

Activity Theory and Interactive Design for the African Storybook Initiative

Alan Amory
Saide and University of the Witwatersrand, Johannesburg
South Africa
alan.amory@saide.org.za

Abstract: This research is concerned with the development and evaluation of a redesign of the online and mobile app African Storybook initiative services that support the authoring and reading of openly licensed storybooks to support literacy development in Africa. This redesign was initiated after a review of the African storybook web site and presented an opportunity to align the sociocultural theory used by African Storybook researchers and design of interactive artifacts and environments. The redesign makes use of a number of cultural-historical activity theory principles, including: object of activity (*obyekt* an independent entity and *predmet* the imagined objective outcome), tool mediated and shared objects that are part of the third-generation activity system. Three primary activities were identified (read, author and research). The author activity, implemented as a shared object includes library, create, translate and adapt objects of activity. Each of these objects make use of a single design pattern that includes a list of items that can be sorted, searched and viewed. Results from usability testing sessions lead to a refined design and provided evidence that redesign addresses problems identified during the review. This research illustrated that the reading, authoring and research *obyekts* created by individuals support the outcome of a new storybook (*predmet*).

Introduction

The aim of the African Storybook (ASb) initiative is to support and promote literacy in the languages of Africa using digital storybooks made available through openly licensed digital storybooks distributed by means of web-based Internet and mobile app services. These services make use of the web standards of HTML, CSS and JavaScript to support over 97 African languages as well as English, French and Portuguese. Currently there are close to 4000 storybooks in the repository. Story development and publication was supported by a number of pilot countries including Uganda, Kenya, Lesotho and South Africa. The services made available through ASb include on-line and off-line (mobile app and document download) reading, and online storybook authoring (creation, translation and adaption).

In 2014 the design and functionality of the ASb web site (www.africanstrybook.org) was externally reviewed (Kujua IT Limited) and a number of recommendations were made in term of user experience, performance, story delivery and technology. In particular, the review highlighted poor performance of the landing page overloaded with too many options and images; a poorly designed user experience (UX) that served different uses all at once, the use of inconsistent terms and information excess; and the use of Drupal that is not well suited for such a web-based application. With regards to the technology, the review suggested: 1. Implementation of a responsive design to support mobile devices; 2. Separation of reading, creation and third party access; 3. Development of apps from reading and creation; 4. Use of an agile development process to support rapid updates and feature implementation; and 5. Separation of the ASb web components into distinct sections so that each section can be addressed separately (Separation of Concern).

The research presented here documents and evaluates the redesign of the Internet-based services (reading, authoring, research), which include the ASb web site and Reading app for iOS and Android, to address these practical problems identified above and to make use of theoretical heuristics that not only underpin the design and use of the storybooks, but also the redesign of the reading, authoring and research services. Research associated with the ASb initiative often make use of sociocultural theory (see Janks, 2000). For example, Treffry-Goatley (2016) argues that analytical tools offered by critical literacy would allow children to engage with the perspectives and positions presented in texts. In particular, such an approach includes affect, fantasy and play. Therefore, to create coherence between the theory that is used to research the use and design of storybooks that are part of ASb, it is

appropriate to use Cultural Historical Activity Theory (CHAT) allied to Human-Computer Interactions (HCI) to design the tools to mediate the reading, authoring and research of these storybooks,

Contrary to the use of information processing psychology theory that was part of the early development of HCI development (Card, Newell, & Moran, 1983), Kaptelinin (1996) argued that a number of activity theory principles, which take into account cultural factors and aspects of human development, are better suited to support HCI studies. These included the unity of consciousness and action (objective reality); human activity is object-orientedness (social and cultural interactions as important as physical, chemical and biological ones) and hierarchical (processes take place at different levels); internalization-externalization organize mental processes; and that all human activities are mediated by external (pencil, paper, scissors) and internal (language, concepts) tools. Pertinent to this project are two important principles: the object of activity and tool mediation.

