale	Very useful Useful Moderately useful Not useful
Q4	**Please state your level of agreement with each of the following statements in regard to the workshop.** 1. Overall, this workshop showed me the importance of integrating PDC topics in introductory programming courses. 2. Overall, this workshop provided information that I can use to teach PDC concepts in my introductory programming courses. 3. Overall, this workshop motivated me to integrate PDC topics into my introductory programming courses. 4. As a result of this workshop, I feel confident that I can teach PDC concepts in my introductory programming courses. 5. As a result of this workshop, I plan to integrate PDC topics into my introductory programming courses. 6. I intend to maintain contact with workshop organizers and participants during the next academic year. 7. The logistics of this workshop were well done. 8. The workshop organizers were effective in communication. 9. I would recommend this workshop to other computer science faculty members. 10. This workshop compares favorably with other workshops I have attended. 11. Overall, the workshop met my expectations. 12. I would participate in a follow-up workshop in future organized by iPDC organizers	Five level Likert Scale	Strongly agree Agree Neutral Disagree Strongly disagree
Q5	**Would you like to share any "new" modules or exercises that you might develop yourself for your course with iPDC organizers to share with the community (with appropriate credit to you)?**	Multiple Choice	Yes No Maybe
Q6	**Would you be willing to collaborate with iPDC organizers in the future in wider scale efforts?**	Multiple Choice	Yes No Maybe

Q7	**What did you like about the workshop?**	Freeform	
Q8	**Please share any additional comments you may have about improving the workshop**	Freeform	

Table 2 Post-Workshop Questionnaire

Figure 2 shows the distribution of responses. The graph shows that, overall, the participants were pleased with the workshop, and that the participants believed that the workshop positively impacted both their willingness and preparedness to teach PDC topics in their introductory courses. In particular, all of the participants either agreed or strongly agreed that the workshop motivated them to integrate PDC topics in their introductory courses. Furthermore, nearly 77% of the participants agreed or strongly agreed that they felt more confident that they could teach PDC topics in their introductory CS courses.

