

Using a lab wiki for longevity and knowledge transfer in undergraduate research

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Abstract

Continuity in research group collective knowledge is critical for running a successful research program, but in an undergraduate research lab, this can be particularly challenging. A wiki site dedicated to the research laboratory, a lab wiki, can bridge gaps in student-to-student knowledge transfer and contribute to the longevity of a research program. A lab wiki is an organized, easily accessible, collaborative resource that can contain tutorials, group-specific directions, links to resources, and guides to writing papers or proposals. The wiki language is easy for students to pick up and contributes to their participation in preserving group knowledge. This tutorial introduces the concept of a lab wiki, the advantages of it, example content, and practical implementation advice.

KEY WORDS

best practices, technology, undergraduate research

1 | INTRODUCTION

This article is part of a special issue on best practices in undergraduate research, specifically highlighted by members of the MERCURY Consortium.^[1,2] Undergraduate research has been deemed one of the high-impact practices.^[3] Through close faculty-student mentorship, it provides a personal education that trains students in the art of inquiry and encourages intellectual independence.^[4–7] Undergraduate research is challenging for many reasons,^[8–10] including that the students know less content in the chosen field. Oftentimes, faculty must teach a student everything about the research because students have not carried out the prerequisite course work. Systematically, undergraduate research faculty mentors often dedicate 70% to 100% of their effort toward teaching and service; therefore, maintaining momentum in research is that much more difficult. Sustaining an undergraduate research program becomes highly dependent on a steady transfer of knowledge between the faculty member and the students or among students. Thus, while many of the issues highlighted here are pertinent to a graduate research program, they are particularly critical for the longevity of undergraduate research programs. For the subset of faculty who choose to design their research programs exclusively around undergraduate student involvement,^[11] a research group-specific wiki site can make student-to-student knowledge transfer more efficient.

One of the largest impediments to maintaining group productivity is short student research group membership. To lengthen the research training period, some faculty let students join their research group as early as freshman year or in a pre-frosh program, the summer before freshman year. In the best of circumstances, students are in research groups for 4 years plus a summer before or after college. On the other end of the spectrum, students may join a research group for an academic year or a summer. In the ideal scenario, someone in the group besides the principal investigator always knows a portion of the collective group knowledge to pass on to new students. In undergraduate research labs, sometimes, the interests of incoming students do not overlap with outgoing students, or there are few overlapping students. In addition, students who are knowledgeable might spend all their time training other students in the lab and not have adequate time to accomplish their own work. Traditionally, gaps in knowledge transfer have been covered by maintaining a paper repository of protocols, a lab manual for the group, a series of How-To PowerPoints deposited in a communal drive, or theses and supplementary materials of undergraduate theses.

Collective knowledge can also be maintained with a laboratory wiki, a wiki website customized for your laboratory. The author's group has had a laboratory wiki, lab wiki for short, since 2006. It has survived two institution moves and a rotation of group projects spanning disparate methods and applications. Over 50 students have contributed to the lab wiki. At first, the lab wiki just contained the group's short list of tutorials, such as a short guide to Unix, Vi text editing, how to submit jobs to the queue, and some data analysis tips. As students gained expertise in topics, they were asked to write a tutorial or lab wiki page on their topic of expertise. Now, the lab wiki is the central resource for maintaining and passing on research group knowledge.

2 | ADVANTAGES, USES, AND USERS

The wiki platform allows for collaborative content sharing and editing to anyone who has access to the site. Users can add content with very little programming knowledge.^[12] Examples of wiki language can be learned by going to a public wiki such as Wikipedia, finding the desired formatting, and mimicking it. Students do not have to learn a new language such as html, reducing the barrier to participation. In addition, the lab wiki format is conducive specifically to computational research because command-line syntax or code for short programs are autoformatted in a separate gray box by just putting a space before each line of text. The ease of writing a wiki page makes it possible for novice students to contribute to the group knowledge. The lab wiki also includes edit histories for each page. Student mistakes can be blacked out; nothing is permanent and mistakes can be easily fixed. Because MediaWiki is mainstream open software, updates to the operating system are made by a third party. The broader wiki community also continually develops extensions. It is a searchable, collective project.