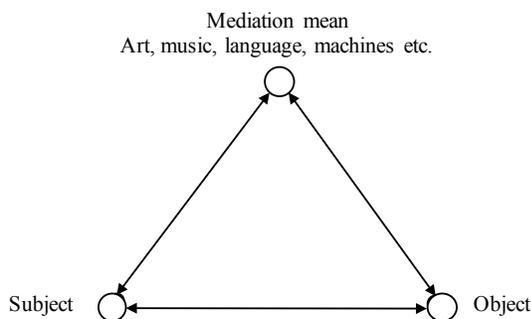


Figure 1. Vygotsky's mediated learning.

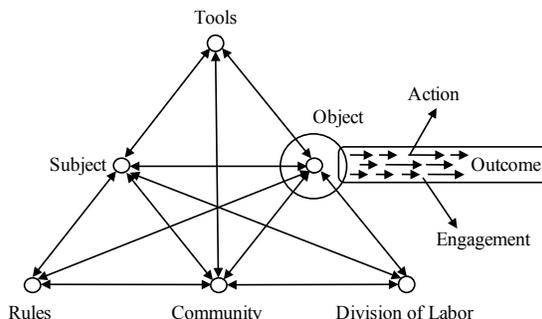


Figure 2. Engeström's conceptualization of an activity system (redrawn from Engeström, 1987, p. 78).

Vygotsky (1978) proposed, as part of Marxist socially orientated psychology, that development and use of higher cognitive functions in humans are embedded in mediated processes associated with the use of cultural tools (Fig. 1). Innate actions, similar to those of animals, is when a subject interacts directly on an object (the motive of a learning task). Vygotsky saw the direct actions on an object as the natural line of development and tool-mediated actions as part of the social-cultural development of humans (Wertsch, 1985). The object of activity is one of the most central concept of activity theory and the meanings of this concept are complex and depend on the context (Kaptelinin, 2005; Nardi, 2005). Issues related to its meaning include the translation of the ideas of Leontiev from Russian into English; the separation of the object of activity from the motivation of activity and Nardi suggests that it is the "instantiated object"; and the conceptualization of an object developed by Leontiev and expanded by Engeström.

With respect to translation into English from Russian, Kaptelinin explains that *obyekt* and *predmet* both translate to "object". Leontiev described an *obyekt* as something that exists independently of the subject (more subjective) and *predmet* as the imagined objective outcome (more objective). Nardi (2005) explained that *predmet* is related to that "which is realized" (p. 39) and that the *obyekt* as the "object of desire" (p. 40). When a concrete object is created by an individual it is formulated (Kaptelinin, 2005) and it is realized when there is an outcome (Nardi, 2005). Therefore, an object should be understood with its context. Actions and engagement on an object are part of the processes supporting the outcome and this requires social engagement.

The inclusion of the social context (rules, community and division of labor) into the activity system extended the work of Vygotsky and Leontiev and incorporates the idea that activity includes contradictions (disturbances, conflicts and various forms of problems) that are always part of collective social engagements (Engeström, 1987) (Fig. 2). However, this expansion does not fundamentally change the object of the activity. But this model neither describes interactions between different activity systems, nor support the develop of conceptual tools to explore multiple perspectives, dialogues and interacting activity systems.

To solve these problems, Engeström (2001) created the third-generation activity theory (Fig. 3) in which shared objects are created when more than one activity system interact.

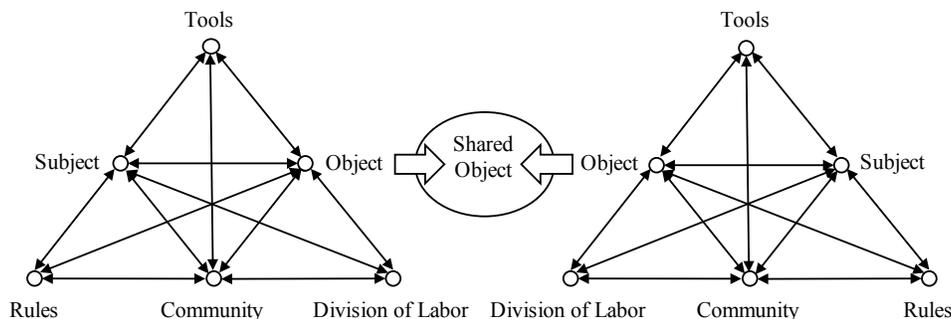


Figure 3. Third-generation activity theory.