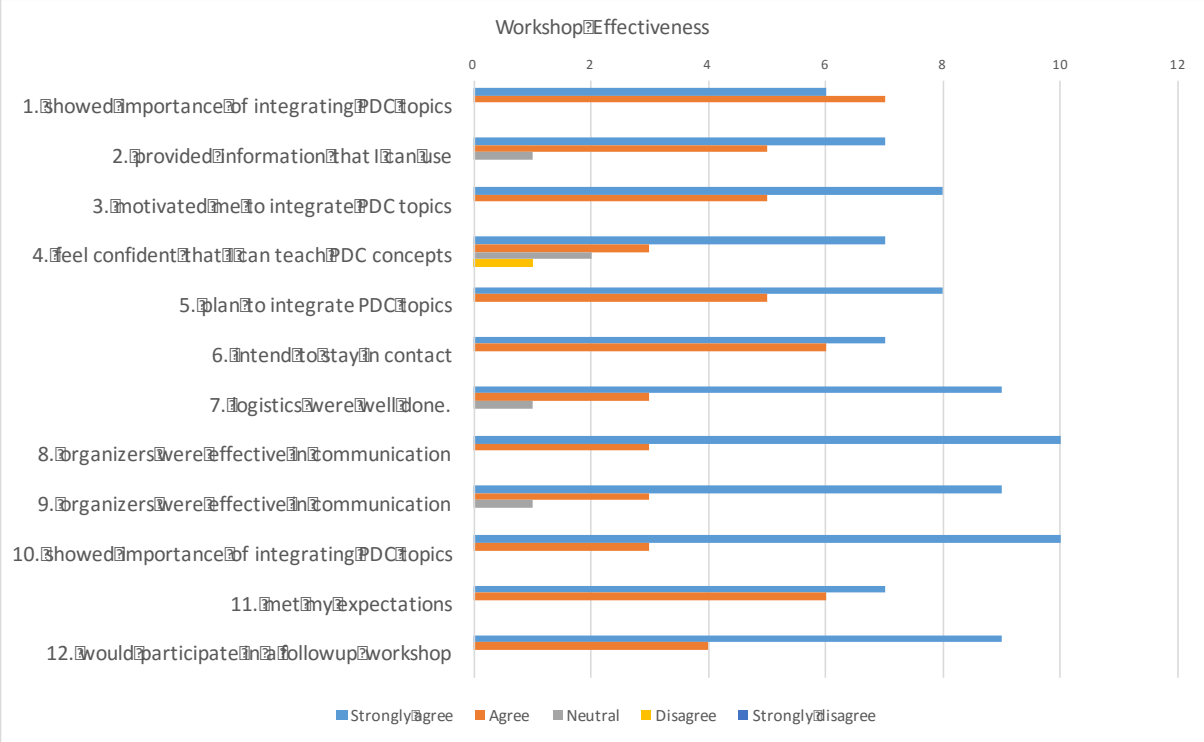

Figure 2 Distribution of results from Q4 of Questionnaire

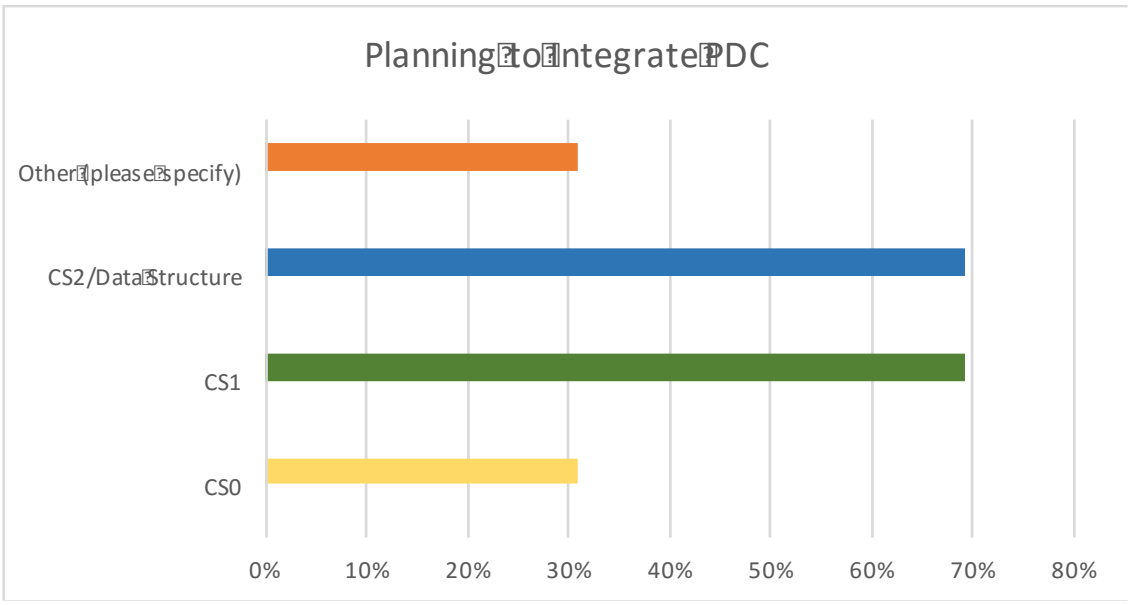

Figure 3 Participants Planning to integrate PDC Topics

This motivation and preparedness is also reflected in the participants answers to question Q2. The distribution of answers for Q2 are shown in *Figure 3*. Of those participants that are planning to teach CS0 in the coming year, which is over half, a majority of them plan to integrate PDC topics. Furthermore, during the coming year, nearly 70% of the participants plan to teach CS1, and nearly 70% of the participants plan to teach CS2 or Data Structures. All of those participants plan to integrate PDC topics in those courses.

