

Cloze: An Authoring Tool for Teachers with Low Computer Proficiency

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Abstract— The Multiple Mice project demonstrated the financial [1] and learning [2] benefits of enabling students in resource-constrained schools to share one computer. In India, the lack of Multiple Mice authoring tools coupled with teachers' low computer proficiency means little or no customized content is created. This is problematic as the capability to create digital content enables teachers to prepare digital lessons that address the particular learning needs of their students [3], [4], [5].

In this paper, we report on a 34-week field study in three Indian peri-urban schools. We identify key issues impeding digital content creation by low computer proficiency teachers. We also present an authoring framework, Cloze, which successfully enables these teachers to create content for MultiPoint applications. Finally, we recommend guidelines for designing authoring tools for teachers with low computer proficiency.

Index Terms— **Authoring tools, computers and education, teachers, user interfaces**

I. INTRODUCTION

Developing countries like India are increasingly employing computers in the delivery of education [6], [7]. Initiatives by both the Indian government and non-governmental institutions have seen mixed results: an increasing rate of computer penetration in schools – currently at 16% [8] – but no clear sustainable impact on learning [9]. Barrera-Osorio, in evaluating computer-based interventions in education, attributes the ineffectiveness of computers to a "failure to incorporate the computers into the educational process" [6].

The dominant usage paradigm of computers in Indian schools revolves around Computer Aided Learning (CAL)

applications [10]. CAL applications are typically self-paced and combine various multimedia elements to guide a student through a particular topic with little or no teacher mediation. For example, to teach fractions, a CAL application would have videos or animations that introduce the student to the concept of fractions. Next, using games and other interactive elements, it would guide the student through more advanced manipulations and applications of fractions. Commonly, they conclude by administering a self-assessment test that allows the student to gauge their level of comprehension of the subject. This paradigm of use, however, is not always suited for the Indian education process. For example, in resource-constrained schools, of which there are many, CAL applications are used as substitutes for teachers. In these cases, the research shows that significantly less learning occurs [11].

Furthermore, CAL applications tend to leave teachers out of the learning loop as teachers often have limited control over the CAL content. The Multiple Mice project allowed students to gain the benefits of collaborative learning by each using his or her own mouse at one computer. Applications built for schools on that technology adopted the CAL model and allowed students to collaboratively interact with vocabulary acquisition games and other such learning games. However, one drawback with these applications was that, unlike in typical teaching practice where teachers adapt learning materials to suite their lesson needs, the teachers could not do so with the content in the MultiPoint-enabled CAL applications (e.g. add new words to the vocabulary game that would appropriately challenge the students). To use their own content, the teachers needed to know how to write computer code – a skill a typical teacher does not possess.

Ultimately, the lack of control over content limited the teacher's capacity to engage with their students in the computer-mediated learning experience. This represents an example of the failure to properly incorporate technology in the education process as teachers engaging students in their own learning is a proven pedagogical strategy [12].

The goal of this research was to design an authoring environment that teachers, especially those with low computer proficiency, could use to create content for CAL applications, specifically, MultiPoint¹ ones.

In this paper, we report observations of key issues hindering digital content creation by low computer proficiency teachers in three Indian peri-urban schools. Building on these

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¹ The Multiple Mice project was taken over by Microsoft and the core technology renamed Windows MultiPoint Mouse: <http://www.microsoft.com/multipoint/mouse-sdk/>

observations, we present an authoring tool that successfully employs content templates and task-oriented interfaces to simplify content creation for CAL applications. Finally, we discuss general issues associated with designing authoring tools for teachers with low computer proficiency.

II. RELATED WORK

This section briefly covers related work on teacher content creation, authoring tools for learning, and interfaces for novice computer users.

A. Problems with Content Creation

J. Mueller, E. Wood, T. Willoughby, C. Ross, and J. Specht identified certain factors that keep some teachers from fully embracing computer use: levels of comfort with computers, doubts about using computers as pedagogical tools, lack of training, etc. [13]. Another important factor is time. Some teachers shy away from computers, and particularly content authoring applications with unintuitive interfaces [14], [15] that require time to understand and use. Our interviews indicate that this is especially so for teachers with low computer-proficiency. Some mentioned creating only a few PowerPoint presentations because it took them more than seven hours to make a 20-slide presentation.

A key note from these works is the importance of the teacher's perception of the time it will take them to accomplish a task based on the interface. This seems critical to their general willingness to accommodate the tool as a pedagogical device.

B. Authoring Tools for Learning

While several content authoring tools aimed at teachers are available (e.g. yTutor [16]), very few have been rigorously evaluated. This section briefly covers related work on authoring tools for teachers and the design of interfaces for novice computer users.

Mouse Mischief [17] is single display groupware that extends MultiPoint to support whole classroom formative assessment. It is the only existing MultiPoint application in use in schools that offers teachers an authoring interface. However, it has certain drawbacks. First, it works as an add-on to PowerPoint, a relatively expensive application that is beyond the means of most resource-constrained schools. Second, while some teachers are familiar with PowerPoint, others, particularly those with low computer proficiency, are not as adept and require significant amounts of time to create a presentation. This time sink limits the utilization of Mischief. Thus, Mischief is limited to teachers with PowerPoint proficiency.