Apart from the object of activity, tool mediation is also an important part of activity theory. Vygotsky (1978) described tools from two perspectives: the physical *tools* (such as pencils and technological artifacts), and the psychological *signs* and *symbols* (especially language). Tools are object-orientated to material activity, while signs and symbols are part of social and intrapersonal interaction, used to solve problems (that is, part of higher cognitive functions). But depending on the context, a material tool could function as a tool, a sign or both – all artifacts could therefore be seen as both material and conceptual, and as parts of our world, modified over historical time, and shaped by human activity (Cole, 1996). The co-constructed interactions between subject/actor, object and mediator allow the differentiation of three kinds of constructs as the physical object evolves to sign: tool as extension of oneself, physical object interacting with other, and interaction between subjects via sign and language (Yamamoto, 2012). These three levels could be aligned with explicit and implicit mediation that are necessary for human transformation (Wertsch, 2007). Explicit mediation is the introduction of a stimulus into an activity to change/mediate the activity (non-transitory and obvious) and implicit mediation involved signs (language and communication) that support individual transformation. However, while tool mediation is central to use of higher order cognitive function, the concept can also be used to support the design of technological objects.

Kaptelinin (2015) analyzed the concept of mediation with respect to current HCI research to identify a number of dimensions useful to the design of technological objects. These included:

- **Mediational means**
 - Me vs the world:* for example, personal technologies
 - Coupling between different means:* “the degree, to which the use of a technological artifact is integrated with the use of other mediational means.” (p. 3). Coupling can either be loose (independent use) or tight (high dependency)
 - Versatility:* for example, a software programme can be used for a variety of anticipated and unanticipated purposes
- **Subject of mediated activity**
 - Diversity:* mediation means can be through either narrow requirements, or designed to support different activities
 - Individual or collective:* mediation either supports individual or collective activities
 - Impact of mediation:* impact either short- or long-term
- **Object of mediated activity**
 - Types of objects of interest:* activities orientated to different types of objects of interest
- **Levels mediation**
 - Mediational means in the structure of activity:* activities that take place at several levels mediated by different means
- **Dynamics of mediation**
 - Appropriation:* technology appropriated by its users
 - Disruptive or incremental remediation:* new technologies substitute existing mediational means
- **Context of mediation**
 - Diversity:* use of technologies in various contexts

This research makes use of a number of activity theory concepts to redesign and evaluate the ASb online services to address issues identified by a technological review. The ASb designed services are *obyekts* that are

instantiated during the processes of reading and authoring to produce language proficiency and new storybooks respectively (*predmet*). Furthermore, the conceptualization of reading, authoring and research reporting tools as objects, addresses the software design SoC requirement discussed above. Furthermore, the design of the system and each of the associated objects takes cognizance of the varied ways in which technology can mediate outcomes and the third-generation activity theory provide a framework to integrate the different ASb services into a coherent system. The next section describes the conceptual components of the redesign. Thereafter, a usability evaluation of the new designs is reported and finally the mediational dimensions are used to contract the original with the new design.

Reconceptualization of ASb technological assets

The ASb technology review identified a poorly designed user experience (UX) that served different users at once, used terms inconsistently and included pages with an excessive amount of information. Also, the design was not aligned to the SoC concept. Identification of the *objects of activity* associated with the ASb assets (read, authoring and research reporting) can address these critiques. Therefore, each asset is conceived as a single activity system with the authoring asset including four activity systems to support a library function and the creation, translation and adaption of storybooks (Fig. 4). The Read, Author and Research activity systems are accessed from the primary links on the landing page. Other links related to the ASb team, terms of use and policies were relegated to the bottom section of the landing page.

