A Workflow for Practical Programming Class Management Using GitHub Pages and GitHub Classroom

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[Abstract]

In programming classes, there is always a need to efficiently manage programming assignments. This is especially important as class sizes and assignment complexity grows. GitHub and GitHub Classroom makes the management of student assignments much simpler than uploading files and folders to a LMS or shared online drive. Additionally, git and GitHub are industry standard tools, so introducing students these tools in class provides them a good opportunity to start learning about how software is developed in the real-world. This study describes a workflow that uses both GitHub Pages and GitHub Classroom for more efficient classroom and assignment management. The workflow outlined in this study was used in two practical web programming classes in Spring 2023 with 46 third and fourth-year university students. GitHub Pages was used as a classroom website to distribute class announcements, assignments, lecture slides, study guides, and exams. GitHub Classroom was used as a class roster and assignment management platform. The workflow presented in this study is expected to assist other lecturers with the formidable tasks of distributing, collecting, grading, and leaving feedback on multiple students' multi-file programming assignments in practical programming classes.

Key Words: Git, GitHub Classroom, GitHub Pages, Classroom Management, Programming Assignments, Practical Programming Classes

I. INTRODUCTION

One of the biggest challenges for any classroom teacher is effective classroom management. This includes not only management of students, teaching time, lecture materials, and the classroom environment. It also includes management of student assignments. For the most part, a seasoned teacher should be able to manage both students and the overall classroom environment without much difficulty. Additionally, a seasoned teacher should be able to prepare more than enough lecture material to cover the class time. However, managing student assignments is one area that

even seasoned teachers may have difficulties.

For example, if one weekly assignment, quiz, or test is given each week in a 15-week semester to 20 students, there will be 300 total files or documents to manage – in *one* class. Loose paper assignments are often collected, graded, and returned in a timely manner, but digital assignments, even when graded and returned, are usually also collected and stored in some way.

Post-COVID-19, most schools offer an LMS or shared online drive where students can upload completed assignments. Digital bulletin boards, such as Padlet, or discussion forums on the LMS may also be used to collect

student work and discussions. In some situations, students may also be asked to email assignments to the teacher. However, emails are easily lost, forgotten, or sent to the wrong addresses. These are all common situations in regular classes. However, programming classes often require a different assignment management strategy. This is especially true in more advanced coding classes where assignments become more complex and the number of files increases.

These days, git and GitHub are industry standards for software version control. When students complete their coursework, many of them will find jobs in companies where these technologies are prevalent. Therefore, there is no reason they should not be used in practical programming classes as well.

GitHub Classroom was developed in 2015 to aid classroom management for computer classes. By June 2018, it had already been used in over 10,000 courses, and students had created more than two million repositories on the platform [1]. In 2020, when schools around the world were closed for the COVID-19 pandemic, a GitHub Education survey of 53,000 faculty showed that 54.7% of respondents had already used GitHub for more than five years. Additionally, faculty who reported using version control in 2019 rose from 72.6% to 73.3% in 2020, and faculty use of GitHub Pages increased from 41.5% in 2019 to 49.1% in 2020 [2].

This paper describes a workflow for implementing GitHub Classroom and GitHub Pages in a practical programming classroom setting. This workflow was employed in two Node.js programming classes for 46 3rd and 4th year students at T University in Spring 2023. An informal oral survey of the students prior to the start of the class indicated that less than 5 students had any prior experience with git or GitHub. A second, informal oral survey of the students near the end of the class indicated that most of the students thought that learning version control with GitHub Classroom was beneficial.

The combination of GitHub Pages for class material distribution and GitHub Classroom for student and assignment management was selected for three reasons. First, students can use their personal email or their school email to sign up for GitHub and link their GitHub ID to their name in the student roster. The school LMS requires a school email to login, and Google Classroom requires a Gmail account. But a GitHub ID can be created with either a personal or a school email. Second, GitHub is an industry standard cloud-based service for software management and version control with git. Most students who get a job in a tech company will be regularly using some form of version control and a cloud-based software management system. So, introducing these industry-standard tools to students in a school setting gives them practice building "real-world" projects while learning the basic flow of software development. Third, GitHub Classroom helps teachers with class management by automatically cloning assignment template repositories into student accounts and linking those repositories to their student IDs in each assignment page. GitHub Classroom also includes auto-grading features that can be used if tests are included in the template repository, and teachers add comments and hints with pull requests.