REDEEM [18] helps teachers create learning environments from existing computer-based training applications by specifying their own pedagogical principles. Of interest is the design of the authoring tools in the system: it is highly task oriented and guides the user through a question and answer process to create the learning environment. The design allows the teacher to accomplish a very complex task with very

simple actions. This is relevant particularly for teachers with little computer skills.

The *JeLSIM toolkit* [19] is a software suite, which facilitates easy creation and customization of Physics and Math simulations. A relevant aspect of the toolkit is that it provides different interfaces based on user computer proficiency. To create identical simulations, a JAVA programmer has access to a programming interface whereas a teacher, without the programming skills, has a graphical interface with visualization objects like graphs that simplify the process of creating a simulation. An interesting note in this work is the notion of a graduated interface, which caters to users with different proficiency levels.

Lastly, learning content development systems such as Cognitor [20], Hot Potatoes [21] and Microsoft LCDS [22] primarily focus on designing learning content for e-learning environments. However, such applications tend to target professional educational content creators and do not cater to end-users with limited computer proficiency.

While all the above provide digital content authoring for teachers, none of them specifically consider and evaluate content authoring for simple CAL applications by teachers with limited computer proficiency. This is the gap in the literature this work hopes to fill.

C. Interfaces for Novices

Another informative related area of work looks at the traits of novice users as distinguished from experts [23]. These traits include, for example, dependence upon system features such as informative feedback [24] that assists in recognition memory and help with task completion. Considering these traits will be essential particularly given the computer skills of the target teachers.

III. METHODOLOGY

The study began with two weeks of in-school class observations and semi-structured interviews with teachers. The findings from the observations and interviews resulted in a 4-month iterative design of an authoring framework and finally, a field evaluation consisting of a 3-month pilot in a school.

A. School Selection

It was vital to find schools where teachers were already creating content for and using computers in their teaching. This was important because the success of computer usage in education depends on having the right social context vis-à-vis the willingness on the teacher's part to use the technology and on the administration's part to provide the right support for the teacher to do so. As the focus of the study was to design and develop an authoring environment for teachers, it would have been unproductive to also tackle the issue of non-usage, a common problem in most rural/peri-urban Indian schools. Finding teachers already engaged in computer use guaranteed that the study did not have to deal with issues of motivation of use, which, while an important topic, falls beyond the scope of this study.

Thus, the three schools selected for the study were all equipped with a computer lab that was in active use. The labs had computer managers whose primary tasks were to assist the teachers use the computers for lessons and in some cases teach students how to use the computers and related technology like the Internet. Two of the schools had a close to 2:1 student-to-computer ratio (for about a 30-students class size), while the other had 1:1 ratio. The latter is highly uncommon in rural and peri-urban Indian areas. Only one of the schools had a computer cart setup that allowed them to use the computer in a classroom. Scheduling conflicts for lab time was an issue for most of the teachers. Some schools got around this by pre-scheduling computer lesson times for each class. This change allowed the teachers to plan ahead of time when and which aspects of their curriculum they would use computers for, however it also limited the impromptu use of the labs.

B. Class Observations and Interviews

For two weeks, we observed and interviewed 28 teachers in the three schools prepare lessons and teach in class. They were selected by their respective school administrators and they exhibited differing levels of computer proficiency as described in the next section. The goal of the observations was twofold: First, we sought to understand how the teachers used computers to teach. Second, we wanted to gain insights on how these teachers created and used digital content. In addition, we conducted semi-structured interviews with the teachers to get their views on the use of computers for teaching.

Teacher Profiles

The teachers ranged in teaching experiences from 1 to 20 years of experience. Together, they taught subjects covering Computers, Languages, Math & Science, Social Science and Physical Education. All the teachers lived in nearby cities and had to commute, some for an hour, to their schools. A majority of the teachers taught grades six to ten students. Only 4 of the 28 taught lower grades. Gender wise, 24 were female and 4 males. The teachers had hectic schedules in which administrative and other student-management tasks consumed their free periods. Accordingly, they tended to gravitate toward classroom activities that involved little time and effort to prepare, and more importantly, did not require an inordinate amount of their 45 minute lesson period to execute.

Ultimately, the academic welfare of their students was their first priority. Any proposed interventions, technical or non-technical, they judged, at times to their own disadvantage, in terms of how well their students would receive it and the potential for beneficial learning outcomes.

Whereas all the teachers had access to computers at school, only 7 of the 28 had and used computers at home. These seven mostly used the home computer for E-mail, viewing pictures, information searches and preparing lesson documents. In the interviews, most of the teachers (25 of 28) shared positive views on computer use in education; however, three teachers expressed serious doubts. Two of the three intimated that computers have no relevance for their subjects, while one feared that computers devalued the direct interactions teachers

have with students. Those who spoke positively about computers centered on the computer's ability to grab students' attention. They also noted that visuals and simulations helped students understand concepts better. Four out of the 28 indicated that computers helped them keep abreast professionally with the latest news in their subject areas.