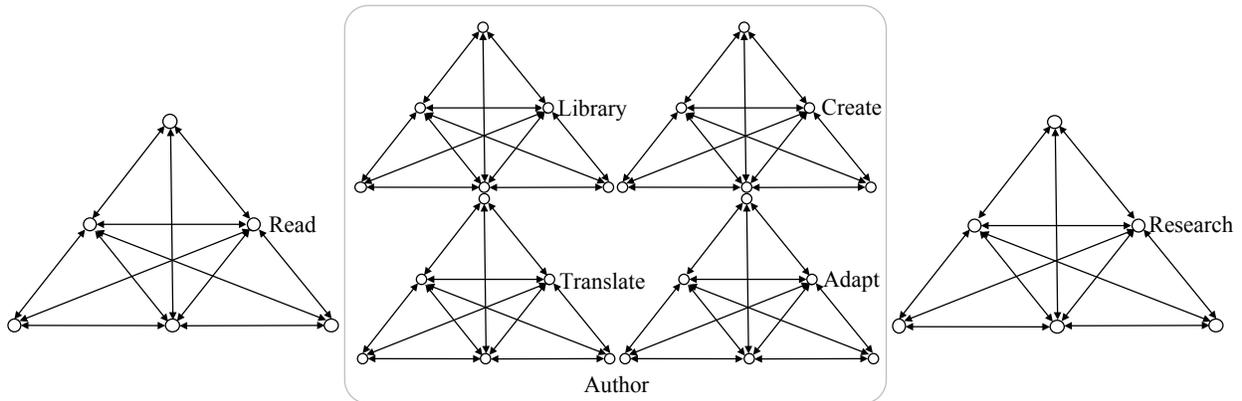


Figure 4. Activity systems for ASb.

Different rules and tools are associated with each activity system. Rules are implemented as object properties.

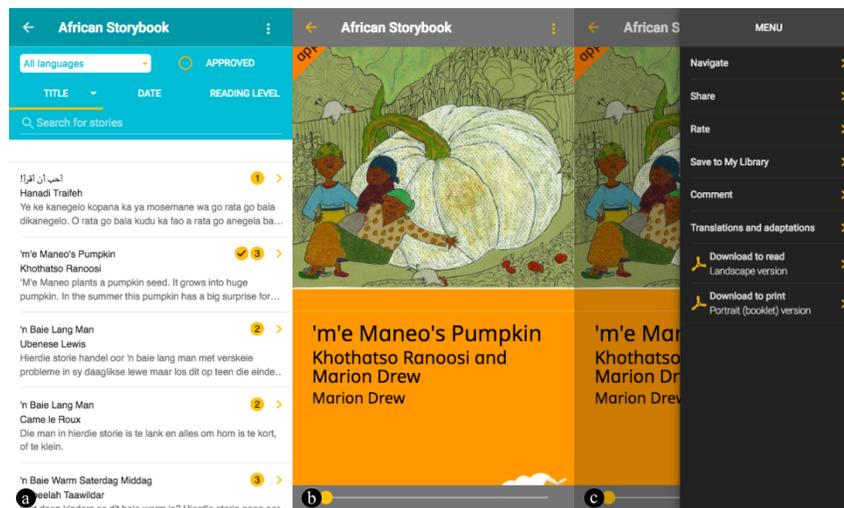


Figure 5. Design of the read activity system.

The primary tool of the read activity system (part of the web site and mobile apps) is a list of all available storybooks. A number of properties are associated with each individual storybook, including: title, author/translator/adaptor, language, publication date, story summary, reading level, approved status, identification. These properties are used to sort, or search, the list of storybooks (Fig. 5a). The identification property is used to display a particular storybook for reading that includes addition properties: help; sharing information via Twitter, Facebook or URL; comments; saving to the Library object for logged in users; other translations and adaptations; and pdf downloads for reading offline and printing (Fig. 5b, c). This design pattern (Gamma, Helm, Johnson, & Vlissides, 1995) of a list that is searchable without a round-trip to the Internet server and links to a specific tool is repeated in each object of activity.