II. RELATED STUDIES

Even before GitHub Classroom was developed, teachers and researchers have been interested in how GitHub could best be used for education in real classrooms. A study from 2013 examines the benefits for individual students in keeping coding assignments private and learning about git branching to maintain code stability [3]. Another study published in 2015 focused on using GitHub for collaborative programming to help direct student interaction around programming projects [4]. In 2019, researchers surveyed 7,530 students and 300 educators about how classrooms using GitHub differed from those that didn't [5]. Overall, they found that classrooms using GitHub had better classroom experiences and learning outcomes overall. A 2021 study from Brazil found similar positive outcomes for students and educators using GitHub in the classroom, although it noted that students felt they needed more time and training on the tools [6]. Beyond these studies, various case studies on GitHub Classroom have also been written, including using GitHub Classroom to teach statistics [7], and an in-depth study on assignment management and automatic feedback [8].

III. METHODS

Firstly, this paper will briefly introduce the different technologies that are used in the GitHub Pages and GitHub Classroom workflow. Secondly, the workflow will be presented in three parts: 1) setting up the GitHub services, 2) creating and grading assignments, and 3) student access and assignment submission.

A. Technologies

1) Git

Git is a distributed version control system (DVCS) that began development in 2005 by Linus Torvalds and others in the Linux development community. It has since become the industry standard version control system (VCS) [9]. A 2023 Stack Overflow survey found that 93% of respondents use git [10]. A DVCS keeps track of changes to an entire folder of files, which is called a repository. This record of a repository's change history allows users to maintain a single copy of the folder and its files on disk, while also allowing them revert to any previous save state with a simple command.

2) GitHub

GitHub is an online cloud-based service that uses git. GitHub allows users to have access to their cloud-based git repositories from any Internet-enabled device. As of January 2023, GitHub boasts 100 million global users [11] and more than 330 million repositories [12]. GitHub is free and it has an interface that is easy for even non-coders to use. There is also a Desktop application and a command line tool that makes integration with existing workflows simple. Additionally, the platform also houses many of the world's largest open-source projects and developers from 90 of the Fortune 100 companies have repositories on the platform [12]. All these things make GitHub widely popular.

3) GitHub Pages

GitHub Pages is a static website hosting service that uses Jekyll and GitHub Actions to build and deploy a static website. By default, a GitHub Pages website can be contained in the root directory of a repository, or within a /

docs folder in the root directory. The website is most often and easily developed with Markdown, but it include HTML and CSS code or separate pages as well. Whenever code is "pushed," or uploaded to the site, GitHub Actions runs Jekyll to build and deploy the site. The simple interaction of Markdown, Jekyll, and GitHub Actions makes the creation of a repository website as simple as writing a document file and saving it.

4) GitHub Classroom

GitHub Classroom was begun as a Student Developer Pack in 2014 and repurposed into an online classroom management service by 2015 [1]. Although it is not as powerful as a full LMS, it includes all the essentials, such as a class roster, assignment management, and even auto-grading if test files are included in an assignment. It also is integrated into the GitHub CLI for easier management and downloading of student repositories for grading. Assignments are created from template repositories. These can be individual or group assignments, and deadlines and a default online code editor can also be set. These include GitHub Codespaces, Microsoft MakeCode, or a link to open Visual Studio Code (VS Code) on the computer. The class roster can be imported from Google Classroom or another LMS, or input directly. Students select their own name from the roster when they first login and accept an assignment.

5) Visual Studio Code

GitHub Classroom allows teachers to select VS Code as one of the default code editor options when creating an assignment. This creates a link in the assignment to download and open the assignment repository directly in VS Code on the computer. Additionally, the 2023 Stack Overflow Developer Survey revealed that nearly 74% of both professional and learning developers prefer VS Code as their IDE [10]. VS Code is well-designed, includes an integrated terminal (command line), and is closely integrated with GitHub so that uploading or downloading repositories is as simple as clicking a button. For these reasons, it is an ideal tool to help introduce students to git and GitHub for the first time. Students who have never used the command line before may have difficulty quickly understanding GitHub's CLI, but with a few button clicks, they should

have no trouble accessing and submitting GitHub Classroom assignments.

B. Workflow

Next, this paper outlines a workflow for using GitHub Classroom and GitHub Pages in a practical programming class in three parts. Part one is for teachers setting up the GitHub services. Part two is for teachers creating and grading assignments. Part three is for students accessing and submitting assignments. An overview of the workflow is shown in Fig. 1, and each part is presented in later sections.

