Building Open Educational Resources from the Ground Up:

South Africa's Free High School Science Texts

ISKME | Institute for the Study of Knowledge Management in Education

October 2007

By Lisa Petrides, Cynthia Jimes, and Thad Nodine

Table of Contents

Executive Summary

This paper presents a case study of the development of the South African project Free High School Science Texts (FHSST). The goals of this paper are two-fold: to examine and analyze the practices associated with the successes and challenges encountered by FHSST; and to encourage a participatory, analytical process that will assist other open education projects in thinking about and sharing their practices, processes, and strategies. Ultimately, the findings from this study will be used as early input into the development of assessment tools and resources that can assist any open education project in tracking, sharing, and advancing their learnings and success. The long-term goal is to develop ongoing mechanisms for knowledge sharing on open education initiatives worldwide.

Findings

Free High School Science Texts (FHSST) was created to develop a free high school science text for all teachers and learners in South Africa. As the scope of the project expanded from creating one text to developing four (in physics, chemistry, life sciences, and mathematics), FHSST faced the following key challenges and opportunities:

1. Recruiting volunteers and adapting for growth. Although FHSST used multiple methods to expand its base of project participants, its most successful means for generating active participation was through face-to-face networking. At the time of this report, FHSST had recruited over 400 volunteers, 50 of which were active. Of these 50, approximately ten became core participants, contributing content regularly and consistently. Most of its ten core contributors were colleagues of the founders or directly approached by one of the founders to engage their participation. Comparatively across OER projects, this highlights the potential importance of recruiting through traditional networking, and finding ways to package and share the project vision and benefits through electronic and other means of recruitment.

2. Sustaining communities of volunteers. To maintain and support its growing community of volunteers, FHSST experimented with a variety of ways to encourage volunteers to stay engaged and productive, including:

- Developing an effective peer production platform that met volunteer needs and their ability to submit content easily and efficiently;
- Dividing large content assignments into smaller segments so they were more manageable for volunteers to work on and complete;
- Developing and supporting three stages of content development and editing, and refining the roles of editors;
- Facilitating face-to-face means of content creation and support through “hackathons” for groups of volunteers living in the same geographic area; and
- Providing collaborative tools such as online forums and local meeting opportunities, through which volunteers could communicate and offer feedback to each other.

The development of these methods was an evolving process through which FHSST sought to accommodate volunteers' technology skills, work styles, schedules and geographically disperse locations, as well as meet their need for face-to-face interaction and motivation.

3. Ensuring that content is relevant. Through teacher participation, networking, user trials, and workshops, FHSST solicited feedback from the intended end users of its content early in the content creation process in order to facilitate their buy in and ensure that the content was relevant, usable and adaptable to local teaching and learning needs. Importantly, this was accomplished within the parameters of curriculum guidelines at a country-wide level, so that the content matched policy requirements. The teacher and learner trials proved instrumental in improving FHSST's expertise and helping FHSST to confirm and identify and address the textbook areas in need of improvement.

4. Sustaining the project and its processes. The sustainability of FHSST has been facilitated through the project's ability to continuously assess and develop solutions that sustain volunteer engagement, ensure that the project reaches its goals, and that result in the development of textbooks of use by teachers and learners. On the whole, the findings of the FHSST case study imply that an important aspect of project sustainability involves the implementation of practices that replicate the characteristics of open educational resources themselves: namely, those that are collaborative and peer-based, and that invite continuous improvement by stakeholders. For other OER projects, this indicates the potential necessity of developing community-centered technologies, processes, and cultures that can support experimentation, self-assessment, and adaptation, while maintaining and continuously reinforcing a clear sense of overall mission.

Discussion and Implications

FHSST offers insights into overall approaches and goals that may prove instrumental across open education projects as they seek to reach their vision. The text below provides a discussion of these overarching themes in order to explore the implications for the field of open educational resources at large.

1. Experimentation and Adaptation. An important insight gleaned from FHSST is that experimentation and adaptation are central components of an open education project's ability to sustain itself, both in terms of the communities it works with as well as in terms of meeting its goals. For other OER projects, this points to the importance of instilling structures and practices that are aligned to project goals, but which also can be adapted and iteratively tuned to shifting stakeholder needs—regardless of whether it is in terms of technology choices, peer production practices, funding models, etc.

2. Culture of Collaboration and Support for Volunteer Engagement. The case of FHSST points to the importance of supporting a culture of collaboration within OER projects, particularly through structures and practices that support two-way, peer-based interactions and engagement around the everyday work of the project as well as around strategic decision making. The study of FHSST also indicated that because supporting such a culture—especially in terms of creating

a community feeling and a sense of urgency around project involvement—can be difficult in pure online environments, finding ways to replicate the benefits of face-to-face interactions within the content authoring platform and project website becomes central.

3. Top-Down, Bottom-Up Facilitation. From the onset, FHSST leaders focused on two parallel strategies for creating textbooks: (1) bottom-up: ensuring that the texts were relevant, easy to understand, and adaptable to local needs; and (2) top-down: ensuring that they adhered to the high level curriculum guidelines and South Africa's outcomes-based education system. For other OER projects, the issue potentially becomes: how can local user needs and higher-level structures be addressed and mediated so that content is relevant, usable, adaptable, and sustainable?

4. Leveraging Community Resources. In adapting and improving, FHSST was able to draw upon and look beyond the purview of its internal resources in meeting its project goals. For other OER projects, this points to the potential necessity of carefully brainstorming and determining what internal and external resources can be leveraged to support project goals.

On the whole, the case of FHSST suggests that a central aspect of project sustainability involves the implementation of practices that replicate the characteristics of open educational resources themselves: namely, those that are collaborative and peer-based, and that invite continuous improvement by stakeholders. For other OER projects, this indicates the potential necessity of developing community-centered technologies, processes, and cultures that can support experimentation, self-assessment, and adaptation, while maintaining and reinforcing a clear sense of overall mission. Drawing on the case of FHSST and a series of other case studies, the Institute for the Study of Knowledge Management in Education (ISKME) is currently developing tools and templates that other OER projects can use in their own internal assessment and continuous improvement efforts.