Wikis have been used in a variety of educational contexts.^[13-16] Here, the lab wiki is both an educational tool and a repository of research group knowledge. It can contain tutorial materials for certain research steps, background for computational theory/methods, guides for using specific programs, group scripts, weblinks to key resources, and introductions to basic science and specific projects. These are all items that graduate students might be expected to find themselves after being referred to a few recent papers. Undergraduate students need more guidance, and a lab wiki provides an intuitive interface with structure. Others also use a lab wiki as a repository of group documents. This might include group meeting presentations, proposals, or theses. As students are ready to learn soft skills such as writing a proposal, these documents serve as examples. New students can also become oriented to the project by reading the introduction of a thesis or group meeting presentation. Repositories on a lab wiki do require disk space considerations on the server, and some flags need to be customized (see Practical Implementation).

A research lab wiki serves several different groups. The faculty member and new undergraduate students who join the lab have an organized repository for research group collective knowledge. New students find the lab wiki accessible and easy to navigate. As students progress in a project, they have access to group collective knowledge through the lab wiki. More advanced students involved in creating the wiki sites are also actively engaged in constructing group knowledge.^[14] Pedagogically, undergraduate students gain confidence from writing the tutorials because they are considered experts on a topic, and the process additionally serves as a vehicle to reinforce knowledge. The lab wiki can similarly be shared with other faculty or colleagues who are not familiar with the logistics of a particular technique, and its contents are already organized.

Collaboration is one of the key advantages of a lab wiki, but due to the slower pace of undergraduate research, group knowledge privacy may be protected with a lab wiki password. In this way, only those with a username and password can edit or read the site. Individual standard users can be created, but that can make management cumbersome. Some labs choose to create different access levels. For instance, one group username can be created for all group members with edit capabilities. Or novice members, transient members, or classroom students could receive a username with read-only access. Password protection gives the research group optional privacy for sensitive information such as group meeting presentations and proposals but still encourages collaboration.

3 | CREATING LAB WIKI CONTENT

Content creation becomes a community effort with a lab wiki and should be managed. On the author's lab wiki, all undergraduate research students have edit capabilities. If there is uncertainty in material, students are advised to add content rather than delete it. However, the principal investigator ultimately serves as the editor. In the unlikely event that an erroneous entry is created, and the previous version of the page should be restored, lab wiki page edit histories are saved. For each lab wiki page, select the histories tab. By choosing the previous version, the previous page is restored. In this way, management is minimal, students feel freedom to contribute, and disasters are correctable.

The Main Page of the lab wiki is a table of contents to the site. This is the first page that a user encounters. It can be made into an organized list (Figure 1). After four headers are made, the header titles are automatically made into a list. Each blue item under Contents is a Topic Heading. Contents can be organized by general topic, much like chapters in a book. Under each Topic Heading is a set of wiki pages. The introductory material for new students may come first, followed by more project-specific information, specialized methods, and guides for creating dissemination materials such as papers or posters.

FIGURE 1 Example Main Page of the author's lab wiki

Main Page

Contents [hide]
1 Welcome to the Nagan Lab Wiki
2 New Nagan Group Member Assignments
3 Intro to Computers
4 Introduction to Biomolecules
5 Visualization
6 Using Amber
7 Building Systems
8 Running MD Simulations
9 Analyzing Trajectories
10 Background Specific Project Information
11 New Modified Nucleoside Parameters
12 Natural Bond Orbital Analysis
13 Running REMD
14 Writing Proposals
15 Presentations and Posters
16 Building Computers
17 Writing Wiki Pages

Welcome to the Nagan Lab Wiki [\[edit\]](#)

This is the Nagan group's lab wiki. It contains information to carry out Dr. Nagan's computational research. All Nagan group members can view/add content to the lab wiki. If you need an account, email Dr. Nagan (maria.nagan@stonybrook.edu).

New Nagan Group Member Assignments [\[edit\]](#)

- [Checklist for New Nagan Group Members](#)
- [Download a PDB from the PDB Databank and Learn VMD](#)
- [Learn vi and Unix](#)

FIGURE 2 New Nagan Group member assignments

The lab wiki can serve as a transfer knowledge mechanism from a faculty member to a student, where parts of the lab wiki are referred to in an in-person meeting. For example, the lab wiki can contain sets of directions commonly given, such as a checklist for new group members and beginner basic science information and resources, as well as links to key project articles. The Checklist for New Members (Figure 2) is a list of tasks such as attending fire safety training, obtaining keys, and who to talk to about obtaining accounts on various machines. In addition, all new members have beginning tasks and software they must learn before they can be productive. These are listed, and directions for the assignments are given on the lab wiki. Additional resources are listed in the assignments.

