What Makes It Hard To Design Instructional Software?
Towards a Collaborative Platform for Stakeholders of Instructional Software

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Abstract—People and communication between them is often ignored in software engineering even though they are crucial to the success or failure of a software project. During the life cycle of software, there is communication, cooperation and collaboration (C3) between a wide range of diversified stakeholders ranging from management team to maintenance team. We believe that the lack of emphasis on improving C3 is often the major cause for software failures. In this paper, we summarize four and half years of our experience of analyzing decade-long instructional software for adult literacy developed by 9 different teams spread across 9 different locations following 9 varied processes. We present the different kinds of stakeholders that we came across during this analysis and present the challenges of C3 in that context. We then present the initial facets of our solution from three major dimensions (i) designing a unifying modeling language for improving stakeholder C3 (ii) modeling information for multiple stakeholders using various modes of rendering at multiple levels of granularity (iii) harnessing the power of social networking to improve C3 among all stakeholders.

Keywords—instructional software; collaborative platform; stakeholder communication; cooperation, collaboration; modeling language; social networking

I. MOTIVATION & CHALLENGES OF STAKEHOLDER C3 IN INSTRUCTIONAL SOFTWARE

It is often observed that a holistic view of software development considering all stakeholders perspectives’ drives success of a software project rather than emphasizing only on technical activities like requirements, analysis, design, construction and maintenance. Facilitating better communication, cooperation and collaboration (C3) among stakeholders is another key factor for successful software projects as discussed in [1]. Unfortunately, when the same C3 is not well supported by the environment can lead to failure of projects [9]. There has been enormous research [3][5][6][15] broadly trying to improve stakeholder C3 and to understand the impact of C3 on software development. The emergence of communities like CHASE [11], CSCW [16] further looked at human and collaboration aspects of software development while the agile software development community has emphasized the importance of people over processes [12]. While improving C3 during the design of instructional software was discussed in [13], there is significant need to further integrate ideas from HCI, design, interaction design and social networking to address the challenges of C3 in instructional software.

In this paper, we summarize our experience of analyzing decade-long instructional software for adult literacy and argue about the importance of C3. The Adult Literacy Program (ALP) initiative [7] targeting 200 million adult illiterates in India involves design and development of eLearning Systems for 22 Indian languages and their major dialects. Each eLearning System aids in teaching adult illiterates of a particular language. We have created an eLearning Platform that supports automation of this family of eLearning Systems reducing the amount of development effort from 5 person-years to 5 person-months [17][18]. Based on this experience, we present challenges faced during our collaboration with the diversified set of stakeholders and outline few preliminary solutions.

Designing and building instructional software requires the involvement of stakeholders from various backgrounds ranging from Psychology to Software Engineering to Government officials. Hence, our effort involved collaboration between different people from widely diversified backgrounds ranging from researchers in adult literacy, software engineering to computer illiterates. It is natural that such diversified backgrounds gave rise to diversified perspectives. For example, Instructional Designers focus on designing the process of instruction and learning materials using appropriate learning theories, Language Experts are roped in for standardizing instructional material of 22 Indian Languages and their dialects, Government Authorities are involved at multiple levels for ensuring the quality of instruction and timely delivery, Software Developers and Maintainers are associated for developing and maintaining eLearning Systems, Voluntary organizations on the field have helped us to take the systems to adult illiterates. Naturally, Instructors and Learners are two primary stakeholders with Researchers (authors) in Software Engineering involved for reducing the massive effort of creating and maintaining these eLearning Systems. In addition, there are people performing traditional roles during software development life cycle like software architect, program manager, marketing and so on. Table 1 lists some specific stakeholders of ALP along with their background and perspective. Stakeholders may be implicit or explicit and in ALP most of them have non-technical background creating further challenges for stakeholder C3.
How do stakeholders from widely varied backgrounds communicate, cooperate and collaborate during design of instructional software and how to enrich their experience?

