OPENEDUCATIONHUB: INCREASING EDUCATIONAL PROCESS AUTOMATION

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The education world has moved from analogue mediums to digital. This offers teachers the opportunity to take advantage of tools and features that can decrease the load. By using new technologies, we increase the availability of educational content by hosting it online, and we can increase its quality by allowing outside contributions to the content. Teachers can use their time more efficiently by handling menial tasks like spell checking through automated scripts which enables them to scale up the number of tasks they can handle in parallel. This paper proposes the Open Education Hub framework, which introduces automation that makes eases the task of creating materials, deploys materials through public platforms, to allow more access to the resources.

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1. Introduction

Education has long lagged in implementing the advancements that software development has enabled in other fields such as automation, cloud resource hosting, and outside sourcing for contributions. Following the 5Rs principles for Open Educational Resources (**r**etain, **r**euse, **r**evise, **r**emix, **r**edistribute), we have identified a set of goals for class organization in a digital age:

- resources must be easily available online or offline, so more users can have access to them, and later contribute;
- classes have to use as much automation as possible; teachers are tasked with guiding and mentoring students, having them do administrative tasks defeats this purpose;
- the resources have to be easy to contribute to, as this allows interested parties to contribute without hassle.

The focus of our work is on creating automation mechanisms to **reduce time spent building and maintaining materials**, allowing teachers to focus on the act of teaching. We intend to **increase resource availability** by making hosting resources online for teachers using our Open Education builder framework. By using a Git-centered workflow, we make it **easy for parties to contribute** by creating change requests through Pull Requests or raising issues through the community features Git repositories have. The building framework has been implemented for three classes and other classes have expressed interest in migrating to it.

Building class materials is just one aspect of class preparation. Evaluating students is another facet of teaching that requires the attention of teachers.

This paper makes the following contributions:

- a framework to automate the workload of building and maintaining class materials;
- processes, tools, and materials that can be used by educators to create their class materials;
- an educational resource management platform and class-building framework that builds and deploys classes, permitting others to contribute to them;

We will present the background and tools that are being used in education now for building content, deploying content, and the pitfalls that these solutions have in Section 2. Section 3 presents the goals, architecture, and implementation of the content building platform, called the OER-builder. Section 4 debates the results obtained when deploying the implementation, the classes that we have migrated. Section 5 concludes the paper by highlighting the work done, and the growth opportunities for the Open Education Project moving forward.

2. Background and related work

In this section, we will be exploring the current tools used by educators for creating content and evaluating students' output. We will be focusing on criteria such as ease of use, ease of setup, license, ease of contributions, and ease of reuse.

The content used in classes can take the form of assignments, quizzes, tutorials, and lectures. These forms of content themselves contain questions, slides, written essays, follow-along content, and more.

2.1. Static content on e-learning platforms

Universities have been using books, written tests, and slide decks for learning. Books and slides have been moved online to e-learning platforms, such as Moodle [16], where they are now stored as PDFs, Microsoft Word files, and question banks. The new types of classes depend on the e-learning platform setups that the institution provides. The platforms are closed to outsiders in most cases, and changing the content hosted can be done only by the teachers. Outside contributions are made by contacting the professor and having them change the content. All actions are dependent on the person who creates the content, and they need to spend time on creating the e-learning class, populating it, creating the content, and maintaining it.

2.2. Wikis

A push has been happening to move class materials to a wiki-based format [13]. Wikis are a type of hypertext-based website based on a collaborative content model. A content creator can push content to a wiki, and it will be publicly available, as wikis are built with the collaborative model in mind. The wiki format makes it a good fit for written content, such as tutorials, as they are just essays that the students follow along.

Hosting other types of content on a wiki is difficult. Slides need to be hosted as PPT or PDF files, so they cannot be easy to contribute to. Assignments can't be hosted on wikis unless the pages are locked, so students can't modify their problem statements.

Educational content does not fit the wiki collaborative model, as the content has to be vetted first. Wikis allow for content to be changed, and the changes will be evaluated retroactively. This can be mediated by locking the content contribution to a certain group of people, but it will decrease the engagement of students in class to contribute to the content when they cannot do this themselves. Infrastructure needs to be set up and maintained for class wikis. This requires person hours from the teachers, and they need technical knowledge to host wikis.

The UNSTPB has been using an Open Course Ware platform to host course materials since 2012 [10].