1) Part 1: Setting up the GitHub services

GitHub is integrated with GitHub Pages and GitHub Classroom, but the two GitHub services (Pages and Classroom) are not directly connected to each other. Table 1 gives an overview of the primary uses of each service and how GitHub is integrated with it.

First, teachers without a GitHub ID should create an account. It is also helpful to become familiar with git commands such as "pulling" (downloading) and "pushing" (uploading) repositories to GitHub. Teachers with a school email account may be able to access some educator benefits

by registering their school email account.

Second, teachers should login to GitHub Classroom with their GitHub ID, and create a class (accessible on the first page). In the new class, a student roster may be created by connecting GitHub Classroom with an LMS, such as Google Classroom, or entering unique student identifiers in the online form, one per line. Because names appear alphabetically, it is recommended to create the class roster by copying the school's official attendance sheets, i.e. using a school-assigned student ID number with the full student's name.

Third, a class repository should be created in GitHub to house the class website content that will be deployed through GitHub Pages. GitHub Pages can be set up in the repository's Settings Tab, with the Pages menu under the "Code, planning, and automation" subheading in the left sidebar. The default source for building and deployment is "Build from a branch" with the default branch being the *master, main*, or default branch. If the default branch is used for deployment, either the root folder or a */docs* folder at the root level should contain the site's content. All pages can be created in Markdown with a .md file extension. HTML and CSS can be added to the Markdown files, but after deployment, these pages will only be accessible by changing
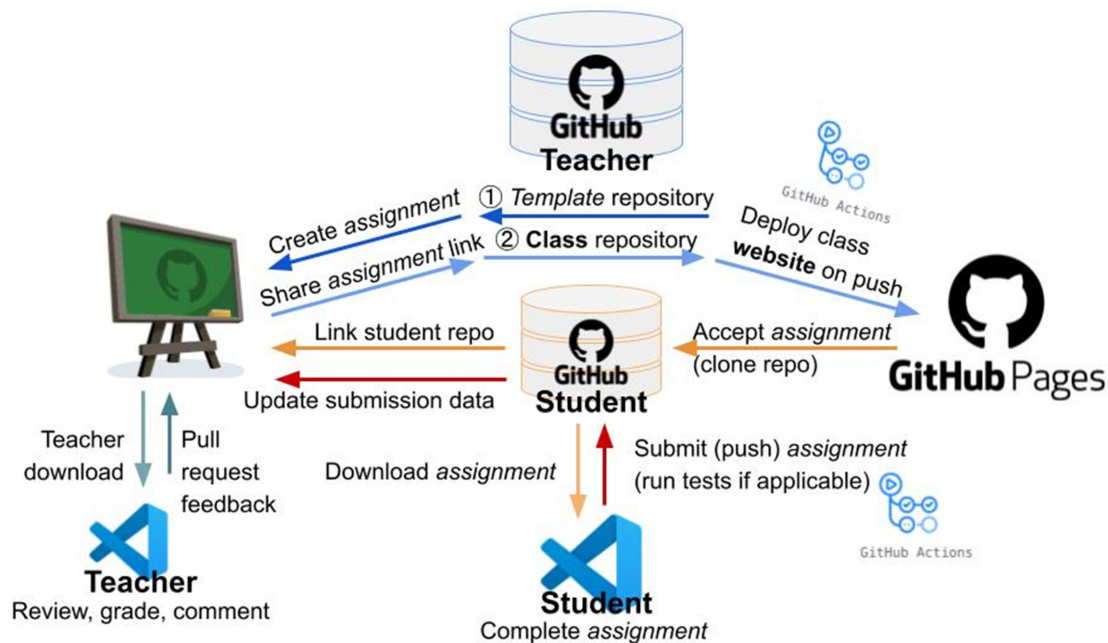

Fig. 1. GitHub Pages and GitHub Classroom Workflow.

Table 1. GitHub services and uses

Service	Description	Uses
GitHub	Repository cloud-storage	Template repositories: used for assignments Class repositories: used for class website
GitHub Classroom	Class roster and assignment management	Create assignment: *teachers* select a template repository on GitHub Accept assignment: *students* select their ID from the class roster first Submit assignment: linked to *student ID*; can be marked as late or blocked if deadline is past; can be auto-graded if test files are included Grade assignment: *teachers* submit pull requests with comments or suggestions
GitHub Pages	Class content and assignment links	Class content: updated as necessary with through GitHub Actions with a "push" Assignment links: regularly shared on the class's Assignments page

the page name's file extension to .html. If a README.md file is present in the deployment directory, it will be used as the site's index.html file. Lecture files can also be added as PDF files and accessed directly from the GitHub Pages site with relative links.