The lab wiki also contains tutorials, resources, and descriptions in small tractable portions that undergraduate students can digest at their own pace. For instance, the Intro to Computers section (Figure 3) started out with information on common commands in Unix and Vi Text Editor. However, as the group grew, students began to have conceptual issues about working remotely and where their files could be found. Tutorials describing a file path, remotely logging into a computer, and how to transfer files between computers were created. Some of this can commonly be found on the internet or through books, but the advantage of the lab wiki is that it can be customized with lab-specific information, such as the research group's directory structure or the addresses of specific computers.

Individual research steps can also be easily explained in a lab wiki format. If a student is going to go through a common process, the lab wiki can have a page for each step of the process. For example, if an undergraduate needed to build an explicit water system in the software Amber, the steps in Building Systems (Figure 4) would be followed. Most of these beginning tutorials were written by the faculty member, but as students worked through the steps, modifications to the wiki page were made by undergraduate students.

Preservation of research group knowledge is a significant advantage of the lab wiki. Analysis methods and scripts are often created for a specific project. Through a tutorial on the lab wiki, analysis types can be preserved. For instance, a student in the group might develop inputs for monitoring water residence lifetimes in a particular system. Then, if that student graduates, and another project needs similar analysis, there is no student-student transfer of knowledge. A thesis, which may have a general description of the analysis philosophy, may not have detailed inputs and scripts used to create the end result. A lab wiki tutorial explaining the analysis philosophy but also giving step-by-step instructions might be more productive.

Intro to Computers [edit]

FIGURE 3 Intro to computers

- [Unix](#)
- [Vi Text Editor](#)
- [File Path](#)
- [Working from Home - ssh](#)
- [Transferring Files with scp](#)
- [Disk Space](#)
- [Interactive Jobs](#)
- [Submitting jobs on GPUs](#)
- [Perl Scripting](#)
- [Nagan Data](#)
- [Your Homespace](#)

Building Systems [edit]

FIGURE 4 Building systems

- [What is a pdb file?](#)
- [Making Amber-happy PDB files](#)
- [Making Gas Phase Topology and Crd Files](#)
- [Make a PDB File in cpptraj](#)
- [Adding Water and Ions](#)
- [Randomizing Ions in the Buffer](#)

The lab wiki can also be used as a repository with examples of student theses, presentations, and posters. Using examples, students are able to see what is acceptable and also the variation in quality. These can be used as templates for future students. The lab wiki also organizes sometimes haphazard student files into a coherent, accessible list. If organized by project, a poster would be much easier to find in a wiki page list than in each student's user space.

There might also be a Proposal Writing section on the lab wiki. In this section, there might be a guide to writing proposals or directions for a specific call for proposals. For example, if there is a local on-campus call for summer research proposals, there might be guidelines and examples of successful proposals. Sometimes, departments teach a writing-enhanced course in which the students write proposals. A link to National Science Foundation (NSF) or National Institutes of Health (NIH) proposal guidelines could be made, but for undergraduate students, a guide with explicit page lengths and descriptions of each section is more useful. Externally funded proposals from the faculty member could also be posted in this section. Oftentimes, students find these useful when trying to become oriented to a project and to see the future directions of the project.

4 | PRACTICAL IMPLEMENTATION

Making a lab wiki requires wiki software and usually a database. The author's lab wiki site is hosted locally. To host your own website, Apache HTTP software installed on a Mac mini or Linux machine is a common method. To easily point lab members to a website, a domain name should also be purchased or obtained from the Information Technology (IT) department. The author uses MediaWiki^[17] and MySQL databases,^[18] both of which are freeware. Nowadays, there are many options for wiki software, supported by different database types^[19,20] with even LaTeX compatibility. Besides MediaWiki, common free wiki software is also available through TikiWiki^[21] and DokuWiki,^[22] which does not require a

database. Some companies will host your wiki for a monthly fee, such as SiteGround, TMD hosting, A2 hosting, cloudways, and greengeeks. In addition, learning management software such as Blackboard and Moodle have wiki creation tools. A class centered on research would need to be created and then propagated every semester. These wikis are not as versatile as one managed on your own, but they also require less administrative knowledge. Syntax and formatting examples given here are specific to MediaWiki, and analogous options are available through other wiki software.