2.3. IT Documentation Builders

There exist many documentation builders, as this is a task often needed for documenting projects. Examples include Sphinx [9], used by the Linux Kernel project [6], Docusaurus [2], used at Facebook, Docsy [1], and others. The content can be hosted in Git repositories, which makes the content easier to contribute to, and adds more visibility. Documentation builders generate content that can be deployed automatically in a public environment, even one hosted externally The build process can be automated to use spell checking and format checking and to output and even set actions such as rewards or labels for contributors

Although these projects build documentation, the process of configuring them requires advanced technical knowledge, which is not available for many content creators and contributors. Configuring these solutions is not easy to automate and set up, so each class that would like to set up the content must go through a difficult set of steps.

The documentation builders are created as a way to build code-centric documentation, and this is not the case for all documentation content. They cannot build quizzes or slides, and they are focused on tutorial-based content.

Existing builders output HTML code which can be hosted on static content repository hosting such as GitHub Pages or GitLab pages. Configuring HTML code deployment is a task that has to be implemented by infrastructure administrators, or teachers. Checks also have to be implemented per class by the infrastructure administrators, adding to the overhead of setting up class materials.

3. Open Education Resources Builder

Educational content has been hosted online since the dawn of the internet [14] in the form of wikis, tutorials, blog posts, and others. The internet has, by its nature, increased access to educational resources, and it has increased the amount of information that is proliferated. As part of the Open Education Hub project, we have taken to creating tools that make building, distributing, and using educational materials across the internet easier.

The issue with current educational resources is that in many cases they are not built in an OER fashion. Resources cannot be remixed, or reused without hassle, or they have restrictive licensing, especially if they come from higher education institutions, which use them to generate more revenue. As part of OER resources, they should also be easy to contribute to and remix. To achieve this, resources should be organized in an easy-to-change format to the maximum extent.

3.1. Educational Content Builder Goals

Open Education Hub wishes to use a framework with which students and teachers can build and contribute to educational resources. Using existing

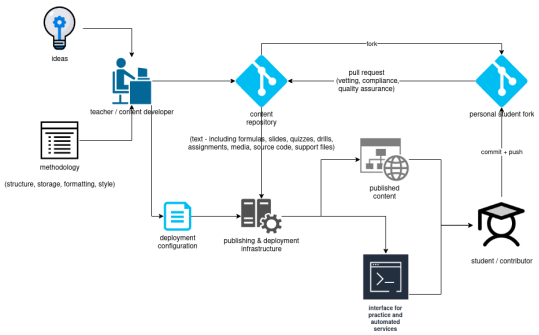

FIGURE 1. Open Education Content Flows

software solutions for enabling OER contributions is a priority because this means less time spent on maintaining code, and adding new features. An existing solution can evolve without the need to change the framework.

An OER builder should allow for an automated setup for the required resources, to spend less time managing the framework and more time creating content. The framework should have options for automated checking for various aspects, such as spelling errors, or bad formatting.

While documentation builders exist, as mentioned in Section 2, they are focused more on generating content such as manuals and tutorials. They do not cover the breadth of materials such as quizzes, tutorials, slides, and interactive work. This limits the amount of resources a class can include in them if used as an out-of-the-box experience.

A content builder has to be easy to use and configure. A minimum number of steps should be taken to start creating and deploying content. The content that is deployed has to be easy to copy and re-build by other interested parties.

Text must be de primary content storage method because it can be easily edited without requiring special tools. It should be used whenever possible, even for diagrams, because changes can be easily tracked using a versioning tool.

Since all the above-mentioned documentation builders work with text, most have a rigid directory hierarchy that has to be respected. This makes it hard for newcomers to add their changes to the code.

As a result, we have created our builder project, which can satisfy all our requirements. It will be built with the use cases mentioned in Subsection 3.**2** in mind, and according to the Free and Open Source Software philosophy.

3.**2**. **Educational Content Use Cases**

The Open Education Hub project defines expected behaviors for each type of person who wants to use, create, or contribute to the content. These use cases are defined in Figure 1.

The content creator is the teacher who wants to create a course or convert a previously existing course into an open format. This type of user does not have to be from a technical field, but they have to be able to use text editing tools and have a basic understanding of versioning systems. The builder software must accommodate this type of user by setting as little overhead as possible for creating content and automating its deployment.

Content curators are tasked with integrating changes from third parties in the educational content repository. Their tasks include reviewing content change requests made by users and integrating them into the existing repositories.

The job of content curator must be automated as much as possible, so the new changes can be checked for spelling mistakes, format errors, and integration conflicts without the input of the curator. The curator's primary task is to see that the content makes sense in the context of the class's curriculum and stated goals.

Once the changes are accepted the new version of the class must be rendered as soon as possible including the new modifications.