Students should be introduced to the class website on the first day of class. This is the location students will go to access Classroom assignment links.
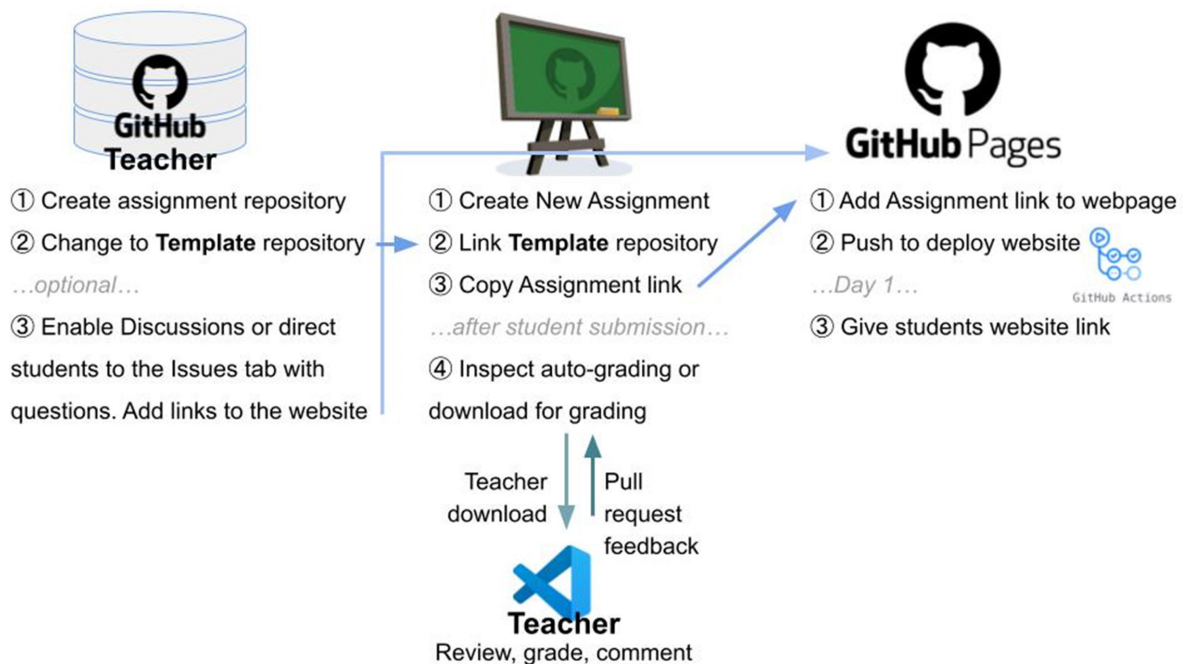
2) Part 2: Creating and grading assignments

Creating a new assignment is done in two parts. The first part involves creating an assignment repository on GitHub. The second part involves linking that assignment repository to GitHub Classroom. The following section details the workflow for creating, linking, and grading an assignment. Fig. 2 shows this part of the workflow for teachers in more detail.

First, teachers create an assignment repository with assignment content in GitHub. After the assignment repository content is uploaded to GitHub, it should be changed to a Template repository under the General heading in the repository's Settings tab. If the assignment repository is not changed to a Template repository, teachers will not be able to use it in GitHub Classroom.

Second, in GitHub Classroom, teachers open the class and click the green "New Assignment" button in the upper right-hand corner of the class page. After defining the "Assignment basics" in the first window and clicking

Fig. 2. Detailed look at creating, linking, and grading a GitHub Classroom assignment.

the "Continue" button, teachers will be able to select the Template repository and supported code editor if applicable. It is important to note that assignments can only be created from public Template repositories, or Template repositories in the same GitHub organization as the class. If VS Code is selected as the code editor, the assignment will be created with an "Open in VS Code" link. When students click that link, GitHub attempts to automatically download and open the assignment repository in VS Code on the student's computer. Additional assignment creation options include Individual or Group assignment, deadlines, the inclusion of optional testing files, and selection of a testing environment, such as Node.js. If testing files are included and a testing environment is selected, whenever the student pushes code changes to their assignment repository, the tests are run and automatically score the assignment. Once an assignment is created, an access link is made available at the top of the assignment page. This link should be copied and shared with the students in GitHub pages.