Table 1. Properties associated with authoring objects

Property	Create	Translate	Adapt
Author/Translate/Adaptation	✓	✓	✓
Language	✓	✓	
Dual language		✓	
Reading level	✓		✓
Cover colour	✓		
Title	✓	✓	✓
Summary	✓	✓	✓
Original source	✓		
Preview	✓	✓	✓
Publish	✓	✓	✓
Sort pages	✓		✓
Add page	✓		✓
Page image	✓		✓
Page content	✓	✓	✓

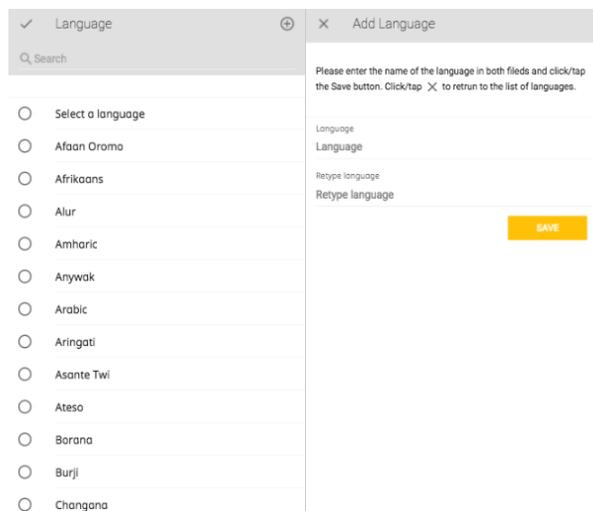


Figure 6. Example of the tools associated with a storybook authoring activity system.

An individual login is required to use the author component, called My Space, which includes three activity systems related to storybook creation, translation to a different language and adaptation to a different reading level and one, the library, that lists storybooks selected from the read object. Each of these activity systems makes use of similar design patterns. A list of storybooks is given that can be sorted by title or date, search using the storybook properties of title, author, and language or open for editing. Properties associated with storybook authoring activity systems vary as different rules apply for each system (Table 1). Additional software tools are associated with the properties of author/translate/adaptation, language, reading level, cover colour and images. Except for the cover colour (a selection of one of six colours) and reading level (a selection of one of five options), each property lists

possible choices and includes a mechanism to add additional items to the list. For example, the user can add additional languages by clicking the + symbol (Fig. 6).

A system to translate and adapt storybooks is also included through the download of an authoring template (Word document) for editing. Thereafter, the template is uploaded to the system and the storybook created for further editing.

It is planned to include a number of properties for the library activity system to allow bulk downloading and the creation and publication of storybook anthologies.

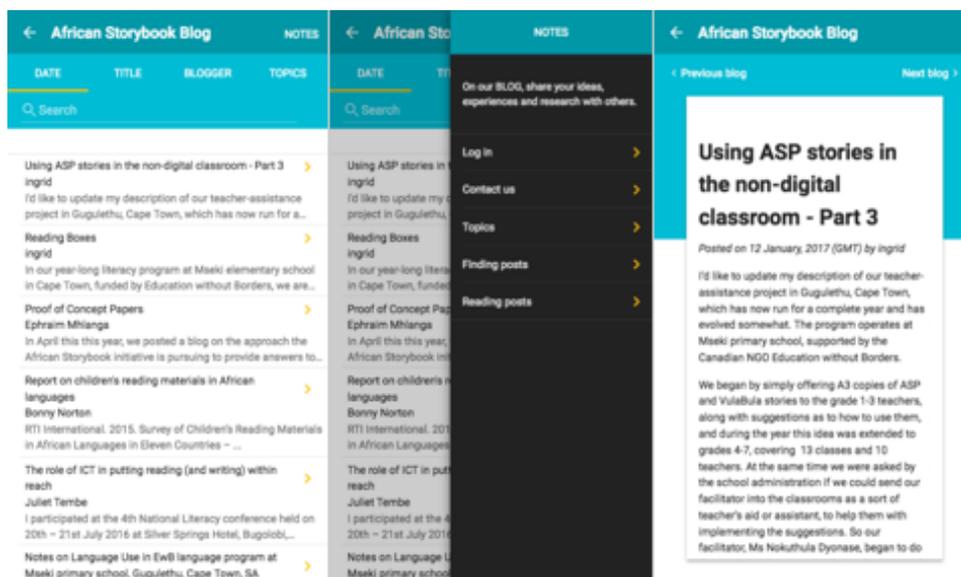


Figure 7. The design of the research blog site demonstrating the design pattern used for each object of the activity.