Based on the observations and interviews, 3 types of teachers, with regard to computer use, were identified in the sample: the *Non-User* teacher, the *Low Proficiency* teacher and the *High Proficiency* teacher. Table I summarizes the distinguishing characteristics between these types. Overall, it should be noted that the proficiency and usage patterns of even the *High Proficiency* teachers ranked below the average skill level of a *digital native*.²

TABLE I: Types of teachers based on computer usage.

	Non-User	Low Proficiency	High Proficiency
Frequency of use (weekly)	0 - 1	0 - 3	5
Assistance Required	Most of the time	Sometimes	No
Familiarity with MS Word & MS PowerPoint	Low familiarity. Most times they delegated work to others more proficient.	Familiar. However, they only utilized the few features which they knew.	High familiarity. Could create PPTs with complex animations and manipulate Excel sheets.
Familiarity with other applications	None to Low familiarity	Low familiarity. Some could use Internet browsers	High familiarity. Some could create their own web pages and software code
Sample	6	17	5

Use of Computers in Teaching

Computer-mediated lessons mostly occurred in computer labs. Teachers would take students to the computer lab for a class period – they avoided splitting a class period between in-class teaching and computer lab time as the transition between the two rooms was time consuming. We observed only three instances of in-class use of a computer/project system: one was in support of student project presentations, another was a kindergarten teacher who showed pictures of sea creatures from a prepackaged application, and the third was a science teacher who interleaved videos of seed germination with regular teaching.

The lab lesson typically took one of two forms: *cal* or *presentation*. In the *cal* form, students interacted with CAL applications in a self-directed manner. During the course of the lesson, the teacher was at times hardly involved, apart from answering a few questions or keeping order. We often observed some teachers leaving the students alone with the computer lab manager and only returning after the period was over. During a typical school week, students participated in 2-4 *cal* mode lessons.

²A term coined by M. Prensky to refer to people who have grown up with technology and are fully conversant with computers [25].

In the *presentation* form, teachers introduced new topics via *PowerPoint* or showed videos or pictures related to a topic already covered in class. In this mode, the teachers were more engaged, interleaving teaching with visualizations of concepts or projected problem questions that the class worked through together.

This latter mode did not occur often: 25 out of the 28 teachers reported doing such presentations about two times in six months, with the rest, all *High Proficiency* teachers, reporting a rate of twice a month or more. Teachers noted that a major hurdle limiting the *presentation* form of computer use was the time required to gather materials and author the presentations.

Digital Content Creation

The teachers authored three main types of digital content: administrative documents (e.g. lesson plans), worksheets including quizzes, and PowerPoint presentations. The teachers mainly used the presentations to introduce new topics or show images related to the week's lesson topic. The worksheets were used for end-of-lesson assessments.

On average, the teachers created and used 2-3 worksheets a month and two PowerPoint presentations in a 6-month period. Whereas most teachers took an average of 3 hours to prepare a 45-minute lesson, *Non-User* and *Low Proficiency* teachers took upwards of 6 hours spread over several days. These teachers attributed this time sink directly to their slow typing speeds and unfamiliarity with the various shortcuts available in the application. We also observed that some teachers would gather information and have the computer lab managers or students create their presentations for them.

C. Key findings from observations and interviews

From the initial interviews and observations, we identified key issues related to computer use and content creation:

- 1) Although *cal* mode was the most common form of computer usage, it did not always support good interactive learning: teachers were hardly involved in the learning process. The teachers felt frustrated by this: a few viewed the *cal* mode as the "children only playing games," and a loss of valuable time that they could have used to cover more content in the classroom. Those who found *cal* applications useful still expressed a desire to specify the content the students interacted with especially for the applications with self-assessment portions. The teachers wanted control over the content so that they could be as involved in the learning as they were in the *presentation* mode.
- 2) When creating content with an application, the *Low Proficiency* teachers mainly used features in the interface that were readily visible to them and whose functionality were obvious (e.g. using the bold icon to bold a piece of highlighted text). They only stayed in the main activity area of the application and rarely explored or used unfamiliar features. Furthermore, they frequently repeated the same steps to accomplish a particular task, even when an alternative, more efficient path was provided. For

example, one teacher always opened an application via the 'Start' menu, even after being told about the icon on the desktop.

- 3) Low computer skill resulted in long content authoring times. As a result, this limited the frequent authoring of digital content among the *Low Proficiency* teachers.
- 4) Only the *High Proficiency* teachers and a small number of the *Low Proficiency* teachers often created content from scratch. The teachers relied heavily on their textbooks and other curricula materials as sources for their digital content. The teachers would redact and add extra content like images as they digitally duplicated the textbook content, but sometimes they created slides or worksheets that were exact copies of the textbook content.

IV. SYSTEM DESIGN

A. Design goals and Prototyping

Based on the findings, three design goals were established. These were to inform the development of an application that *Low Proficiency* teachers could use to create content for MultiPoint applications. The goals were as follows:

- The application should have a simple and intuitive user interface.
- The application should require little of a teacher's time to generate content. The interface and interaction modes should also reflect this goal.
- The application should facilitate the integration of textbook and other curricula materials to support the teachers' existing practices.

From the design goals, an initial prototype of an authoring environment was developed. From there on, the design process was highly iterative. Incremental improvements were made based on feedback from in field-testing with teachers and two formal usability tests involving seven teachers.