A content contributor is a person who wants to include additional content to the existing materials. The additions can be small changes, such as spelling changes or clarifications, or they can add whole new sections or chapters to the classes.

The contributor must be able to download the class, add changes to it, view the changes, publish them, and open a change request to the class repository to have the work integrated.

Teachers' primary attribute is to take the content created and adapt it to their class; they can also be content contributors if they want to upstream their changes. The primary functionality needed by teachers is the reusability and remixability of the content. It has to be easy to download and select the content needed for a specific instance of the class. The content also needs to be easy to rebuild and publish for consumption by users other than the creator.

A teacher can either teach based on the main class materials, or they can use their own adapted materials.

The content consumers are in most cases, students. The content is geared towards their educational needs and should be easily accessible.

To make content easily accessible, it should be available both online and offline.

3.3. **oer-builder Architecture**

The oer-builder project has been built as a modular project, that can be flexible in integrating different kinds of materials in a class. The builder also needed to allow for integrating different kinds of use cases.

The programming approach for the builder was iterative. We have designed and built the necessary modules to include all the required class materials for the Operating Systems class, which uses tutorials, slides, slide notes, figures, demos, and quizzes to deliver its content. The needs of the solution have evolved with the needs of the Operating Systems class, and they have helped flesh out the requirements and expectations for an open source content builder. Figure 1 shows the final form of the oer-builder and how users interact with them.

Git was chosen as a text management solution for class materials. Since we require that all class materials be in text format, so we can edit them with basic applications, using Git was a viable solution. It is one of the most used code versioning tools. The ease of use was a factor in making the decision, as there exist platforms that host Git content, like GitHub. Text editor plugins and web interfaces allow users to manage text without running the Git commands in a command line interface. Text-backed solutions were chosen to fill the needs of the class, whereas in the past static, binary content would have been used.

Classes need to be built in a rich text format that can be converted into deployable content. The rich text needs to support links, formulas, itemized lists, enumeration, images, GIFs, and more.

We have chosen to create content in the Markdown (MD) format because it is used by many existing documentation builders. Markdown is extendable and text can be converted to it from other formats such as RST or LaTeX using already existing tools, allowing easier migration from other content forms.

The builder is packaged as a container environment so that users can use it no matter the operating system and environment they are using. Containers allow users to pull the latest version using a container image manager. The running environment setup overhead is passed from the user to the builder developers.

We have concluded that the Minimum Viable Product for a class would be an interactive class where students would follow tutorials available on a page online.

This requirement would map directly to the use of a documentation builder. Docusaurus was chosen as a documentation builder because it is fully featured and provides plugins for added functionality. Docusaurus supports the Markdown text format, which supports the use of rich formatting, and admonitions and can even include in-page iframes, allowing us to add more advanced features to pages.

We have written an oer-builder module that automatically installs Docusaurus, configures it and builds a page based on the user requirements.

A user has to create a configuration file in which they have to specify the paths to the markdown files they wish to include and the chapter name. Mode advanced options can also be included, to customize the course.

Listing 3.**3** displays a basic configuration that includes configuring the course name, subchapter, and the URL where the documentation will be hosted

```
docusaurus:
  plugin: docusaurus
  options:
    course_name: Example Course
    sidebar: js
    structure:
      - Class1:
        - Chapter1: content/chapters/chapter1/lab/
            README.md
    static_assets:
      - Compute: /build/make_assets/content/
          chapters/compute/lecture/_site
    config_meta:
      title: Operating Systems
      url: http://localhost/
      baseUrl: /
      onBrokenLinks: warn
      onBrokenMarkdownLinks: warn
```

Listing 1. Configuring Docusaurus

This is the minimal configuration file needed to use the oer-builder.

Tutorial content can contain static assets such as pictures or figures. They must also be integrated as text as much as possible. Figures can be drawn using Draw.IO [3], saved as SVG files, and integrated as such, because it is a format that can be modified after the fact. This is possible because the Draw.IO save format is text-based.

In academia, slides are regularly stored and displayed in PDF or PPT format. We chose not to use this because while the slides contain text, they are stored in binary format PDF and PPT slides make integrating feedback a manual process that cannot be tracked and automated easily.

reveal-md [8] is a tool that builds markdown files into JavaScript content to be viewed inside a browser window. The JavaScript content can be integrated into other forms of content, or it can be viewed by itself.