The research activity system is a WordPress component with a theme specifically designed to integrate with the ASb UI design that makes use of the ASb design pattern (searchable and sortable list, integrated help and display of a single item (Fig. 7).

The technology stack makes use of Linux, Apache, MySQL and PHP and no longer uses the Drupal content management system. Furthermore, the site makes use of the HTML5, JavaScript and CSS standards. The UI makes use of the Framework7 (<http://framework7.io>) HTML system for building web sites and apps for iOS and Android. Therefore, HTML, JavaScript and CSS assets used for the development of this responsive web site, are also used in the development of the reading app.

Every design requires that it is used by the intended audience. The ASb services *obyekts* were designed to support reading and authoring to produce language proficiency and new storybook development respectively (*predmet*). The usability testing undertaken in this research was to evaluate all the ASb services for those who are involved in storybook development.

Usability testing

Usability testing made use of a number of approaches. First, expert opinion was elicited and a number of internal scenario testing sessions were undertaken. During each of these iterations changes were made to the design. A final usability testing was undertaken with partner members (14) from different regions of Africa. This workshop included a number of tasks related to storybook reading, translation, creation and adaptation that the participants were asked to undertake working in pairs. Thereafter, a usability questionnaire of 23 usability and three scenario Likert-like scale (1-5, strongly disagree to strongly agree) items (Lewis, 1995; Nielsen, 1994) were answered by the participants. During the session two other members observed the participants as they undertook the

scenarios and made notes on their observation. In addition, two participants submitted written comments. After participants completed the questionnaire I reported and interrogated the results (Table 2, 3) with the participants.

Table 2: Usability items scored from most unsatisfactory (1) to most satisfactory (5).

Item	<i>n</i>	1	2	3	4	5	Mean ± SE
There are no irrelevant images that clutter the interfaces.	14	0	0	0	3	11	4.8 ± 0.1
Similar-looking icons result in similar actions.	14	0	0	1	2	11	4.7 ± 0.2
The website does not have too much text on it.	13	0	0	1	4	9	4.6 ± 0.2
I would recommend it to a friend.	14	0	1	1	2	10	4.5 ± 0.3
There are no redundant links that slow me down.	14	0	1	2	5	6	4.1 ± 0.3
Help instructions are useful.	14	0	1	3	3	7	4.1 ± 0.3
It is fun to use.	14	0	1	2	5	6	4.1 ± 0.3
The different components of the website function in similar, or consistent, manner.	14	0	1	2	6	5	4.1 ± 0.2
I do not notice any inconsistencies as I use it.	14	0	1	2	7	4	4.0 ± 0.2
It is easy to enter the requested information.	14	0	1	2	8	3	3.9 ± 0.2
I learnt to use it quickly.	14	0	1	3	6	4	3.9 ± 0.2
Appropriate feedback is provided when I make an error.	14	1	0	4	4	5	3.9 ± 0.3
I can use it successfully every time.	14	0	0	4	7	2	3.8 ± 0.2
The website is easy to use.	14	0	1	4	6	3	3.8 ± 0.2
The website requires the fewest steps possible to accomplish what I want to do.	14	0	1	3	8	2	3.8 ± 0.2
I easily remember how to use it.	14	0	2	3	5	4	3.8 ± 0.3
Help instructions are easy to find.	14	1	0	5	4	4	3.7 ± 0.3
Error messages are easy to understand.	14	1	1	4	5	3	3.6 ± 0.3
The website uses simple and natural language.	14	1	1	5	6	0	3.2 ± 0.3
I can use the website without written instructions.	14	0	6	1	5	2	3.2 ± 0.3
It is easy to 'learn' how to use the navigation, layout and data inputs on the website.	14	0	2	9	3	0	3.1 ± 0.2
Both occasional and regular users will like it.	14	0	4	6	3	1	3.1 ± 0.2
I am never stuck on a particular page.	14	2	5	3	4	0	2.6 ± 0.3

Table 3: Scenario items scored from most unsatisfactory (1) to most satisfactory (5).