In MediaWiki, the LocalSettings.php file contains the configuration settings for the wiki site, including how it interacts with the internet. To set up your wiki, customize variables such as the \$wgSitetname and database settings.

```
## Set the ScriptPath to where people should go to find your wiki (https://your_website/labwiki)
$wgSitetname = "Set_to_Name_of_Wiki";
$wgScriptPath = "/labwiki";

## The protocol and server name to use in fully-qualified URLs
$wgServer = "https://set_to_your_website_address";

## Database settings
$wgDBtype = "mysql";
$wgDBserver = "localhost";
$wgDBname = "dbname_here";
$wgDBuser = "admin";
$wgDBpassword = "set_to_admin_password_for_database";
```

To make the wiki password protected, edit the \$wgGroupPermissions. Different groups can be created with different permissions. For example, the wikireader group has read-only access, but the research group can make new pages and edit material. After a username is made, it can be assigned to a preexisting group, logged in as an administrator, under Special Pages and User Rights Management.

```
/// Block everyone from creating an account, including reading and editing
$wgGroupPermissions['*']['createaccount'] = false;
$wgGroupPermissions['*']['edit'] = false;
$wgGroupPermissions['*']['read'] = false;

// Read-only accounts
$wgGroupPermissions['wikireader']['move'] = true;
$wgGroupPermissions['wikireader']['read'] = true;
$wgGroupPermissions['wikireader']['edit'] = false;
$wgGroupPermissions['wikireader']['createpage'] = false;
$wgGroupPermissions['wikireader']['createtalk'] = false;
$wgGroupPermissions['wikireader']['upload'] = false;
$wgGroupPermissions['wikireader']['reupload'] = false;
$wgGroupPermissions['wikireader']['reupload-shared'] = false;
$wgGroupPermissions['wikireader']['minoredit'] = false;

// Editing accounts
##$wgGroupPermissions['research']['move'] = true;
##$wgGroupPermissions['research']['read'] = true;
##$wgGroupPermissions['research']['edit'] = true;
##$wgGroupPermissions['research']['createpage'] = true;
##$wgGroupPermissions['research']['createtalk'] = true;
##$wgGroupPermissions['research']['upload'] = true;
##$wgGroupPermissions['research']['reupload'] = true;
##$wgGroupPermissions['research']['reupload-shared'] = true;
##$wgGroupPermissions['research']['minoredit'] = true;
```

To make a new Topic Heading, use the syntax of putting two equal signs on both sides of the header. To make a new wiki page under each topic, place double brackets around the title of each new page. A “**” inserts a bullet point, and to nest a bullet point under another one, use “**.” The syntax below is used to create the Main Page Contents (Figure 1).

```
==="Welcome to the Nagan Lab Wiki"==

This is the Nagan group's lab wiki. It contains information to carry out Dr. Nagan's computational research. All Nagan group members can view/add content to the lab wiki. If you need an account, email Dr. Nagan (maria.nagan@stonybrook.edu) .

==New Nagan Group Member Assignments==
* [[Checklist for New Nagan Group Members]]
* [[Download a PDB from the PDB Databank and Learn VMD]]
* [[Learn vi and Unix]]

==Intro to Computers==
* [[Unix]]
* [[Vi Text Editor]]
* [[File Path]]
* [[Working from Home - ssh]]

==Introduction to Biomolecules==
* [[Central Dogma of Molecular Biology]]
* [[Nucleic Acid Structure]]
** [[2D and 3D RNA Structure]]
** [[RNA Structure Parameters]]
* [[Amino Acids and Protein Structure]]
* [[RNA Recognition]]

==Visualization==
* [[VMD]]
* [[Chimera]]
```

Numbered lists can also be created by using a “#” instead of a “**” in the example above. To edit the newly created pages, select the new page and choose to edit the page. Basic formatting such as bold and italics can be found in the Graphical User Interface (GUI) formatting bar in edit mode (Figure 5). There are also tools to insert internal links or new pages, external links, new topics, pictures, and media.

Both links to internal pages on the lab wiki and external links to websites are useful tools to direct readers to more information. To insert a link to an internal page, put double brackets around the page name. If the page name is piped to a set of words, then insert an “|” between the lab wiki page name and the words to display. Surround the whole internal link with double brackets.

```
==Additional Help==
* For more information about the specifics of the pdb file, see [[pdb file| What is a pdb file?]]
* For a tutorial on how to use VMD, see [[VMD]].
```

Linking to an external page requires placement of single brackets around the web page address. By default, the web address link becomes a number. If the actual web address should be displayed or link text, then include a space between the link and the link text.