This study, which was conducted by ISKME in conjunction with members of the FHSST team, was supported by the Shuttleworth Foundation, the International Development Research Centre, the William and Flora Hewlett Foundation, and Curriki. ISKME is an independent, nonprofit research institute that helps schools, colleges, universities, and the organizations that support them expand their capacity to collect and share information, apply it to well-defined problems, and create human-centered, knowledge-driven environments focused on learning and success. ISKME achieves this goal by conducting social science research and evaluation, developing and sharing innovation, and facilitating knowledge sharing and field building.

I. Introduction

Partly because the development of open educational resources (OER) is a relatively new field that is just now receiving more widespread attention and study, there have been few opportunities to share knowledge across program, organizational and national boundaries. This paper presents a study of the OER project Free High School Science Texts (FHSST) as the first of a series of steps meant to advance and support the sharing of knowledge about effective strategies and models for developing open educational resources both locally and globally. The goals of this paper are two-fold. The first goal is to examine and analyze the practices associated with the successes and challenges encountered by Free High School Science Texts. The second goal is to begin a participatory, analytical process that will assist other open education projects in thinking about and sharing their practices, processes, and strategies. Ultimately, the findings from the FHSST study and five additional studies will be used to develop assessment tools and resources that can assist any open education project in tracking, sharing, and advancing their learnings and success. The long-term goal of is to develop ongoing mechanisms for knowledge sharing on open education initiatives worldwide, through all types of research, stories, and experiences.

FHSST was chosen as the case under study based on evidence of milestones reached in successfully creating standards-aligned, peer-produced open educational content. FHSST started in 2002 by five individuals with a vision for improving South African education through the creation of a single science textbook, and evolved into a four-book project where volunteers from disperse areas of the globe successfully collaborated to complete content that met curriculum standards and local teaching and learning needs. FHSST was also chosen as the case under analysis because it was interested in research as a means of self evaluation and improvement. Before the case study research began, FHSST had conducted teacher and learner trials of its textbook content in eight South African schools in order to ensure that the content met local teaching and learning needs. FHSST expressed further interest in additional research to assess other practices and issues that had not been internally examined, but which were deemed as central to the projects' success—issues including community engagement within its content creation process, and overall project sustainability.

We hope that the study of FHSST might provide a set of insights that other projects and funders of projects can draw upon in planning and decision making. Specifically, the findings from this study can be used to inform common project activities around the peer production of open content, such as how volunteers are recruited and sustained, or how user trials of open content are spurred and conducted. It is important to note, however, that as the purpose of the study was to examine the specific dynamics of a single setting—namely FHSST—it is meant not as a blueprint for open educational projects in general, but as a basis for reflection and understanding of how one project successfully created content and met challenges along the way. We therefore offer this case study to the wider open education community—projects, funders, researchers, and all others—to pull out insights of relevance, to adapt it, and to comment upon it (comments can be posted at http://wiki.oercommons.org/mediawiki/index.php/OER_Case_Study_Project).

II. Background and Methodology

The case study drew upon a participatory research methodology (see, e.g., Fetterman &, Wandersman 2005; Fals-Borda & Rahman, 1991), which entailed the development of research and data collection tools collaboratively with the FHSST. As such, ISKME's role as researchers became that of a critical friend and facilitator, and not as a final decision maker or research expert. Value and weight were thus placed more upon the insights and experiences of importance to the organizational members, as it was deemed that it is from their perspective that knowledge could be cultivated to inform practices and continuous improvements.

The research entailed three initial phone interviews and one face-to-face interview with FHSST founders to shed light on the history and current state of the project, as well as key successes and challenges that were met as the project evolved. Each of the interviews lasted approximately one hour. A semi-structured interview format was chosen in order to successively build upon each interview; issues that arose out of a given interview were used as a basis for further inquiry in subsequent interviews and data collection activities.

The interviews revealed that recruiting and sustaining a community of volunteer authors was of central importance to the project's past and future success. As such, and an email survey was created and distributed collaboratively with the FHSST team to gain insight into how FHSST's author volunteers perceived the project's volunteer recruitment and peer production processes. Specifically, the survey consisted of a combination of open-ended and closed-ended questions that addressed issues around volunteer recruitment, engagement and support. An email survey was chosen because of the volunteers' disperse geographic locations, and because they communicated through this medium with each other already. The survey was also posted on the FHSST website by the FHSST team as an additional channel of communication to the volunteers. Six of the ten volunteers who were emailed directly responded to the survey, providing insight into the mechanisms that were successful in supporting volunteers, and which needed to be added or developed further. Two of the survey participants were selected to participate in follow-up interviews. Informed by the preliminary analysis of survey data, these interviews were designed to elicit a more textured illustration of the volunteers' experiences and perceptions around their participation in the project.

Alongside the interviews and the survey, ISKME conducted observations of activities on FHSST's discussion forums and authoring platform, as well as of internal and external reporting documents and web-based content. These observations served as seeds for further material collection. For example, observations of volunteer postings on the FHSST forum led to interview questions with the FHSST founders and volunteers about the volunteers' level of activity on the forums.