Item	<i>n</i>	1	2	3	4	5	Mean ± SE
Overall, I am satisfied with the support information (online-help, messages, documentation) when completing the tasks in this scenario.	14	0	1	3	7	3	3.9 ± 0.2
Overall, I am satisfied with the ease of completing the tasks in this scenario.	14	0	3	4	6	1	3.4 ± 0.2
Overall, I am satisfied with the amount of time it took to complete the tasks in this scenario.	14	1	3	4	6	1	3.3 ± 0.2

Usability items (Table 2) that scored high indicated that the interface was uncluttered, there was consistent use of icons, and pages were not overloaded with text and contained no redundant links. Items that scored less well included those related to help instructions, use of simple and natural language, use of the site without written instructions, easy to learn navigation, that occasional and regular users would like on the site, and participants got stuck on some pages. During the discussion and evaluation of written texts a number of issues came to the fore.

- Participants found the registration and login processes difficult to complete. One participant commented that they had to submit the form six times before gaining access. This is impossible as no data are submitted to the server unless all the form information is correctly entered. On error, a popup message appeared at the bottom of the page and disappeared three seconds later. The way error messages were displayed was changed. Instead of a pop-up, an error message in red appeared to the right of the Continue button.

- The Library activity system included a process to translate or adapt a library items. This caused confusion. On reflection, the addition of these properties to this object of activity broke the rule of one object per action and disrupted the design pattern. Therefore, these two properties were removed.
- Participants suggested the help system text and help prompts should be simplified and this was undertaken.
- Participants unfamiliar with some of the ASb terminology asked that the definitions for ASb Approved and reading levels be added to the landing page. Two information interactive components were included to provided definitions for ASb approved and reading levels as pop-up.

The participant ratings of the scenarios (Table 3) showed that the interface provided sufficient online support to complete the tasks and that they were able to complete, with ease, the tasks. Participants believed they required more time to complete the set exercises.

These finding are different to those found by the external reviewer and support the proposal that activity theory, especially the separation of the different object of activity, support UI designs. However, it is important to know if the redesign supports tool mediated knowledge construction.

Mediation

Table 4. Evaluation of mediation dimension useful to the design of technological objects (Kaptelinin, 2015).

Mediation	Original web site design	Redesign web site and apps
Means – me versus the world	Not implemented	Personal apps
Means – coupling between different means	Not implemented	Coupling between the read and library activity systems
Means – Versatility	Partial implemented	Different outputs including online and offline reading (app and pdf), and online and offline authoring.
Subject of mediated activity – Diversity	Implemented	Implemented
Subject of mediated activity – Individual or collective	Not implemented	Not implemented
Subject of mediated activity – Impact of mediation	Implemented	Implemented
Object of mediated activity	Partially implemented (reading and authoring as a single object)	Implemented (reading, authoring and doing research as different objects)
Levels mediation – Mediation means in the structure of activity	Not implemented	Implemented
Dynamics of mediation – Appropriation	Partial implementation	Full implementation (web and app services)
Dynamics of mediation – Disruptive or incremental remediation	Disruptive – new paradigm of publishing	Disruptive – new paradigm of publishing
Context of mediation - Diversity	Not implemented	Implemented (responsive design usable on different devices)

Tool mediation is core to any activity system. Kaptelinin (2015) posited the technological artifacts can instantiate a number of mediation dimensions. The redesign of the ASb service, from an activity systems perspective to support a responsive web site and as part of iOS and Android apps, should therefore demonstrate such mediation dimensions in action. An evaluation of the original web site versus the new design implemented as part of the ASb web site and mobile apps was undertaken (Table 4). This evaluation illustrated that both the original and new designs support the mediation dimension. However, the new design demonstrated a wider implementation of these mediation dimensions. The development of the reading app was important and this provided personal mediation means, versatility, appropriation and diversity.