Third, the new assignment link should be added to the class's Assignments page in GitHub Pages. Updates to the website should be saved and pushed to GitHub. This will rebuild and redeploy the class website with the updated assignment link. Then in the lecture or homework assignment period, students can access the new link from the class website.

After students submit their assignments by pushing updated code to their assignment repositories on GitHub, teachers can access their student repositories on the GitHub Classroom assignment page. Table 2 displays the information for each student's assignment that is available to teachers on the assignment page.

If auto-grading is used, teachers can click on the Auto-grading result (green check or red X) to rerun the tests in GitHub Actions and view the test output. Alternatively, the GitHub Actions tab can be opened directly, and tests rerun, from within a student's assignment repository. Teachers can download all repositories using a git command and the GitHub Classroom CLI. Alternatively, teachers can inspect or install an individual student's code by clicking on their repository (code) link from the assignment page. Teachers can leave comments or code suggestions with a pull request on a student's assignment repository.

Additionally, teachers may wish to enable GitHub Discussions in the Settings tab of a repository or the organization account that holds the GitHub Classroom and its repositories. Teachers can then point students to the classroom or repository's Discussions tab, or the repository's Issues tab to ask questions about the assignment or report problems. The information in the Discussions and Issues tabs will be publicly available to the students in the class if any students encounter the same problems.

3) Part 3: Student access and submission of assignments

Students have two primary actions involving GitHub Pages and GitHub Classroom. Students first access the class's GitHub Pages website to accept an assignment, which clones the repository and links it to GitHub Classroom. After completing the coding assignment, they push their code back to GitHub to submit it. The following section explains these steps in more detail.

First, students without a GitHub ID should create an account to access and submit GitHub Classroom assignments. Students should access assignment links

Table 2. Assignment information for each assignment

Class information	Total students	Those in class roster and additional students (not in the roster)
	Accepted assignments	Number of students ("Accepted" and "Not accepted")
	Assignment submissions	Number of students ("Submitted" and "Not submitted")
	Passed students	If tests are run, ratio of passing students to failing students
Student information	Submission status	"Submitted" or "Not Submitted"
	Submission time	"On time" or "Late"
	Time since submission	"Submitted 2 weeks ago", etc.
	Auto-grading result	Green checkmark (pass) or red X (fail)
	Number of commits	"2 commits", etc.
	Links	1) Repository code 2) Open directly in VS Code (if applicable)

directly on the class's GitHub Pages website. The first time a student clicks a new assignment link, they will be redirected to a GitHub login page. After logging in, they will be prompted to select their name from the class roster to link it to their GitHub ID. It is important for teachers to confirm linked student IDs and GitHub IDs to ensure assignments are distributed and submitted correctly. Once a student's GitHub ID is linked to their class ID in the roster, they will not be prompted to relink their IDs if they continue to login with the same GitHub ID.

Second, on the following page, students will be prompted to "Accept" the assignment. When an assignment is accepted, GitHub Classroom clones the class's assignment template repository into a student's personal GitHub account. After a moment, the page can be refreshed and the newly cloned student assignment repository should be visible. If VS Code was selected as the code editor when creating the assignment, a VS Code button will also be visible. When clicked, this will attempt to automatically download (pull) the student's assignment repository to the computer and open it in VS Code for completion.

Third, once the coding assignment is completed, students should push the code back to GitHub to submit the assignment. If the assignment was opened directly from GitHub in VS Code, students can click the git button in the left sidebar of VS Code to see their repository and its changes listed. They should enter a commit message in the input field and click "Commit and Push" to push their code changes to GitHub and complete their assignment submission.

Sometimes, students have problems either downloading or uploading their assignments for various reasons. Either

their computer does not have a record of their GitHub name and email on it, or a different student's GitHub name and email has already been saved (for example, on a public computer), or another error may prevent automatic download and pushing of code to GitHub. Table 3 lists four possible access methods for both downloading and pushing code to GitHub for submission. These methods are listed from top to bottom by priority and ease of use.