In line with the participatory research model, the analysis and synthesis of the FHSST data and findings were iterative and collaborative. FHSST served as a sounding board and communication partner during the development of analytical themes from the data; FHSST also read early

syntheses of findings, and commented upon drafts of this article. One of the FHSST founders also joined an online project community around the case study, where community members could post blogs, make comments, and present updates on the progress of the study

Based on the process and results of this case study, ISKME is developing and disseminating a case study framework for use by program leaders of a set of other OER projects that are also involved in the process of tracking, sharing and advancing their practices and learnings. The framework will include tools, protocols and other resources to assist these projects in capturing, analyzing, and sharing their learnings through the development of their own case studies. ISKME serves as a resource in the use and adaptation of the framework to create the case studies, as well as by providing leadership and quality control throughout the process, while drawing from the experiences of these programs in using the case study framework to refine and improve it for use by others. In addition, ISKME will create a comparative analysis of the case studies in a formal white paper on lessons learned, in order to advance the field of open education content globally, which will be available in fall 2008.

III. Free High School Science Texts: Overview of Development

In March 2002, Mark Horner, a graduate student in physics at the University of Cape Town (UCT), presented a demonstration on waves at a science fair in South Africa. After the demonstration, several high school students approached him, explaining that they did not have a science textbook, and had never had wave phenomena described to them before. The students had pooled their money to purchase a notebook and pen, and they asked Horner to write down the demonstration, step by step, so they could share the notes with their classmates and teachers. Wanting to give the students more than the steps of a wave demonstration, Horner returned to UCT and engaged his colleagues in writing a high school science text that would be free and sharable for all teachers and learners in South Africa. In the process, Free High School Science Texts (FHSST) was born.

From the start, Horner and his colleagues at FHSST focused on the key science concepts that high school students need to know, the aim being to create a usable, relevant science textbook. Yet the more they became engaged in the project, the wider the circle of volunteers became, and the more they learned about the dearth of textbooks in both rural and urban schools in South Africa. The project grew from a vision to create one free high school textbook (covering grades 10 to 12) to four, including physics, chemistry, life sciences, and mathematics. The expanded scope required more volunteers and contributions than expected, which in turn required continuous problem solving around the project's content development process to facilitate a larger community of contributors. The project experimented with refinements focused on enabling volunteers to help reach its content creation goals, including: parsing out content assignments into smaller segments to make their completion more manageable for volunteers; facilitating face-to-face means of content creation and support; and providing more collaborative tools for peer feedback, such as online forums and local meeting opportunities..

As the project progressed, the founders realized that adequately serving the needs of South African teachers and learners required an informed understanding of existing content requirements, both in terms of the government and the schools themselves. Therefore, FHSST worked with a curriculum expert within the government to ensure that the texts met the Ministry of Education's national curriculum guidelines. In addition, FHSST conducted teacher and learner trials and workshops in eight pilot schools, in order to receive feedback about how to make the texts more relevant, useful, and adaptable to local teaching and learning needs. This attention to top-down requirements and bottom-up needs necessitated new levels of attention, expertise, and support. As project leaders began to search for funding to support these needs, the fundraising process itself became a process of trial and improvement. The project obtained its initial funding four years after its inception, in 2006.

As Free High School Science Texts expanded its scope and sought to ensure the success of the project going forward,, it faced many new challenges and opportunities, including that of recruiting volunteers and adapting for growth, engaging communities of volunteers, ensuring that content was relevant, and overall, sustaining the project and its processes. The following four sections discuss each of these in turn.

Recruiting Volunteers and Adapting for Growth: From Inception to Implementation

Two early attributes of Free High School Science Texts (FHSST) were crucial in assisting the project to reach its key milestones. These attributes included developing and communicating a strong vision to its stakeholders, and adapting and modifying practices to better reach its goals. As this section reveals, both of these attributes were instrumental in recruiting communities of active volunteers to the project, and in keeping these communities focused on the overall goal: free textbooks for all.

Developing and Communicating a Vision: Recruiting Communities of Volunteers

> We know that lack of textbooks is the largest problem in South Africa. It's well documented. Many schools have up to four kids sharing a textbook. And that is in science. They have to copy out their homework every night because they can't take the book home with them. So kids aren't taking science simply because they don't have textbooks. This is a real tragedy. –Mark Horner, Founder, Free High School Science Texts

Mark Horner founded Free High School Science Texts (FHSST) in order to address a widely acknowledged need for high school science education in South Africa. The aim was to create a science text (spanning grades 10 to 12) that would be free and sharable for all teachers and learners—in South Africa as well as elsewhere. As the scope of the project grew from creating one text to developing four (in physics, chemistry, life sciences, and mathematics), Horner and his founding colleagues realized that they needed to expand their circle of expert volunteers to assist in writing, editing, and compiling the content. As FHSST developed, it used several processes, both traditional and electronic, for expanding its volunteer base, including posting announcements on

global list serves, distributing fliers on college campuses and at other venues, networking with fellow graduate students and other colleagues, creating contests, and eventually putting announcements on Facebook and other social networking sites.

Through its communication and networking channels, the project grew from an original group of five graduate students who wrote the content locally, to over 420 volunteers who have, since 2002, signed up for an account and logged onto the project website.[1] The number of active and sustained contributors of content, however, was smaller—about 50 volunteer authors globally, from South Africa to India, Pakistan, Scotland, and the United States. Of these 50 active volunteers, approximately ten became core participants, contributing content regularly and consistently (i.e., weekly).

Throughout its growth, the project remained focused on its vision of providing free textbooks for use by teachers and learners. As one of the founders noted, "creating resources that are free has always been the aim." Keeping this overall vision in focus while adapting and improving appears to have been important in attracting and motivating a wide range of diverse volunteers. A core tenet expressed by the volunteers interviewed was that they strongly believed in the vision and purpose of the project. As one volunteer said, "I wanted to make a sustainable difference in the lives of South Africans." Another emphasized the importance of shared optimism in appealing to volunteers and keeping them involved:

> You have to have someone who believes in the viability of the project. It has turned into a huge task, and optimism about it is important. All the people who participate implicitly feel this optimism, and they feel they are contributing something that will do something good.