Conclusion

This development and research was undertaken to align the theoretical positions associated with the African Storybook initiative with the design assets for reading, authoring and research, but more importantly, to address issues identified during the 2014 ASb web site review. Issues addressed in the design included:

- A redesign of the landing page with fewer images and links to each of the objects of activity associated with reading, authoring and research. Other less important opinions were relegated to the footer area of the landing page.
- Users found the interface to be uncluttered, made consistent use of icons, and pages were not overloaded with text and contained no redundant links.
- A similar design pattern was implemented in order to provide a similar user experience across all objects of activity and to create re-usable code. Users agreed that the different components of the website functioned in a similar, or consistent manner.
- While everyone can access the read object of activity, access to authoring (and administration) objects and activity required additional rights.
- The ASb service no longer make use of Drupal but rather makes use of the industry standards of Linux, Apache, MySQL and PHP.
- The design is responsive and usable on desktop computers, tablets and advanced cellular phones.
- Each object of activity is coded as a single item and makes use of the ASb design pattern that includes rules (properties) and tools and therefore addresses the SoC issues.
- An app was designed for reading to support off-line storage of storybooks. As the authoring objects of activity require consistent access to web services and can be used on tablets (due to the responsive design) it was argued not to develop an app for storybook authoring.
- The use of agile development is appropriate for a large development team but not for a single in-house developer.

The use of the core concepts of activity theory, object of activity and tool mediation, aligned to contemporary software design (objects, properties and design patterns) supported the development of complex and integrated ASb services to create an easy to use web site and provided assets for the development of mobile apps for reading.

Work reported here illustrate that the reading, authoring and research *obyekts* when created by an individual support the outcome of a new storybook (*predmet*). Future evaluation should be undertaken to determine whether the newly designed *obyekts* for reading support the development of language proficiency (*predmet*).

Acknowledgements

Special thanks to the African Storybook team for their support, insights, their critical comments and encouragement. This project is generously funded by Comic Relief.

References

- Card, S. K., Newell, A., & Moran, T. P. (1983). *The Psychology of Human-Computer Interaction*. Hillsdale, NJ, USA: L. Erlbaum Associates Inc.
- Cole, M. (1996). *Cultural psychology: A once and future discipline*. Cambridge, MA: Harvard University Press.
- Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.
- Engeström, Y. (2001). Expansive Learning at Work: toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14(1), 133–156.
- Gamma, E., Helm, R., Johnson, R., & Vlissides, J. (1995). *Design patterns: elements of reusable object-oriented software*. Addison-Wesley.
- Janks, H. (2000). Domination, access, diversity and design: A synthesis for critical literacy education. *Educational Review*, 52(2), 175–186.
- Kaptelinin, V. (1996). *Activity Theory: Implications for Human-Computer Interaction in B. Nardi Ed Context and Consciousness*. MIT Press.

- Kaptelinin, V. (2005). The Object of Activity: Making Sense of the Sense-Maker. *Mind, Culture, and Activity*, 12(1), 4–18.
- Kaptelinin, V. (2015). Designing mediation. In *Proceedings of the European Conference on Cognitive Ergonomics 2015* (p. Article No. 1). New York, New York: ACM.
- Kujua IT Limited. (2015). African Storybook Project – Website Evaluation Report. Internal report.
- Lewis, J. R. (1995). IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, 7(1), 57–78.
- Nardi, B. A. (2005). Objects of desire: Power and passion in collaborative activity. *Mind, Culture, and Activity*, 12(1), 37–51.
- Nielsen, J. (1994). Usability engineering. Elsevier.
- Treffry-Goatley, L. (2016). *A critical literacy and narrative analysis of African Storybook folktales for early reading*. MA, University of the Witwatersrand, South Africa.
- Vygotsky, L. S. (1978). *Mind in society. The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard University Press.
- Wertsch, J. V. (2007). Mediation. In H. Daniels, M. Cole, & J. V. Wertsch (Eds.), *The Cambridge companion to Vygotsky* (pp. 178–192). New York: Cambridge University Press.