B. Findings from iterative prototyping

This section explains two key findings from the iterative prototyping that shaped the final design of the authoring environment.

Low proficiency teachers found the mouse difficult to use for interactions that went beyond single click.

To leverage the teachers' familiarity with PowerPoint, we initially designed the application to be similar to a much stripped down version of PowerPoint (see Fig. 1). The interface provided a toolbar from which the teachers could create quizzes and other common interactive activities. The content of the activities was displayed on the slides for the teachers to edit. To edit, the teachers needed to locate the

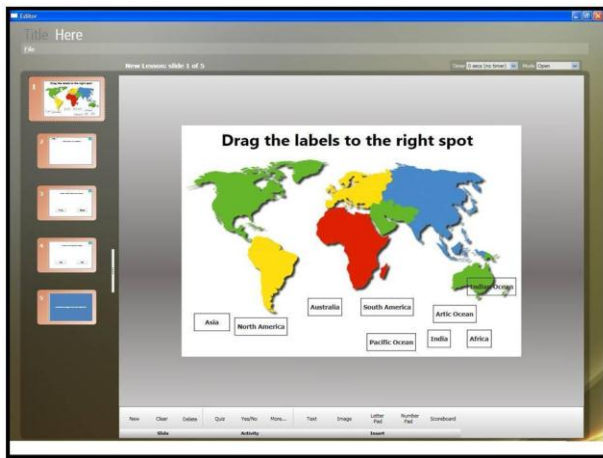


Fig. 1: PowerPoint inspired interface

piece of content on the slide, click on it to activate the edit mode, and then change the item.

Our initial trials with teachers revealed that although they liked the content displayed visually on a slide, editing was problematic. For example, the teachers took a significant amount of time to edit the text on the buttons generated for a quiz. They also found drag and drop a difficult action to do. The inconvenience was such that they would start a lesson all over again instead of fixing the incorrect text on a button.

Given the difficulties the teachers were experiencing, we decided to experiment with other interface layout designs that did not require extensive use of mouse motor skills. It should be noted that the *High Proficiency* teachers had no such issues with this design.

Low Proficiency teachers prefer a task-oriented interface for content creation.

Although the PowerPoint inspired design failed, one aspect of it seemed to work well. This was the wizard feature that was used to create the activities before they were placed on the slides (see Fig. 2). Wizards are user interfaces designed to walk one through complex task completion by sub-dividing the complex task into smaller specific ones.

We redesigned the tool layout from a PowerPoint-like interface to a wizard-only interface (see Fig. 3). This meant a teacher was guided through a series of screens and prompted for the content for an activity. They did not have to handle the nuances of manipulating UI elements. Field-testing confirmed that the teachers preferred this new approach. They noted that it was faster and an easier workflow to work with.

The wizard approach required us to break the process of creating an activity in to several steps. Further iterations and testing showed that this process must be carefully designed to avoid confusing the teachers. Specifically, splitting one task over too many screens presented an undue cognitive load for the teachers. It required them to keep mental track of too much information. We addressed this successfully by bringing all elements of a single task together on one screen. For example, in creating a quiz activity, a teacher specifies the question, the choices, the correct option, and the timer value on the same

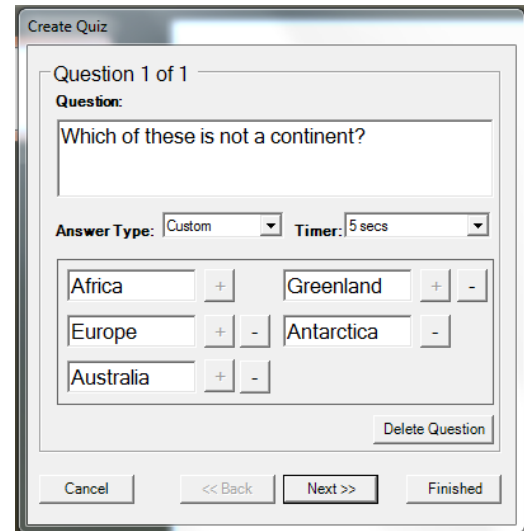


Fig. 2: Quiz activity wizard

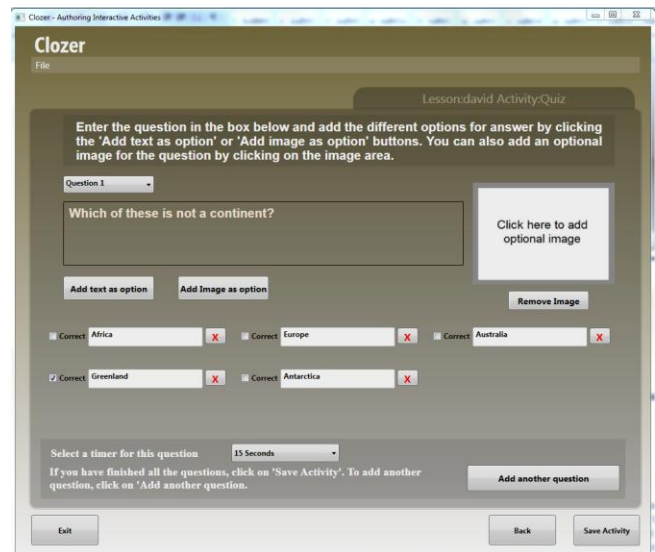


Fig 3: Wizard-only interface

screen (see Fig. 3). Further iterations over the wizard interface concept resulted in a simple, intuitive interface that required little time to enter content. Additionally, it only required the teachers to know how to click once, and type to enter content.