This sense of being part of a larger vision transferred into a shared sense of community and participation. In addition, the core volunteers not only felt part of a community but were also often eager to take on an "evangelist" role in spreading the project vision and its tasks to others. Several core volunteers emphasized their role in spreading the vision and getting others involved in the project. For example, one volunteer said:

> I started out working on FHSST by getting together a group of about five friends [at San Francisco State University]. I thought this would make it easier for me to work, and that we would get more done in a short period of time. I think both those turned out to be true. I've also recruited some other [UC] Berkeley grad students and summer undergrad students.

Another said she would welcome having an expanded role in the project:

> I have had conversations with [one of the founders] about taking the physics book and pioneering an effort to get it accepted in California, which would involve curriculum standards matching. So one place to go is to try to distribute it in other places, and I'm very keen on the project and doing this sort of work.

[1] As of August 2007, the total number of usernames registered was 682, but not all of these had logged onto the site.

Passing along this role of project evangelist from the original founders to new core volunteers was important in helping the project expand its scope. Although FHSST used multiple methods (both traditional and electronic) to recruit volunteers and expand its base of project participants, the most successful means of recruiting active and core volunteers was through face-to-face networking, which they used effectively to communicate the project's vision. For example, most of the ten core contributors were colleagues of the founders or directly approached by one of the founders to engage their participation.

Experimenting with Processes and Technologies to Guide Growth

As well as developing and communicating a vision to potential volunteers, a second early attribute of FHSST was its willingness to continually reassess its practices and processes to achieve its objectives while the project was growing rapidly. For example, one early challenge that required ongoing assessment and adaptation was the selection and modification of an online peer production platform that could effectively facilitate content contribution processes for a wide range of geographically disperse volunteers. The project first set up a concurrent versions system (CVS) repository[2] that was hosted on a platform that is commonly used by open source software development projects. Each content section was stored in the CVS repository, was "checked out" for updating or editing and then "checked back in" for storage. Volunteers needed to have authority to "check out" materials or they needed to send their contributions to the core team volunteers, who would check them into the repository.

Getting volunteers set up to use the CVS repository was a laborious process, and volunteers needed extensive technical understanding. As a result, this placed a substantial burden on the core team volunteers, who had to facilitate contributions from the other volunteers. To lessen this burden, the project experimented with WikiBooks. Versioning control issues arose, however, as the freedom to edit allowed by the wiki platform hindered their workflow design. One text, for example, was changed from South African English to American English, which subsequently had to be reversed, thus slowing down the workflow on the content.

As a result, FHSST shifted to a third solution, the eventual development and implementation of a content management system (CMS)[3]. Drupal was chosen because it was free, relatively easy to set up, and met volunteer needs effectively. The new Drupal platform was installed in early 2006, and facilitated the move to a more structured, yet collaborative method of working on content in a peer-based, online environment. At the time that this report was written, FHSST's new content authoring platform included templates for submitting, sharing, and revising text, activities, and illustrations in personal workspaces. Within those templates, the platform offered a space where volunteers as well as future textbook users could potentially enter teaching notes about how the content could be used in local classrooms. The platform also had features allowing

[2] A CVS repository is an open source system that allows for collaborative authorship, editing, and tracking of content.

[3] One of FHSST's founders, having a technical background, took on the task of developing this content management system.

volunteers to post their personal profiles, as well as to communicate among themselves through online tools such as forums and polls.

These revisions and updates revealed FHSST's emphasis on the importance of online means of communication through newly adapted processes and tools. And overall, its experimentation with finding an effective peer production technology revealed its early and ongoing focus on making internal improvements to meet volunteer needs toward attainment of content creation goals. For FHSST, incorporating the appropriate content authoring technologies to facilitate a smooth workflow and continued volunteer engagement was an ongoing, iterative process.

Sustaining Communities of Volunteers: Content Development

To maintain and support its growing community of volunteers, FHSST experimented with a variety of mechanisms to keep volunteers engaged and productive, including: dividing large content assignments into smaller segments so they were more manageable for volunteers to work on and complete; developing and supporting three stages of content development and editing; facilitating face-to-face means of content creation and support through "hackathons"; and providing collaborative tools such as online forums and local meeting opportunities, through which volunteers could communicate and offer feedback to each other.

As the following sections reveal, the development of these methods was an evolving process through which FHSST leaders sought to accommodate volunteers' schedules and geographically dispersed locations, as well as meet their need for face-to-face interaction and motivation.

Workflow and Collaborative Authorship

One of the early challenges for FHSST was creating a workflow around the production of content. For each textbook, FHSST enlisted teachers to develop overall outlines aligned to South Africa's curriculum guidelines. Working to create the textbooks from these outlines, FHSST developed an iterative process of three stages of content development. The first stage involved soliciting as much raw content as possible, often from teachers who were willing to contribute their teaching notes. The raw content was matched to the outlines, and based on the remaining gaps, assignments were then parsed out to volunteer authors.

As noted previously, FHSST adopted Drupal for its content authoring platform after experimenting with a concurrent versions system (CVS) repository and the WikiBooks platform. In order to submit content to FHSST within the Drupal system, volunteers signed up on the FHSST website, logged on, and chose from the list of available assignments based upon their expertise and interests. The sign-up and log-on processes did not require a screening for credentials. During the initial stages of the project, people volunteered to complete large sections of text, such as chapters. However, FHSST soon found that many of the sections were not being completed within expected timeframes. As a result, FHSST began to divide volunteer tasks into smaller assignments, such as portions of chapters, drawings, illustrations, activities, and examples. FHSST noted that this adaptation facilitated volunteers' ability to consistently complete assignments within expected timeframes.

When volunteers were ready to submit their content, they uploaded it to the FHSST content management system. Originally, they were required to submit written content in LaTeX (a markup language used for scientific equations, but which required substantial technical knowledge), or through a volunteer who did know LaTeX. Diagrams and drawings were to be submitted in PSTricks,[4] which likewise required technical knowledge on behalf of volunteers. FHSST later developed more user-friendly ways for authors to contribute written content as rich text or html; however, PSTricks remained as the submission format for diagrams and figures.