In the oer-builder we call reveal-md using a plugin that calls the `reveal-md` command with specific arguments. Integrating the slides into documentation requires the addition of the already built JavaScript code to the documentation. We have written a module that embeds reveal-md slides in Docusaurus content. It needs to be configured with the chapter name and the directory name of the chapter.

oer-builder integrates support for quizzes in the tutorial material. Quizzes are a way of testing students on the knowledge gained during the tutorials. A

quiz is also a tool to keep them engaged with the content when it skews towards being more theoretical. They can be graded or non-graded. As we do not link the oer-builder to any institutional infrastructure, there is no way to authenticate students to store their grades.

A common quiz template has been created to represent a question and a set of answers, with the correct answer being marked. The plugin parses the Markdown files for references to quizzes. The references are followed to the question location. The question is then read and converted to JavaScript code that is integrated into the Markdown code.

3.4. **Deploying Content**

Deploying content is the action of making content built locally by creators and contributors publicly accessible. This requires having a platform where the content can be hosted The content also needs to be in a format that can be accessed using commodity software.

The action of documentation deployment is done in major software projects automatically by using automated actions in Git hosting platforms such as GitLab or GitHub. The hosting is done through Git repositories.

The deployment actions allow for code to be deployed automatically on changes, not requiring any input from the user after the code is uploaded to Git. Both GitHub and GitLab also provide DNS entries, so the pages can be easily accessible if the user knows the project and repository names.

oer-builder outputs HTML code, which is viewable in an internet browser. Because the code is HTML, it can be hosted as static content on many types of platforms. We have chosen to host both the class content itself and the static HTML content on GitHub because it offers more visibility, GitHub being the most used code repository [15].

Using GitHub allows us to achieve the goal of automating the action of integrating changes. This permits us to run automatic tasks when text is changed, such as checking its spelling and formatting. GitHub provides an action marketplace, which reduces the amount of automation code that we have to integrate.

The automatic code deployment needs to be set up for each repository, which translates to a class. The setup can be achieved by activating GitHub Pages for the repository and creating an action file. The actions file is set up by default in the oer-template repository [7], which we recommend teachers use when writing OER classes.

3.5. **Integrating Changes**

Integrating feedback in the Open Education Hub ecosystem is done by opening pull requests for the repository that maintains the class. An author needs to have created their copy of the repository, and the changes must first be submitted to their copy, before being sent through a pull request.

All the above actions can be done through the web interface offered by GitHub, or text editing tools, such as Microsoft Visual Studio Code [11]. The ease of use for this solution is given by the fact that the changes are checked automatically for spelling mistakes and formatting errors. The code submitted to the pull request is automatically added to a testing play area where reviewers can see the final output of the class, with the proposed changes included.

The checking and deploying steps are done automatically through GitHub actions that are present in the template repository, which should be copied by authors writing OER classes.

3.6. Using the content

The Open Education Hub's goal is to provide teachers with ready-made classes that they can copy, using Git, and write their content to it. We wish to provide a hub of classes that have been already created using our methodology. The classes have already had the work of automating deployment done, so they don't need any more attention from the teachers. A class still has to be adapted to integrate the materials used by the class.

An institutional copy of the class can be used by the teacher, and they can integrate updates that are done in the original repository.

4. Results

The Open Education Hub GitHub organization has been created to automate the operation of the different components that take part in class management and class creation. A methodology has been created to guide teachers in building and maintaining OER classes.

The GitHub organization has been created to maintain classes that have been built using the methodology and whose maintenance is passed to the Open Education Project. This frees content creators from the burden of managing pull requests and issues with the class.

Classes can be freely forked and remixed by other projects or institutions; automation having been put in place to allow classes to have automatic deployment and linting using the GitHub API.

Three classes have been integrated into the Open Education Hub GitHub organization. These courses have been rewritten to take advantage of the oer-builder. They include quizzes, slides, figures, tutorials, and assignments in the repositories.

4.1. The Operating Systems Class

The Operating Systems class was the first one integrated. The repository is based on the class that is taught at the National University of Science and Technology POLITEHINCA Bucharest (UNSTPB). It was migrated from a wiki-based format where the content was hosted on institutional servers. While the wiki was easy to access for the students, including student feedback was