Not only do the participants plan to integrate PDC into their courses, but they also indicated a willingness to continue collaborating with the PDC teaching community. For Question Q5, 84.6% of the participants indicated that they would be willing to share new course material with the community. For Question Q6, 69% of the participants indicated that they would be willing to collaborate with the iPDC organizers in wider scale efforts.

We also attempted, via the questionnaire, to evaluate the parts of the Workshop that were the most effective. Question Q3 asked the participants which sessions were the most useful. Figure 4 shows the results. The participants thought that all of the components of the workshop were, at least, moderately useful. However, most participants found the introduction to PDC and the breakout sessions to the very useful.

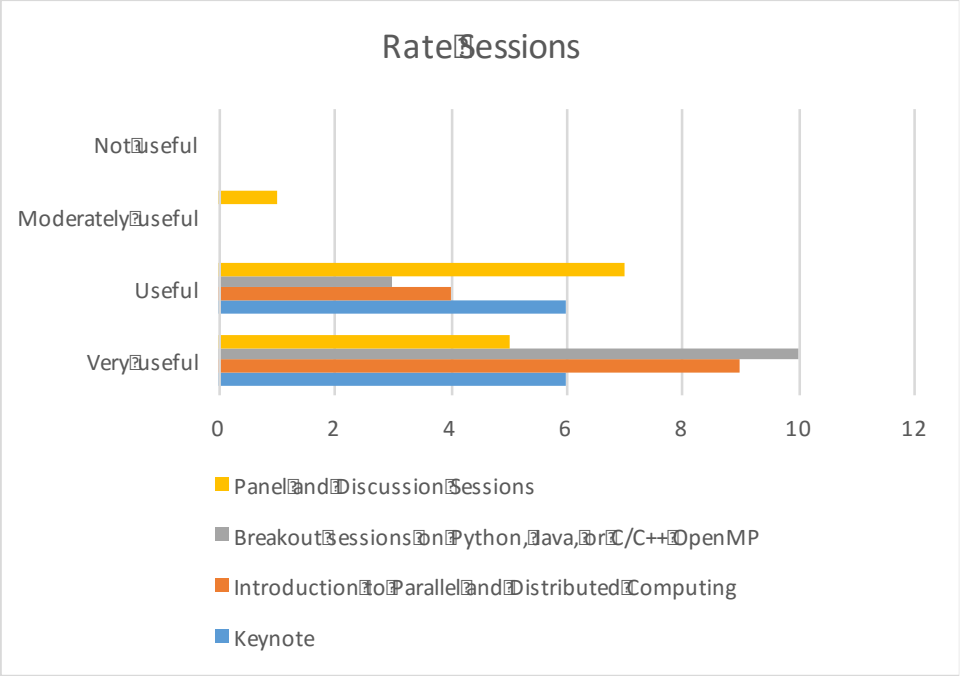

Figure 4 Session ratings

Question Q7 asked the participants what they liked about the workshop. The question was presented to the participants as a free-form question so that they could type answers without constraints. However, we classified their responses into common themes as shown in Figure 5. The favorite parts of the workshop were the hands-on exercises in the breakout sessions, the programming materials (labs, assignments, access to tools, etc.) that they could take with them once the workshop was over, and the collegiality and enthusiasm of the workshop's speakers and the other participants.