The second stage of the content development process involved an initial round of editing and feedback to volunteer authors on their assignments by a few selected editors,[5] to check for quality, alignment with curriculum guidelines, omissions, ease of use, and other criteria. During this stage, unfinished sections could be submitted back into the pool for volunteers to make new contributions. FHSST found that some authors worked well independently to create high-quality content within optimal time frames, while others contributed content that did not meet the needs and requirements of the project (e.g., the writing level was for university students instead of high school students), or did not return completed assignments at all. In response to this, FHSST indicated the importance of developing shorter feedback cycles between editors and content authors throughout the writing process.

The third stage of content development involved a final round of editing prior to completion of the textbook. FHSST indicated that it was important to have at least two full rounds of editing, in order to assure effective quality control. However, not all editors were said to be experienced in providing feedback to authors in ways that were constructive and motivating. In order to develop a more constructive participatory culture, FHSST noted that it was considering ways to provide editors with examples of positive feedback to authors. In addition, it was planning to enable the volunteer community to rate editor feedback, in order to help shape future editor behavior toward the authors.

On the whole, FHSST indicated that beyond improved feedback cycles to facilitate collaborative authorship, workflow efficiency was dependent upon the amount of raw material available up front, and the extent to which technology adequately supported the workflow processes. The skill level of the writers and editors also factored in; FHSST estimated that in general, an experienced full-time equivalent writer produced approximately 75 pages per month; and an experienced full-time equivalent editor reviewed approximately 170 pages per month.

Face-to-Face Collaboration and Motivation

Since its inception, FHSST offered face-to-face work sessions in which volunteers in the same geographic area met together to develop content collaboratively and motivate each other to meet

[4] The LaTeX submission format was chosen because it has code built in that automatically formats content for presentation and printing. PSTricks was chosen because figures are entered as text commands which get rendered when the LaTeX is compiled. This makes the figures more easily editable by other contributors during the editing process, rather than having to recreate a figure (with corrections/edits) from scratch.

[5] Originally, the content sections were to be edited by multiple volunteer editors, but in the end, the editing was undertaken only by a few, pre-selected editors to ensure consistency in style, layout, and quality.

content creation targets. Because these sessions, called hackathons, were successful in bringing together volunteers around common objectives, they were later adopted and organized by individual volunteers as way to interact with others, renew their excitement about the project, motivate each other to create content, and answer each other's questions about content, the authoring process, and project technology. Several volunteers indicated that the hackathons were crucial in maintaining their motivation to create content. As one volunteer explained about his weekly sessions:

> When I don't work with a group, I don't work on the project that much. If we meet every week, then at least I sit down and [work on the project]. And then the next day afterward I'm also thinking about it more, and do even more work. Before I started the weekly meetings it had been at least two months since I had worked on the project.

Another volunteer explained:

> The hackathons have been the best [support]. They forced me to set aside time to do content development. And because of the motivation achieved from working with other people.

The importance of these face-to-face sessions in the content creation process was underscored by a FHSST founder who estimated that without the hackathons, the amount of FHSST content would have been reduced dramatically. FHSST also indicated that face-to-face sessions were crucial in contributing to a participatory culture that valued constructive, positive, and diverse feedback.

Online Communication Tools

As another means to support its community of volunteers, the project established multiple channels through which volunteers could communicate, ask questions, and suggest changes and improvements. These channels were structured so as to promote two-way as opposed to top-down, one-way communication. For example, FHSST established an online forum where volunteers could post questions, comments, or suggestions, and the FHSST leadership and administrative team could post announcements about upcoming hackathons and events, as well as questions to the volunteer community around future project improvements. The intention was to provide a space where targeted questions and answers could be asked—where volunteers could feel confident that their questions were relevant and that they would receive serious answers; and where subsequent volunteers could find answers to their own questions by scanning or searching previous posts.

FHSST structured the forums by topic, including a forum area for: each of the textbooks; technology issues; website improvements or complaints, and new ideas around the peer production process. As the project developed, further forums were added. This structure was adopted so that volunteers could browse questions in the relevant place, and so that the textbook coordinators could check for questions pertinent to them.

FHSST faced a challenge in motivating volunteers to use the forums to post questions and comments, and to respond to others' postings. Interviews with FHSST revealed that this was in part due to some volunteers' limited experience and confidence using collaborative tools such as forums, or their fears that their questions would be viewed as naïve by others in the volunteer community. For example, a volunteer noted:

> The people posting in forums have been a select few. And this might be the technology barriers, and people could be intimidated and don't want to ask about LaTeX in front of the rest of the community.

To spur use of the forums over time, FHSST consistently highlighted the forums in its other communication channels. For example, in its monthly newsletter, FHSST encouraged volunteers to post statements about the status of their content. As a result of these and other strategies, the forums appeared to have evolved into a mechanism where volunteers more regularly posted. In the process, forums assisted in making the content creation process more efficient. For example, responses to common questions prevented the leadership team from having to answer the same questions repeatedly via email. The forums also appeared to facilitate engagement, providing an online means in which volunteers could feel part of a community. As one FHSST founder said, "Although they [the forums] are not used to their full capacity, they are an important communication channel that we will hopefully develop further."

Another FHSST founder further revealed that developing a positive and constructive online forum environment was important in maintaining volunteer motivation and supporting ongoing content contributions. However, creating such an environment required perseverance as both the project founders and volunteers indicated that forum responses that were negative alienated volunteers, particularly those volunteers with limited experience in online forums. As such, one FHSST founder indicated, for example, that face-to-face gatherings such as hackathons helped to contribute to a friendly culture of volunteers, and that these and other mechanisms were necessary to facilitate a constructive forum environment.