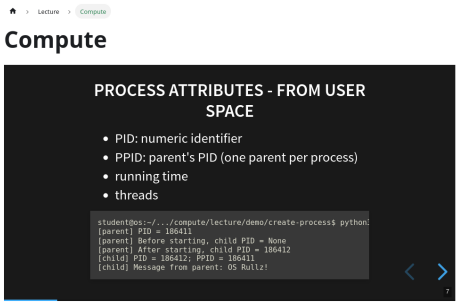

FIGURE 2. Operating Systems Slides

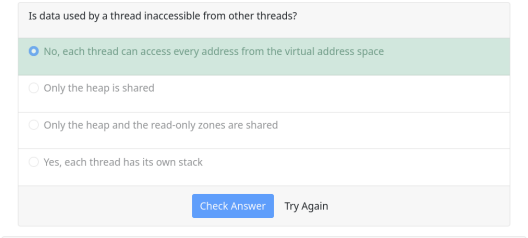

FIGURE 3. oer-builder quiz correct answer

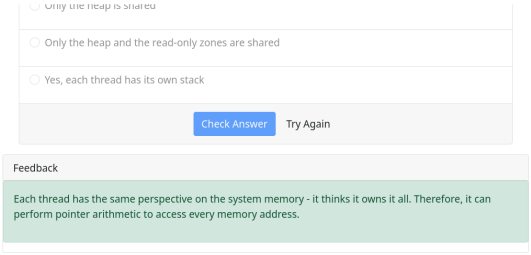

FIGURE 4. oer-builder quiz feedback

difficult without giving students access to the whole class workspace which included internal documentation for the OS team.

The class is focused on tutorial work done by students as part of interactive sessions with TAs. Consequently, the largest part of the repository is taken up by written content and assignments.

Figure 2 displays slides built using the builder integrated into the operating systems class web page.

The quiz format we have deployed is displayed in Figures 3 and 4. We can see they display the right answer and an explanation for why it is correct.

The class has gone through two semesters of teaching based on the new materials. The idea of providing feedback and raising issues in GitHub has been promoted among the students, with them being rewarded with a physical Operating Systems pin for service to the community.

Students have opened 32 pull requests which have been integrated into the class materials.

The new content building process has allowed the team to scale up the amount of people who can work in parallel on the content. By using GitHub, each new content chapter had its pull request. This helped organize the feedback process, as the changes could be discussed on the page, and suggestions were made in-line. The content was automatically checked for format and spelling errors, allowing users to concentrate on the content quality. When merging the new content, it is automatically deployed, removing the need for a systems administrator to do this and coordinate the different merges.

4.2. Computing and Calculus for Advanced Statistics

The Computing and Calculus for Advanced Statistics (CCAS) class is a statistics class taught at the University of Iceland. It is a course focused on lab work based on a class written for the R programming language.

The class has been migrated from a lab book that was built in LaTeX and it was distributed as a PDF document. This approach is not easy to deploy, as you need a shared space with the students or a public website, it is not easy to search for, and it is not easy to contribute to, because the source code is not shared. Another issue is that LaTeX requires more expertise than a rich text format to write in, and the packages needed to use it are large and not ubiquitous on all platforms.

A script based on the `pandoc` tool was used to migrate the LaTeX content to Markdown. Because the classes were already in a text format, stored centrally, the process of converting them to another format was easier than having the resources dispersed in multiple classes or multiple PDFs.

The fact that we were able to use scripts to automatically convert content proves that other classes could convert their content to work with the oer-builder, and take advantage of its features.

4.3. Security Summer School

Security Summer School (SSS) is a workshop focused on teaching security principles. It is taught online, with resources hosted online. The resources were already built using Docsy [1], which is a documentation builder that converts MD files to HTML. It was already using GitHub Actions to automate resource deployment and pull request checking.

Although the setup was done following OER principles, it was difficult to replicate by other institutions and make changes locally because it was using Docsy-specific configuration files. A user would have to learn the Docsy configuration parameters to learn how to contribute to the project. This presented a hurdle in encouraging other users and institutions to contribute content.

The SSS workshop has been migrated to the Open Education Hub. It has been configured to run the oer-builder and integrate with Docusaurus. The

migration was easy to do, as it only involved moving the Markdown files to a new repository which was configured using the builder.

5. **Conclusion and Further Work**

The Open Education Hub project has developed and deployed tools that help teachers reduce the administration load that is set on teachers. We have done this by creating workflows, templates, and frameworks that automate the tasks of integrating and deploying new materials. These actions have been done while also increasing educational resources availability by posting all materials online in an open source fashion, allowing third parties to both consume the content and reuse it.

We have built an Open Source tool that improves the process of creating materials and publishing them. Creating the tool, we have migrated three classes to the OER standard improving the process of maintaining the classes.

The conversion process has already begun for other classes at the UNSTPB. We are targeting easy wins, classes that are already text-based, that can be more easily converted than writing them from scratch.

We aim to increase student and third-party engagement with the public resources available in Open Education Hub. To achieve this, we want to implement digital rewards using Smiley Coins, an educational cryptocurrency. Integrating it in a production environment will be a priority, as we have already implemented a Proof of Concept for the Operating Systems class.

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