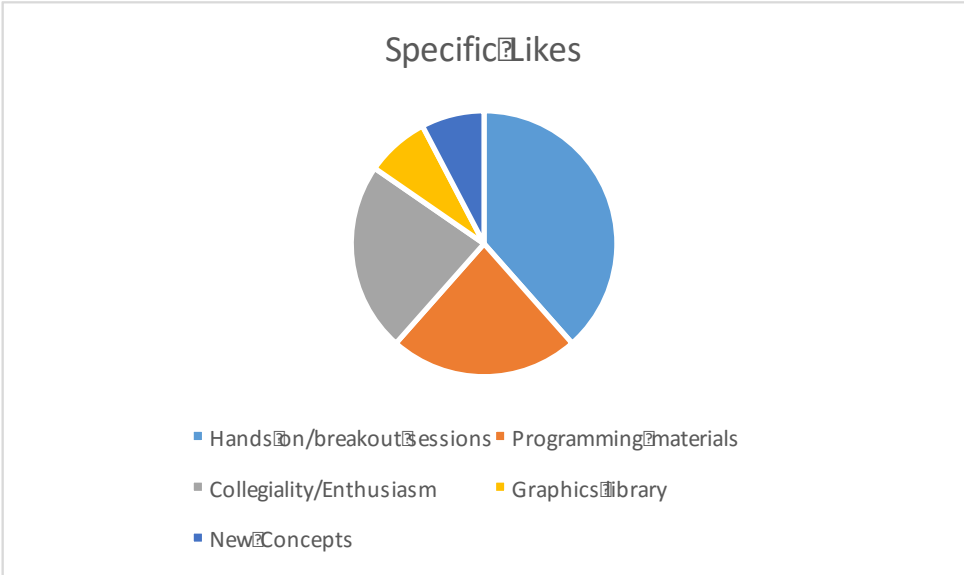

Figure 5 Parts of the workshop that participants liked.

SECTION 5 Workshop Follow-up Email

After the workshop and once the participants had returned to their home institutions, the program committee sent the workshop participants a final email that, though based on the panel discussion, was a questionnaire to each *individual* participant on impediments to integrating PDC topics into their courses at their institutions. The following sections shows the questions and summarizes the participants' responses.

What are the impediments you see in integrating PDC in introductory programming classes at your institutions?

A primary impediment identified by the workshop participants in the follow-up email is that PDC concepts may be too hard for CS1 students. PDC topics are substantially more technical than regular CS1 concepts, and CS1 students may be too inexperienced as programmers to handle the PDC material. In addition, for both CS1 and CS2 students, there is limited lecture time to sufficiently cover the regular content and the PDC topics. In fact, it is challenging to even determine exactly what PDC content is appropriate for CS1/CS2 and what should be covered in upper level courses. Participants also have some concern that setting up the PDC environment on the students' computers will be difficult.

Participants were also concerned that it will be time consuming to modify the existing course curricula and create and integrate the new PDC topics. For this reason, the rest of the faculty is likely to resist including the PDC topics in their sections of CS1/CS2.

What would help to alleviate the impediments?

The primary way to alleviate the impediments identified by the workshop participants is having good PDC course materials available. The PDC course materials should enable parallel concepts to be introduced alongside the regular material, minimizing the time required to cover the additional PDC topics. As developing such course material is a challenging task, these materials should be piloted and adjusted to meet the specific needs of CS1/CS2 students at each institution. The exposure to PDC should be gradual, with more time spent on PDC as students become more proficient programmers. For example, CS1 PDC materials should include exercises and demos that are light on code (if any) to allow CS1 students to, at a minimum, be exposed to PDC and appreciate the importance of PDC. For CS2, a few modules and assignments with good starter code and full solutions to reinforce PDC lecture material would be useful.

In addition, colleagues must be convinced of the importance of taking the effort and time to include parallel processing into the CS1/CS2 curriculum ("buy-in"). Participants can stress the parallel nature of real world problems. Participants can share what they have learned at the workshop. It may be necessary to increase and expand the PDC workshops with participants encouraging fellow faculty to attend.

Based on your workshop experience what we as a community (iPDC organizers and likes, ACM, ABET, NSF General CS faculty members) should do for wider and effective integration of PDC in undergraduate curriculum specifically in introductory programming classes. Give us some specific ideas and action items (for example regional workshops like iPDC, follow up workshop, packaged easy to integrate modules, include PDC chapter in CS0, CS1, CS text books).

To achieve a broad and effective integration of PDC in undergraduate curriculum, a wider awareness is needed. Participants thought the iPDC workshop was excellent! It providing more workshops and more exposure at conferences that include modules will be very beneficial in convincing faculty to integrate PDC. Furthermore, participants thought that the workshop effort should result in forming a special interest group and submission of a panel or some other presentation at SIGCSE to advertise PDC modules. Likewise the educators should participate in the next iteration of the ACM/IEEE Model Curriculum to ensure the inclusion of PDC.