In addition to the forums, email was described as an important communication channel for volunteers, especially for questions and discussions that were not relevant to the wider community. Several volunteers indicated that they used email frequently for communicating with each other and with FHSST leadership and editors about the content they were working on, during the writing and editing phases.

In communicating information to the volunteer community currently, FHSST used multiple channels, including the forums and monthly updates that are emailed to subscribing volunteers and posted on the website. The monthly updates included information on recent milestones for the project, such as recent hackathons, the recruitment of new expert content editors, and changes in leadership and administrative team roles. The updates also included information on future challenges for the project, for example, involving printing and distributing the textbooks. By maintaining a high degree of transparency in its milestones and challenges, FHSST sought to inspire community engagement and emphasize the project's progress. As one volunteer stated, "I

think that the monthly updates are very well written. They are a great help, reminder to work, and motivator."

The monthly updates were also said to serve as an avenue toward problem solving around existing project challenges. According to FHSST, two printers responded to an item in a monthly update about the need to secure resources for printing and distribution of the textbooks. The printers, who saw the monthly update on the FHSST website, subsequently posted an entry on the forum, stating that they were willing to support FHSST's efforts.

As a whole, FHSST's communication channels served to inspire and support community engagement through creating a culture of openness, two-way communication, and peer-driven problem solving around content creation and the FHSST project overall. One challenge that remains for the project is to make its website more interactive and engaging for volunteers and to improve ways to push information to potential contributors, especially those who had logged on but had not yet contributed to a textbook. For example, one of the FHSST founders pointed to the potential development of a functionality for viewing the progress for the project as a whole, for each textbook, and even each chapter or assignment, so that volunteers would be able to see at a glance the progress made in each of these areas. In this way, community is creating a face-to-face feeling, and seeing progress.

Ensuring that Content Is Relevant: Localization and Use

Through teacher participation, networking, teacher and learner trials, and workshops, FHSST solicited feedback from the end users of its content early in the content creation process in order to facilitate their buy in and ensure that the content was relevant, usable and adaptable to local teaching and learning needs. Importantly, this was accomplished within the parameters of state curriculum guidelines, so that the content matched policy requirements.

Over time, FHSST deemed that content creation and development needed to be accompanied by stronger efforts to ensure that the content met local teaching and learning needs. This learning and adaptation process included developing strategies such as more rigorous and defined editing procedures identified above. In addition, the project facilitated and improved authors' ability to create content that was aligned with the level of English appropriate for grades 10 to 12 in South Africa. To facilitate this, the project placed a standard readability calculator tool (the Flesch-Kincaid Readability calculator) on its website. Volunteers could paste a portion of their written content into a dialogue box, and the tool would report the grade level of the content. As another example, FHSST reached out directly to teachers through its own networking channels. One of the FHSST founders contacted the high school she had attended as a student, and then identified and partnered with teachers. These teachers, in turn, shared their teaching notes and content as a boiler plate for the life sciences textbook that was then under development.

FHSST further initiated other, larger-scale initiatives to ensure the localization and usability of the finished textbooks. These included curriculum guidelines alignment and teacher and learner trials, as discussed below.

Curriculum Guidelines Alignment

Because teachers in South Africa are required to use materials that are aligned with the Ministry of Education's (MOE) curriculum guidelines, FHSST worked early on with the author of the MOE guidelines, and used the guidelines to help teachers create the outlines for textbook content. As South Africa's approach is outcomes based, the guidelines seek to define curriculum in terms of what each learner needs to know or be able to do if they have mastered the curriculum. For example, one physical science outcome is to: "Use process skills, critical thinking, scientific reasoning and strategies to investigate and solve problems in a variety of scientific, technological, environmental and everyday contexts." In line with this approach, FHSST's website states that learning outcomes written for their texts also incorporate these outcome-based skills. In meeting its goals, FHSST engaged its volunteers in interpreting and using South Africa's curriculum guidelines to develop lessons for teachers and learners.

Classroom Trials

In early 2007, FHSST conducted classroom trials in order to gather and incorporate user feedback from both teachers and learners into subsequent revisions of the textbooks. According to one FHSST team member:

> The aim of our trials was to identify the weaknesses in the books to inform our second-round editing process and make sure we fix the issues to make the books as usable as possible to our target audience. We also wanted to identify […] what is the [science] laboratory situation at the schools? Do they have equipment to do the experiments so that we could […] tailor our content accordingly.

For these trials, FHSST identified and partnered with eight Durban-area South African schools. The schools were identified through existing local networking channels of FHSST members. For example, one FHSST team member had attended one of the high schools. The FHSST team first met with the school personnel to introduce them to the classroom trial concept and to identify specific content needs in science and mathematics in the classrooms that would participate in the trials. The participating teachers were then provided with textbook content from FHSST in order to pilot-test the text's use over a two-month period. Both teachers and learners were given pre-trial questionnaires to gather baseline data about their perceptions of their current textbooks, and post-trial questionnaires to assess perceptions of the FHSST textbooks. The assessments included issues of readability, content, alignment to outcomes-based guidelines, and overall usability. A follow-up workshop was also conducted with teachers involved in the trials to report back on the findings from the post-trial questionnaire, and to delve deeper into the feedback received on the texts. Much of this feedback centered on the need to incorporate more examples and activities into the texts, to augment lab experiments to account for the limited resources and lab equipment within the schools, and to simplify the language of the text.

After the trials and workshops, FHSST created a list of high-priority raw content and editing needs to address the feedback received from the teachers and learners. Specific examples of changes that resulted from the teacher and learner feedback included revisions on lab exercises to

account for lack of school resources. The exercises were rewritten to incorporate tools that were available to the classrooms, for example, homemade tools or equipment. A second example of the changes made included the development of new content authoring tools and templates on the FHSST website to support volunteers' ability to add examples, illustrations, and activities to the textbooks. In addition, FHSST recruited and paid small stipends to four teachers who would serve as experts during the final round of textbook editing to ensure user needs were met and adherence to the outcome-based syllabi. In a country where its teachers are not particularly well-paid, these types of stipends played a significant role in the ability to recruit additional expertise to FHSST.