Explicit instructions for each screen were added to help the teachers identify what they needed to do. This had the added benefit of helping them know what stage of the creation process they were in.

C. Final Prototype

The final prototype of the authoring application was named Cloze [26]. Cloze combined two key design features. The first was the task-oriented interface and interaction model, and the second was a content template system. The next section explains how the two features simplified the authoring process. It describes the process of creating an interactive activity with Cloze.

Cloze currently supports the authoring of four types of interactive activities. These were determined from

observations of the activities teachers engaged most in with their students:

- *Labeling*: given a piece of text or an image, students provide labels for different parts of the text or image.
- *Matching*: given two lists, students match elements from one list to elements in the other.
- *Identifying*: given an image or text with a list of labels, students have to select the labels that match the areas of the image or text the teacher specifies.
- *Quizzes*: a set of questions with or without answer options that the teacher poses to the students.

To create an image identification activity in Cloze, a teacher would first either choose to create a new lesson or work of an existing lesson by selecting a content template (see Fig. 4). The content template feature enables the teachers to create content from existing materials. This aligns well with their natural methods of content creation. More importantly, it saves them time as it provides them with digital copies of their existing content, allowing them to skip the digitizing phase and concentrate on adapting the content.

Once a lesson is created, the teacher is shown an 'Activity Selection' screen where they would choose the image identification activity (see Fig. 5). To create an image identification activity, a teacher would usually need to find the image and identify the parts of the image they would like the students to identify. Similarly, upon selecting the identification activity, Cloze guides the teacher through a series of screens (activity areas) that allow the teacher to accomplish each of the steps needed to create the activity.

In this case, the first activity area would allow the teacher to specify an image to use. If the teacher was using content template, then an image would already be selected. However, this image could be changed as well. After the teacher has selected an image, they would click the 'Next' button to move to the next activity area. For image identification, this would be the area where they label the image (see Fig. 6). To do this, a teacher needs to click on the part of the image they want to label. This would bring up a textbox in which the teacher would type the label name (see Fig. 6).

To rename or delete a label, a teacher would simply need to click on the label button. This would present them with a dropdown menu with the rename and delete options. As shown in Fig. 6, other options related to the activity would be also visible. For example, the teacher could set a time limit for the activity. When the teacher is done labeling the image, they have the option of adding another image to the lesson or clicking the 'Next' button. Choosing the 'Next' button in this case would save the lesson as no further input is required from the teacher. The content is now ready for students to interact with (see Fig. 7).

It should be noted that Cloze's task-oriented design properly guided the teacher through the content creation process. For each step in the process, the teacher was presented with an appropriate interface (activity area) for that step. Each activity

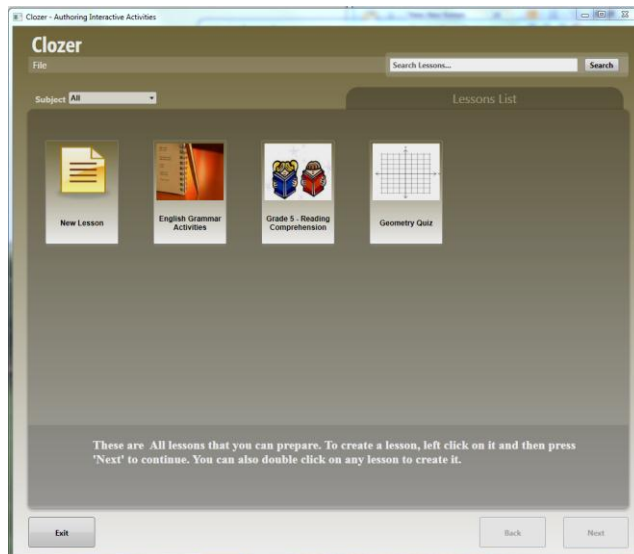


Fig.4: Content templates allow users to use pre-existing content

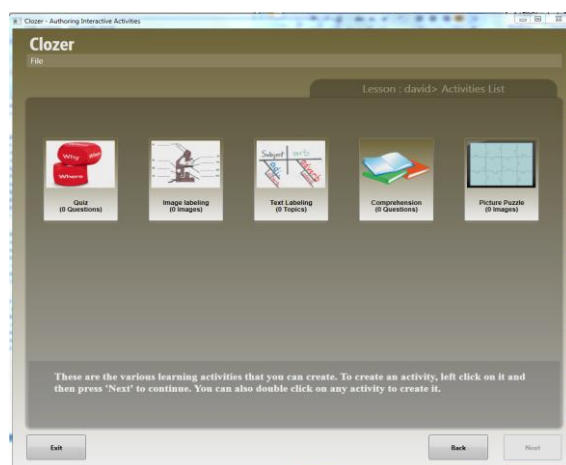


Fig. 5: Activity selection screen: users can pick an interactive activity to create.