Participants felt that the material/modules from these workshops are excellent spring-boards to creating the content that will fit in their own personal classes. It gives educators a starting point. Educators should have a central repository for materials, ideas, and assignments that people have successfully used and can share with others that can grow as PDC integration spreads. Another useful tool would be a webinar to which educators can refer colleagues that will give them general info/pedagogical motivation, and perhaps a follow-up webinar with a language-specific tutorial to boost their confidence.

Please write one paragraph about your plan of integrating PDC topics at your institutions as a result of this workshop.

The following are some direct quote from the respondees to this question.

"As a result of this workshop, I am leaving with something in hand that I can attempt in my CS1/Python class. (I have my first lecture and lab planned!) As part of the workshop, I was given time to think through both the new material presented as well as our current structure and create a proposed plan for integrating the material into my course. I team teach this course, so I will be taking this proposal to my peer for us to discuss. It has not only given me a mindset that teaching PDC concepts is imperative, it has also given me material to use as a jump-start to getting this topic more incorporated into my classes."

"Next semester I will teach Data Structures. For sure, I plan on showing parallel versions of *sorting* methods. I hope I will be able to show visually how the numbers are sorted for different serial methods and then see how these differ in parallel. I also like your addition of image processing techniques in CS1. I think I will also add an activity about converting a color image into gray scale."

"I like the examples used during the Python demonstration to review CS1 concepts. I would like to do this in Java. I hope we have access to those code examples he showed."

"Our OS, Systems Programming and Architecture courses are places I think parallelism can also be covered. I do not teach these courses but will share the things I have learned at this conference with the other faculty."

“My plan after this workshop will be to include a week of PDC in CS0 and CS1 this Fall. The CS0 class will focus on the high overview concept and it will be non-programming. CS1 will do some basic PDC programming in python. After the Fall, it will be the CS2 turn to include a more advanced PDC topics (length of time to be determined with the appropriate teacher in charge of the class). Eventually I am planning to have our student take an advanced PDC class before they graduate.”

“I plan to introduce parallel programming concepts in my CS1 course with a small lecture and code demonstration, and an in-class exercise not involving programming. In my data structures/algorithms course, I plan to demonstrate performance improvements in recursive sorting algorithms and perhaps offering 1-2 assignments.”

Appendix – Workshop Participants

Name	Institution	Roll
Sushil Prasad	National Science Foundation	Keynote Speaker
Steven Bogaerts	DePauw University	Organizer
Joel Adams	Calvin College	Organizer
Roger Frye	Arkansas Tech University	Participants
Mario Nakazawa	Berea College	Participants
Marcus Golden	Mississippi Valley State University	Participants
Joe Elarde	Austin Peay State University	Participants
Michael Verdicchio	The Citadel	Participants
Dawn McKinney	University of South Alabama	Participants
Julie Henderson	Lander University	Participants
Arisoa S. Randrianasolo	Lipscomb University	Participants
Timothy Holston	Mississippi Valley State University	Participants
Bilal Gonen	University of Cincinnati	Participants
Junhua Ding	East Carolina University	Participants
Kamal Al Nasr	Tennessee State University	Participants
Gita Phelps	Georgia College	Participants
Katie Burks	Tennessee Technological University	Student Helper
Amela Gjishti	Tennessee Technological University	Student Helper
Deepika	Tennessee Technological University	Student Helper

Sheikh Rabiul Islam	Tennessee Technological University	Student Helper
Mark Boshart	Tennessee Technological University	Organizer
Sheikh K. Ghafoor	Tennessee Technological University	Organizer
Luke Jackson	Tennessee Technological University	Technical Help
David Brown	Tennessee Technological University	Participants
April Crockett	Tennessee Technological University	Participants
Mike Rogers	Tennessee Technological University	Organizer

Table 3 Workshop Participants