FHSST indicated that the time required for the teacher trials impacted overall project deliverables significantly, and that it would have been better to have factored this into its early strategy and deliverables planning. In addition, FHSST noted that during the teacher trials, the teachers did not use all of the content that they said they would need; the teachers had overestimated the amount of material that they would be able to cover. Because preparing the content in time for the trials was exceedingly time consuming, FHSST leaders noted that future trials would need to involve a more realistic assessment of content needs for the teachers participating in the teacher trials. Importantly, however, the teacher trials proved instrumental in improving FHSST's expertise in helping FHSST to confirm and identify the areas in need of improvement of the content itself. Meaning, by including teachers and learners as part of its peer production model, FHSST strengthened its textbooks' quality, adaptability and use in local teaching and learning situations.

Sustaining the Project and its Processes

FHSST grew and developed from an initial idea to create a single science textbook into an online, collaborative, multi-text project with 50 active and sustained volunteers. Meanwhile, the project's core team worked to continuously improve its practices, processes, and outputs (the texts) by developing efficiencies and innovations. These adaptations ranged from new technologies, tools and mechanisms to facilitate workflow and volunteers' ability to contribute content, to teacher trials to ensure adaptability and usability of the texts, to hiring paid editors at the final stages of the textbook writing to ensure content quality. In this sense, the sustainability of FHSST has been facilitated through the project's ability to create products that are usable by teachers and learners.

As the project grew, FHSST found that all of its work could not be accomplished through volunteers alone, as there were real and ongoing costs that needed to be met. As FHSST began to explore funding possibilities, they found that fundraising was itself an iterative process of development and adaptation. In 2004, two years after the project's inception, FHSST approached a potential funder through an initiative that sought to match education projects with sponsors. At that time, FHSST sought to cover the costs of the classroom trials, pay external editors to ensure content quality, and cover the costs of the printing and distribution of the books. It was understood early on that the majority of the FHSST textbook dissemination and use would necessarily be through print copies, due to a lack of Internet connectivity, computers, and

electricity in parts of South Africa. Although FHSST was not successful in securing funding through this initiative and with this approach, the project did begin to build a relationship with an eventual funder.

In 2005, FHSST approached the funder directly with a different approach, requesting support for full-time project employees. During this process, FHSST discovered that many funders preferred to tie funding directly to clearly-defined deliverables. FHSST revised its approach by requesting a specific amount of support for the development of a number of edited textbook pages per month, for activities such as classroom trials and teacher workshops, and for content development competitions. No money was requested for printing and distribution of the textbooks. In adopting this approach, FHSST received the support needed to develop the textbooks.

At the time of this report, FHSST still has outstanding needs for external funding—specifically the printing and distribution of the math and physical science books and for continuing administration aspects of the project while it completes the remainder of its life sciences textbook. For this second round of funding, FHSST plans to approach corporations with strong social investment records in South Africa. However, questions about the sustainability of the project remain, including who will lead the project when the founders transition from graduate students within their respective science disciplines.

IV. Discussion and Implications

FHSST serves as an example of a project that started with a vision for improving education, based on a an articulated need and demand, through the creation of free high school textbooks. They successfully moved toward that vision by creating open educational resources (OER) from the ground up. With its textbooks projected for release and distribution in 2008, the project has the potential to improve teacher and learner access to quality educational content in South African high schools. In addition, the project has spurred the initiation of a wider South African project which aims to create additional open content textbooks for primary and secondary students in all subjects.

Beyond its implications for South African education, the FHSST project can serve as a model for peer production of open content, offering insights into planning and decision making. At the most concrete level, for example, it can provide insights into how a project might consider: recruiting volunteers; sustaining their participation; using technology to create effective workflow; conducting hackathons; or facilitating teacher trials. At a more general level, the FHSST project also offers insights into overall approaches and goals that may prove instrumental across open education projects as they seek to reach their vision. The subsections that follow provide a discussion of these overarching themes in order to explore the implications for the field of open educational resources at large.

Experimentation and Adaptation

The case study of FHSST implies that creating and sustaining OER is an iterative, experimental, and adaptive process that pays heed to continuously changing environment and shifting stakeholder needs. With the expansion of the FHSST project, the core team realized the need for technology and communication solutions that would increase efficiency, lessen the burden of administrative tasks, and facilitate workflow among geographically disperse volunteers. FHSST thus experimented with a central repository and WikiBooks before moving to a content management system that allowed for the development of communication and authoring tools that supported a truly two-way work flow, peer-to-peer environment, and which was better matched to the technology skills of the contributing volunteers. Additionally, as the project's success was dependent upon the ability of volunteers to finish content assignments within set time frames, their process moved from offering large content assignments to smaller chunks that were more manageable for volunteers.

As FHSST moves into the final phases of textbook completion, it faces a new set of changes and challenges. Two of FHSST's core team members, who were graduate students when the project began, have now completed their studies and are transitioning into full-time, paid positions outside of the project. FHSST is thus faced with the issue of addressing reorganization of the leadership team after this transition occurs. Additionally, as the South African Ministry of Education embarks upon its initiative to create open textbooks across a range of subjects and grades, FHSST leadership has indicated that it needs to consider the implications for its own continuation and potential role in supporting the initiative, for example, by sharing its content authoring platform or serving as a model for peer production of the new textbooks. Finally, FHSST recognizes that it needs to address the issue of the continuation of the textbooks going forward. Questions remain around whether processes and tools should be developed to support the use of teacher/learner feedback into textual revisions over time, so that they are improved, updated, and usable in the long term.