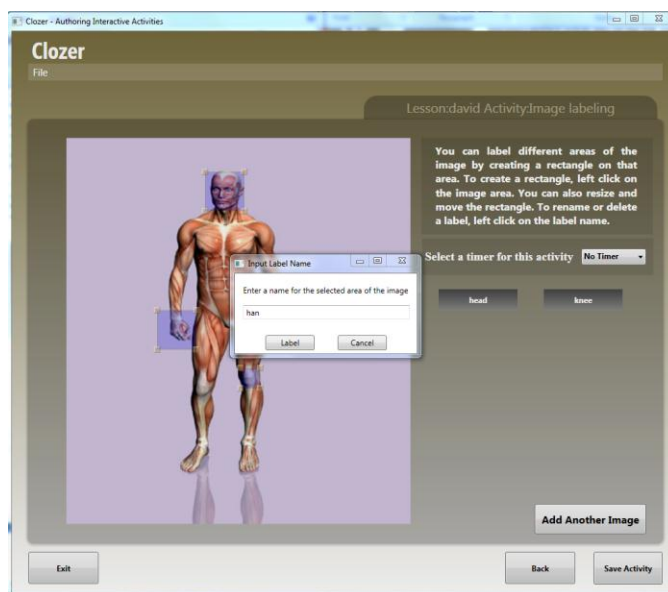


Fig. 6: Labeling an image for an image identification activity.



Fig. 7: Students collaboratively engage in an image identification activity.

area only exposed and allowed functionality related to that step. This allowed the teacher to focus solely on the task at hand. The activity areas also included instructions, feedback and navigation cues. This informed the teacher of what was required of them in that area, and also oriented them to where they were in the creation process. Additionally, each activity area tried to minimize the number of mouse-based interactions that went beyond clicking. Altogether, Cloze allowed teachers to create content in a simple, task-focused manner that was intuitive.

In addition to the content creation environment, Cloze included a ‘Player’ application that allowed users to interact with the created content. This ‘Player’ was at its core a MultiPoint application. It allowed two or more users to simultaneously interact with the activities the teachers had created. Thus, once a teacher creates an activity with his/her own content, students could open the saved lesson file using the ‘Player’ to complete the activity in a fun and engaging manner (see Fig. 7).

V. FIELD EVALUATION

Having established the usability of Cloze through the iterative design process, a 3-month pilot was conducted to validate its efficacy in a proper school environment. Cloze was installed on nine computers in one of the selected schools. Ten teachers recommended by the administrators of the school then underwent a two-hour long course on how to use Cloze. Of the ten teachers, two were *High Proficiency* teachers and another two were *Non-Users*. The remaining six were all *Low Proficiency* users. It should be noted that the teachers were never specifically directed to use Cloze during the course of the pilot. The goal was to identify the ways in which, and the reasons why the teachers used or did not use Cloze in their teaching.

A. Data Collection

We used two main data collection methods. First, we used user-log data. The version of Cloze installed on the machines included a logging feature that tracked the teachers’ usage of Cloze. The log files contained the following information: the lesson name, the author of the lesson, the number of activities in the lesson, the name of the machine it was created on, and a timestamp of when the lesson was created. If the file was edited at a later date, a timestamp and information on the changes were appended to the file. The participating teachers were made aware of the logging feature.

Second, we conducted semi-formal interviews with the participating teachers every two weeks. During this time, the researchers tried to get a sense of what the teachers thought of Cloze and collected feedback for improvements. Additionally, in the cases where the log files showed interesting activity, we followed up with the teachers to get a better understanding what had happened. The final evaluation of Cloze was based on observations during the bi-monthly school visits, the interviews and the user-log data.

B. Results

The logged data indicated that five different authors created twelve lessons over the three-month period. One teacher created eight lessons. Three of those lessons were done on behalf of two teachers who were not members of the informants. Two of the authors were in the *High Proficiency* group, whereas the other three were in the *Low Proficiency* group.

As expected, the two *Non-User* teachers did not even consider using the application. Of the remaining three teachers, one also did not use Cloze whereas two started but did not complete a lesson. These teachers reported time constraints as the main reason for non-usage. Further inquiry revealed that logistical issues also played a role. These teachers were mainly interested in using Cloze for in-class quizzes. However, this required them to move their students between the computer lab and the classroom. The time involved in the shifting process was significant enough that they found printing or writing questions on the blackboard a more suitable option. Although the number of created lessons seemed small, conversations with the three *Low Proficiency* teachers who used Cloze revealed that over the same 3-month period, they had only created an average of two other digital activities or presentations.

All the activities created were quizzes, except for two, which were image-labeling activities. One quiz activity was a derivative of a pre-existing one, with some questions removed and others added. On average, the quizzes contained ten questions, with an average of four answer options. Of the ten quizzes, seven consisted of content from textbooks and other supplemental materials. The other three contained new content created by the teachers. The two image-labeling exercises came from curriculum materials, but used pictures obtained from the elsewhere.

The authors used three different computers – two of these were the primary workstations of the two *High Proficiency*

users. The logged data also revealed several uncompleted lessons started by various teachers who were not members of the participating teachers.