FIGURE 5 GUI formatting bar in edit mode

==Manuals==

The most current Amber manual can be found at [https://ambermd.org https://ambermd.org]

Files can be uploaded to the wiki and then referred to in links, although the types of files extensions may need to be expanded. The allowed filetypes can be customized to include, for example, word processing files, image files, presentation files, and spreadsheets. ImageMagick^[23] is common freeware that can edit images but also make thumbnails for the wiki. To turn it on, set the variable to \$wgUseImageMagick = true and set the \$wgImageMagickConvertCommand to the correct path.

```
## To enable image uploads, make sure the 'uploads' directory
## is writable, then set this to true:
$wgUploadPath = "$wgScriptPath/uploads";
$wgUploadDirectory = "$IP/uploads";
$wgEnableUploads = true;
$wgUseImageMagick = true;
$wgImageMagickConvertCommand = "/usr/bin/convert";
#Override the default with a bundle of filetypes: $wgFileExtensions = array( 'png', 'gif', 'jpg', 'jpeg', 'ogg',
'zip', 'tar', 'gz', 'doc',
'ppt', 'txt', 'csh', 'xls', 'pdf', 'pdb', 'xyz', 'top', 'crd', 'frcmod', 'lib',
'scr', 'perl', 'awk', 'in', 'out', 'com', 'xlsx', 'docx', 'pptx', 'ai', 'psd'
);
```

The maximum file size limit may also need to be increased beyond the 500 KB default, and enough disk space on the web-hosting machine should be ensured. To change the maximum file size, edit /etc/php.ini and change the upload_max_filesize value to the desired value. Then, restart apache.

Links to images, media, and files can be accomplished through the word image, file, or media followed by a colon and the name of the uploaded file. Media displays a link to the actual file name. For images, formatting options such as centering or resizing specifications can be incorporated after an "|," all surrounded by double brackets.

The Amber19 Tools Manual: [[media:Amber19_and_Tools.pdf]]
[[image:dna_rna.jpeg|center]]

Wiki management capabilities can be found under Special Pages. Here, user accounts can be created, blocked, and assigned to groups. In addition, there is a list of all pages and maintenance reports. Pages with broken links and uploaded file lists can also be seen here.

5 | CHALLENGES

There are a few challenges of keeping up your own lab wiki site. After the setup, the largest barrier to lab wiki success is upkeep of the content. If protocols change, then the tutorials need to be updated. This author encourages everyone in the group to constantly update the wiki, but the majority of the upkeep falls on the principal investigator. As students work through tutorials or follow directions, they find errors in the wiki pages or find better ways to accomplish the same task. At group meetings, if a student finds an error, a shortcut, or a preferred syntax, small edits are encouraged within the week. About a month before the end of the semester, students who have mastered a particular task are asked to write a tutorial or update a tutorial. This is part of their end-of-semester product. It is also difficult to delete users because MediaWiki associates users with wiki contributions. One solution is to block a user, which renders the user read-only access. The other option is to merge the username into another username; this action also transfers the page contributions. Because MediaWiki is commonly used, there are often solutions posted online. If one chooses to maintain a local webserver and wiki site, security is always a concern. If a wiki site needs to be moved to another server, it does take effort. Both the wiki site (tar the folder of the wiki) and the database should be backed up and then be reconfigured for the new webserver.

6 | CONCLUSION

Lab wikis are tools in preserving group research knowledge that are particularly helpful for the success of an undergraduate research lab. A lab wiki can contain tutorials and links to resources, explained in a step-wise fashion amenable to undergraduate students. Customized, specific

directions can be incorporated, which ease the barrier to learning the technology. The wiki format is easy for students to master, increasing their ability to contribute collaboratively to group knowledge. In addition, the lab wiki can serve as a repository for previous student works and faculty proposals. In the lab wiki format, it is an organized list rather than files buried in inaccessible folders. Complicated methods can also be enumerated easily in detail on lab wiki. When there are discontinuities in student-to-student knowledge transfer, a lab wiki can fill the gap.

AUTHOR CONTRIBUTIONS

Maria Nagan: Conceptualization; project administration; supervision; visualization; writing-original draft; writing-review and editing.

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