In short, an important insight gleaned from FHSST case study—both through its past practices and decision making as well as through the impending challenges and changes faced—is that experimentation and adaptation are central components of an open education projects' ability to sustain itself. For other OER projects, this points to the importance of instilling structures and practices that are aligned to project goals, but which also can be adapted and iteratively tuned to shifting stakeholder needs—in terms of technology choices, peer production practices, funding models, and so on.

Culture of Collaboration and Support for Volunteer Engagement

Particularly for projects with significant online communities that are dispersed geographically, it is challenging to create a participatory culture of collaboration that inspires diverse input and feedback, and that creates a sense of urgency in ongoing contributions from community members. Through adaptation and experimentation, FHSST established online and face-to-face ways to create a culture of collaboration, particularly through mechanisms that allowed people to

cross boundaries and problem solve around the authoring process as well as around higher level, strategic issues. For example, the peer production process and workflow at FHSST were structured around work flow stages and roles to facilitate coordination of the content authoring, editing, and quality control activities. As such, author volunteers could draw upon and get support from editors who had expertise in a given content area. At the same time, communication tools and the establishment of hackathons enabled local communities of volunteers to create new content, discuss the content they created, and resolve challenges. Forums and monthly updates invited volunteers to contribute ideas or feedback that could be fed into strategic planning and ongoing improvements in the overall project.

FHSST's leadership, by directly inspiring volunteers to take on central roles in recruiting others, and by promoting face-to-face interaction, created a community of stakeholders who viewed themselves as part of a truly participatory environment where their contributions made a difference. In general, the FHSST case study points to the importance of establishing a culture of collaboration within OER projects, particularly through structures and practices that support two-way, peer-based interactions around the everyday work of the project as well as around strategic decision making. Doing so can potentially serve to not only facilitate day-to-day work activities (such as content creation), but can also lead to innovative ideas and new practices as community members—inspired by the invitation to fully participate—contribute to project goals.

Finding new ways to engage and inspire volunteers through online channels is central to this process. For example, only 10 of the 420 registered volunteers became core, regular content contributors. This means that beyond the recruitment of volunteers through traditional, face-to-face networking, it is also necessary to identify means to share project vision and benefits through electronic channels, in order to convert interested volunteers into more active volunteers. Furthermore, because establishing a community feeling and a sense of urgency around project involvement can be difficult in pure online environments, instilling mechanisms that replicate the benefits of face-to-face interactions within the content authoring platform and project website likewise becomes central.

Top-Down, Bottom-Up Facilitation

From the onset, FHSST focused on two parallel strategies for creating textbooks: (1) bottom-up: ensuring that the texts were relevant, easy to understand, and adaptable to local needs; and (2) top-down: ensuring that they adhered to South Africa's curriculum guidelines and its outcomes-based education system. Examples of the first strategy included the teacher and learner trials, the procurement of boiler plate content from teachers willing to share their teaching notes, and the hiring of teachers as editors for the final round of textbook revisions. The second strategy involved obtaining outlines directly from the Ministry of Education (MOE), which served as guides for volunteers as the texts were written and compiled.

By adopting this two-tiered strategy, FHSST sought to ensure that it met local needs as well as took into consideration the policy environment in which those needs were situated. In short, it aimed to ascertain that within the structures (the MOE's guidelines) that set the tone for

education in South Africa, that local users—namely, teachers and learners—will have room to navigate, adapt, and connect to content that was written with their own needs in mind. This in turn can have implications for the lifecycle and continuous improvement of the content, as it can potentially spark teachers' interest in participating in future revisions of the content to meet changing needs. For other OER projects, one key question is how local user needs and higher level structures can best be integrated and mediated so that content is relevant, usable, adaptable and sustainable.

Using Resources from the Community: Find, Leverage, and Learn

The case study of FHSST also reveals the importance of looking beyond the purview of a project's internal resources in meeting its overall goals. Since FHSST did not obtain funding until four years after its inception, team members early on drew on free and openly available resources—including not only volunteers, but also open source technology. As the project progressed, additional community resources were leveraged, even after funding was obtained. These included the teaching notes that were used for the life sciences textbook, and the recruitment of (paid) teachers and contractors with expertise in science and math who could help with editing and writing tasks. The former assisted the project in obtaining content faster than it would have though its established volunteer channels, and the latter meant that FHSST was able to ensure improved content quality.

Another example of leveraging opportunity was that of FHSST's content creation partnership with junior engineers at the chemical company, Sasol in Secunda, South Africa. Having heard about the FHSST project and wanting to contribute to the advancement of education as per Sasol's corporate mission, representatives from Sasol initiated contact with FHSST leadership team to find ways to contribute. The Sasol engineers wanted advice from FHSST on how to create a hackathon on their own, and the result was a full-day hackathon onsite at the Sasol offices where junior engineers created much-needed chemistry content for the textbooks.

Thus, by leveraging multiple resources, FHSST was able to better support its aim of creating free and open quality texts, while at the same time doing it quickly and more efficiently.

IV. Conclusions

Beyond its emphasis on content localization and usability, this study revealed that a central issue of importance for FHSST was the ability to facilitate a community of volunteers who continuously contribute high quality content, and that this in turn necessitated ongoing technology and practice improvements—all toward the aim of making the content creation process as volunteer-centric as possible. Furthermore, because a collaborative work culture that inspired a sense of urgency and shared vision played a large role in engaging and sustaining volunteer contributions, the case of FHSST also points to the necessity of developing both online and face-to-face mechanisms within projects that can facilitate such a culture. On the whole, the findings of the FHSST case study imply that an important aspect of project sustainability involves the implementation of practices that replicate the characteristics of open educational

resources themselves: namely, those that are collaborative and peer-based, and that invite continuous improvement by stakeholders. For other OER projects, this indicates the potential necessity of developing community-centered technologies, processes, and cultures that can support experimentation, self-assessment, and adaptation, while maintaining and continuously reinforcing a clear sense of overall mission.