C. Discussion

In this section, we discuss the key results from the pilot. We cover the following topics: (1) ease of use of Cloze; (2) content creation patterns; (3) the choice of interactive activity; and (4) the limitations of the evaluation. Overall, the pilot re-emphasized the teachers' natural tendencies for content creation and demonstrated that Cloze aligned well with these tendencies and made content creation easier and less time consuming for the teachers.

Ease of Use

Interviews and observations of the teachers indicated that they found the interface and interactions intuitive, particularly for quizzes and image labeling activities. A computer lab manager reported getting increased requests from colleagues to create digital quiz activities for them after word spread that the creation process was now easier.

High Proficiency teachers found Cloze to be a fast way to create activities. They, however, found it limited because it lacked features such as animation controls and text formatting options. Further discussions revealed that they found Cloze simplistic for their advanced needs. Although, PowerPoint took some effort, it had the features they wanted. For them, the speed of creation was what they found most attractive about Cloze.

On the other hand, the *Low Proficiency* teachers particularly liked the limited feature set Cloze provided. One teacher reported that Cloze allowed her to focus on only entering content and not "*fretting over the formatting issues*" she normally faced when making a PowerPoint presentation. For her, the task-oriented interface significantly reduced the time and effort needed to create and administer quizzes in her class.

Content creation patterns

The pattern of content creation closely matched what we learnt from the initial interviews: teachers built off existing materials. Most of the activity content came from textbooks. One teacher created a new quiz by adapting an existing quiz created by another teacher.

As further evidence, during the course of the pilot, the school acquired access to a web-based question bank. Following that, three of the five active informants repeatedly asked, "*can you also hook the program up to Asset [the online question bank], so we don't have to keep copying and pasting?*" This again confirmed the teachers' reliance on pre-existing content. It also underscored the utility of Cloze's content template feature for simplifying the activity creation process.

Choice of interactive activity

One unanticipated outcome was the lack of variety in the activities teachers created. Even though Cloze supports four different types of interactive activities, ten of the twelve lessons created were quizzes. This, however, reflects the pre-

Cloze environment. Quizzes were the most common interactive activities teachers engaged in with students. This outcome, in part, speaks to the conservative nature of teachers when it comes to content creation: they replicate what is most familiar to them.

Limitation of evaluation

Due to time and resource constraints, an important metric could not be evaluated during the study period: the reaction of the students to the teachers' contents created using Cloze could not be properly accessed. This was both in terms their levels of engagement with the content (as opposed to pre-Cloze activities) and impact on learning outcomes. Anecdotal evidence suggests the students did enjoy interacting with the content the teachers had created, but it is not clear that this can be solely attributed to the Cloze-created content.

VI. DESIGN CONSIDERATIONS

In this study, we observed that providing an intuitive, task-oriented interface simplifies the digital content creation process for teachers. In addition, facilitating easy integration of existing content reduces the time teachers take to create content. Below, we present three considerations for designing authoring tools for teachers with low computer proficiency.

A. Consider task-oriented interfaces

Low Proficiency teachers find applications that require significant typing, programming or manipulation of UI widgets (e.g. buttons) difficult to use. From our study, we found that these teachers typically have basic typing and mouse motor skills. Also, they are easily intimidated by an application or interface with numerous features. They assume that the application must be difficult or time consuming to use, so they avoid using it.

The handholding, only-content-needed, nature of a task-oriented interface seems best suited for these teachers. First, such wizard-like interfaces require basic mouse skills to use. Second, the interface typically presents only a few features at a time. Also, these features are related to the task at hand. This gives the teachers a sense of control and confidence in their ability to use the application. This is because at any one moment they can infer from the task at hand what the functionality of each feature is.

When using a task-oriented design model, care must be taken to split the tasks over the screens in a manner that does not overwhelm the user. Additionally, feedback and instructions are needed to aid the user navigate through the wizard.

A task-oriented interface may not be always appropriate. As seen in the study, the *High Proficiency* teachers found Cloze did not given them enough control over the content. Where teachers are more proficient, these types of interfaces are most useful for speeding up repetitive tasks.

B. Consider providing content primitives

Teachers prefer to assemble content from various sources when creating content. Making it easy for teachers to integrate existing content, particularly those they often use, greatly simplifies the content creation process and time required.

Generally, teachers spend a significant amount of time scavenging for content to use in their lessons. For the most part, this content is paper based. Thus, to use it for a digital presentation, an extra digitizing phase is needed. This requires time, something teachers rarely have a lot of. As a result, they often do not utilize the digital medium and rely on paper instead.

Providing access to image banks or digital textbooks within an authoring environment greatly improves its utility to teachers. This cuts down on the time needed to find and digitize materials. Care must be taken to avoid arbitrary content though. As noted above, teachers often use materials that they are familiar with (i.e. within their curriculum). Thus, if possible, the content primitives should be tailored to the particular information domain of the users.

C. Incorporate pedagogy

Teachers use tools that align well with their pedagogical methods, experience, and comfort levels. Even though we provided different types of activities, teachers mostly created quizzes, as this was already part of the school's pedagogy. Integrating pedagogical practices in the design of content authoring tools provides an incentive for a teacher with low-computer proficiency to utilize the tool.