IV. RESULTS AND CONCLUSION

This paper presented a workflow for integrating GitHub Pages and GitHub Classroom for better practical programming class management. This workflow was used with 46 university students in Spring 2023 in two Node.js at T University. GitHub Pages was used to organize classroom materials, lecture slides, and study guides, as well as to make links to classroom coding assignments easily accessible. GitHub Classroom was used to distribute (clone) and accept students' coding assignment submissions, as well as to auto-grade some assignments that contained test files. At the beginning of the classes, fewer than five students had any experience with software version control, but after the classes, most students felt that learning the basics of git and GitHub was beneficial in their programming class. Git, GitHub, and VS Code were chosen as tools for learning precisely because they are widely used in industry and by professional developers. As this study illustrates, both teachers and students can benefit from learning and using the basic concepts behind the flow of professional software development. Additionally, because the assignments that

Table 3. Assignment access and submission methods

|	Downloading code	Uploading & submitting code
VS Code	In the repository, click "Open in VS Code" to automatically download the repository and open it directly in VS Code.	Click the git tab in VS Code's sidebar. Enter a commit message and click "Commit and Push."
GitHub Desktop	Download the GitHub Desktop application. In the repository's green "Code" dropdown button, click "Open with GitHub Desktop."	After the code is saved in VS Code, add a commit message to GitHub Desktop. Then commit and push the code to GitHub.
GitHub CLI	Clone the repository to the local computer using the command line.	Add a commit message and push the code to GitHub from the command line.
Manual	In the repository's green "Code" dropdown button, click "Download ZIP." Unzip to the desired location.	In the repository, to the left of the green "Code" button, click "Add files" and "Upload files." Upload all modified files individually to the same location in the cloud-based repository as the local repository. Add a commit message (or accept the default) and click the green "Commit changes" button at the bottom of the page.
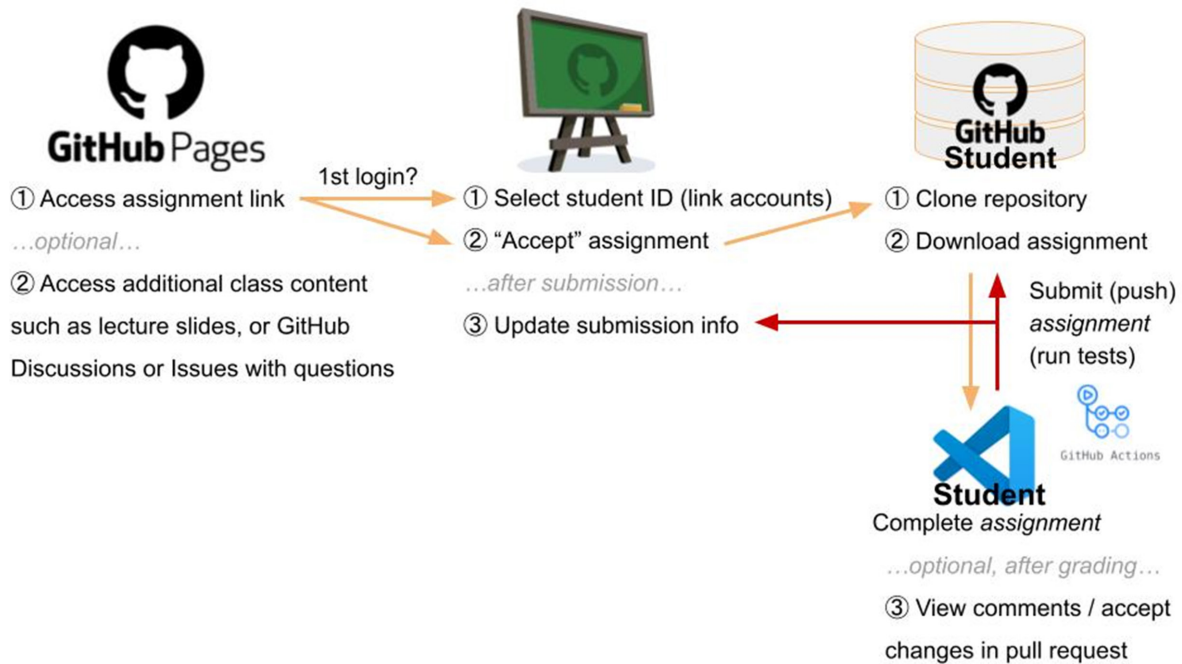
Fig. 3. Detailed look at accessing and submitting a GitHub Classroom assignment.

students complete as part of a GitHub Classroom are saved in their personal GitHub accounts, these projects and assignments can be referred to again later, or used in job applications as evidence of the kind of programming experience they have. Therefore, using GitHub Classroom for better classroom and assignment management, and using GitHub Pages for the distribution of class content is highly beneficial in practical programming classes.

Future research on this topic should seek both individual and collective student opinions with written surveys that include open-ended questions before, during, and after a GitHub Classroom experience. This will help researchers better understand how the learning and classroom experience is impacted, as well as present any gaps or opportunities for future GitHub Classroom experiences and workflows.

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