Overall, we find that the above three factors do lower the barrier for digital content creation by teachers with low computer proficiency. However, given that the study was limited to one particular group of teachers, we caution against generalizing our results beyond this group. Nevertheless, there are grounds to suspect that these findings will apply to broader a set of low computer proficiency teachers.

VII. CONCLUSION

An effective use of computers in learning requires teachers to be engaged in the computer-mediated learning process. This engagement occurs when teachers have control over content creation. In this paper, we present Cloze, an authoring tool that successfully meets the unique needs of teachers with low computer proficiency to simplify digital content creation for them. Through 34 weeks of field study and a pilot, we observe that such teachers prefer to work off existing content, rather than from scratch; and that these teachers perceived Cloze to be intuitive, but made limited use of its features. Additionally, we discuss the implications for designing authoring tools for teachers with low computer proficiency.

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REFERENCES

- [1] U.S. Pawar, J. Pal, and K. Toyama, "Multiple mice for computers in education in developing countries," *IEEE/ACM ICTD*, 2006, pp. 64-71.
- [2] U.S. Pawar, J. Pal, R. Gupta, and K. Toyama, "Multiple mice for retention tasks in disadvantaged schools," *ACM CHI*, 2007, pp. 1581-1590.
- [3] K. Graves, *Teachers as Course Developers*, New York, NY: Cambridge University Press, 1996.
- [4] B. Joyce and M. Weil, *Models of Teaching*, Boston: Allyn & Bacon, 2000.
- [5] J. McDonough and C. Shaw, *Materials and methods in ELT: A Teacher's Guide*, Oxford: Blackwell, 1993.
- [6] F. Barrera-Osorio and L. Linden, *The Use and Misuse of Computers in Education: Evidence from a Randomized Experiment in Colombia*, Education Team, Human Development Network, World Bank, 2009.
- [7] J. Pal, M. Lakshmanan, and K. Toyama, "My Child Will Be Respected: Parental Perspectives on Computers in Rural India," *ACM ICTD*, 2007, pp. 168-176.
- [8] National University of Educational Planning and Administration, "Elementary Education In India: Progress towards UEE," 2009.
- [9] A. Banerjee, S. Cole, E. Duflo, and L. Linden, "Remedying Education: Evidence From Two Randomized Experiments in India," *Quarterly Journal of Economics*, vol. 122, 2007, pp. 1235-1264.
- [10] Joyojeet Pal, "Early-stage practicalities of implementing computer aided education: Experience from India," *IEEE/TEDC* 2006, pp. 26-30.
- [11] L. Linden, *Complement or substitute? The effect of technology on student achievement in India*, MIT Jameel Poverty Action Lab, 2008.
- [12] P. Black and D. William, "Inside the black box: Raising standards through classroom assessment," *Phi Delta Kappan*, vol. 80, 1998, pp. 134-148.
- [13] J. Mueller, E. Wood, T. Willoughby, C. Ross, and J. Specht, "Identifying discriminating variables between teachers who fully integrate computers and teachers with limited integration," *Computers & Education*, vol. 51, 2008, pp. 1523-1537.
- [14] A. DiSessa, *Changing minds: Computers, learning, and literacy*. Cambridge, MA: MIT Press, 2000.
- [15] M.J. Hannafin and J.R. Hill, "Epistemology and the design of learning environments." *Trends and issues in instructional design and technology*, Upper Saddle River, NJ: Pearson Education, Inc., 2002, pp. 70-82.
- [16] "yAuthor – Interactive Content Authoring Tools."
- [17] N. Moraveji, T. Kim, J. Ge, U.S. Pawar, K. Mulcahy, and K. Inkpen, "Mischief: supporting remote teaching in developing regions," *ACM CHI*, 2008, pp. 353-362.
- [18] "Evaluating the REDEEM Authoring Tool: Can Teachers Create Effective Learning Environments?" Sep. 2009.
- [19] R.C. Thomas and C.D. Milligan, "Putting Teachers in

the Loop: Tools for Creating and Customizing Simulations,” *Journal of Interactive Media in Education*, 2004.

- [20] A.T. Neto, J.C. Anacleto, V.A. Neris, M.D.S. Godoi, and A.F.P. Carvalho, “A framework to support the design of learning objects based on the Cog-Learn Pattern Language,” *Proceedings of the 12th Brazilian symposium on Multimedia and the web*, Natal, Rio Grande do Norte, Brazil: ACM, 2006, pp. 128-137.
- [21] “Hot Potatoes Home Page,” Sep. 2009.
- [22] “Microsoft Learning: Rapidly Create Online Courses,” Sep. 2009.
- [23] W.O. Galitz, *The essential guide to user interface design*, John Wiley, 2002.
- [24] W.O. Galitz, *The Essential Guide to User Interface Design: An Introduction to Gui Design Principles and Techniques*, John Wiley & Sons, 1996.
- [25] M. Prensky, “Digital natives, digital immigrant,” *On Horizon*, vol. 9, 2001, pp. 1-6.
- [26] W.L. Taylor, “Cloze Procedure: A new tool for measuring readability,” *Journalism Quarterly*, 1953, pp. 415-433.