While there are many approaches for eliciting and classifying stakeholders based on priorities, goals [2][6][14], the focus of this paper is to specifically discuss the impact of C3 in instructional software and enrich their experience. The key concern that we have observed during our exercise of automating a family of eLearning Systems [17] for four and half years is that the entire life cycle involved people ranging from different backgrounds (as shown in Table I) and there is no uniform way of expressing one’s concern to other stakeholders tampering a uniform understanding of the system. Essentially, instructional designers of adult literacy have no means to express their model to software developers creating eLearning Systems and vice-versa. This lack of synergy between instructional designers and software developers of learning technologies is a major concern affecting the quality of instruction on the whole not just in the case of adult literacy but in most of the instructional software that uses eLearning mode. As emphasized before, C3 is one of the major concerns impacting the success or failure of instructional software. We have analyzed 9 eLearning Systems designed for 9 Indian Languages at 9 different locations developed over a decade in trying to address the above concerns and made few key observations. Firstly, we found that it is hard to convince and motivate non-technical stakeholders that technology would be useful and eliciting information from them in this context is often difficult. During our informative study with 10 software developers and 4 domain experts for about 6 weeks, we have observed that software developers often lacked domain expertise of learning theories and have used generic information available because of the difficulties of expressing their problems with instructional designers. On the other hand, instructional designers often talked in terms of learning theories and motivational theories which are hard for software developers to understand and they often ignored them as most of the times they are invisible in instructional software. Documents, presentations, specifications and other forms of expressing information have invoked minimal interest in stakeholders. When we enquired how many stakeholders would read through material before a stakeholder meeting, only 2 out of 20 stakeholders said they would consider it and the rest of the people responded that they would only look at the information either during meeting or even skip reading it completely. Most of the stakeholders often preferred informal sharing of knowledge rather than writing down specifications. By contrast, often success of software projects largely depends on clear, unambiguous and precise communication of information among stakeholders. In another study of 10 software developers, we found that people often go to their friends and colleagues when a problem arises and use temporary solutions because of lost context during communication. We also observed that stakeholders often used a mix of qualitative and quantitative data to make important decisions.

While most of the observations we made and challenges we discovered are not novel, ALP is yet another case of emphasizing that C3 is crucial in instructional software and is often the cause of failures if not handled the right way. The rest of the paper will discuss some facets of our proposed solution from a broader perspective.

II. TOWARDS A UNIFIED MODELING LANGUAGE

From a software engineering viewpoint, we propose that a unified modeling language (UML) that can be used by all stakeholders to model information pertaining to multiple perspectives of instructional software would help. We envision a unified modeling language that is

- Formal and yet allows informal description
- Precise yet allows changes during evolution
- Granular yet can be described at higher level
- Easy to use but can be converted to specifications
- Allow diversified stakeholder C3
- Zoom In and Zoom Out of information

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Background</th>
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<tbody>
<tr>
<td>Teachers (Preraks)</td>
<td>Who are responsible for teaching with no or minimal knowledge of computers</td>
</tr>
<tr>
<td>Learners</td>
<td>Adult Illiterates - People who can speak their language but cannot read or write.</td>
</tr>
<tr>
<td>Subject Matter Expert</td>
<td>Who knows the content to be delivered to learners</td>
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<tr>
<td>Language Experts</td>
<td>Experts who handle the linguistic aspects of instructional software</td>
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<tr>
<td>Psychology Experts</td>
<td>Who decide learning methodologies from cognitive and psychological aspects</td>
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<tr>
<td>Learning Experts</td>
<td>Who are aware of various learning methodologies and adapt them appropriately for the current context</td>
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<tr>
<td>Instructional Designers</td>
<td>Who use instructional strategies to enrich the experience of teachers and learners</td>
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<tr>
<td>Instructional Technologists</td>
<td>Who develop and deploy educational technologies to aid instructional strategies</td>
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<tr>
<td>Software Developers</td>
<td>Who actually implement and use technologies to develop instructional software</td>
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<tr>
<td>Maintenance Engineers</td>
<td>Who maintain the instructional software for evolving requirements</td>
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<tr>
<td>Usability Experts</td>
<td>Who assess and improve the system from usability and HCI perspective</td>
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<tr>
<td>Field Experts</td>
<td>Who deploy instructional software on the field and evaluate technology</td>
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<tr>
<td>Government Authorities</td>
<td>People at multiple levels in Government are involved including decision makers, managers, administrators and volunteers at grass root level</td>
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<tr>
<td>Voluntary Organizations</td>
<td>Who support deployment of instructional software on the field</td>
</tr>
<tr>
<td>Researchers</td>
<td>Who pose important research challenges from learning methodologies, learning technologies, software engineering and HCI perspectives</td>
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We propose that the unified modeling language should be multi-dimensional and allow rendering of information in multiple modes at multiple levels of granularity to multiple stakeholders. For example, we replicate the text used during the design of instructional software for adult literacy in Figure 1. Here three stakeholders have communicated information using text and we observed that even though this text is usually annotated with visuals has failed to make communication clear. Figure 2 shows the typical process of communicating using UML. The stakeholders have to first decide the information that has to be disseminated and the most relevant stakeholders for that information. Then they should specify or model the information using required modes of rendering (Natural Text, Formal Specification, Visuals and Text, Visuals, Audio and Text, Models, Collaborative Diagrams, Feature Models, Business Processes...). The core idea is that stakeholders should be able to express their knowledge in a form that requires minimal effort from them and is easily understandable and usable by other stakeholders. This can happen only when they specify the information at required levels of granularity and using multiple modes of rendering. The UML acts as a common base to transform information from one stakeholder perspective to another stakeholder perspective. We are currently using XML as the internal form of storing information but this UML notation is still at a preliminary stage and requires a lot of honing in terms of notation and semantics as well. Interaction design and participatory design are two major areas of research that are close to the approach specified in this section. However, we believe that having a language through which informal information can be modeled using formal notation is a potential research direction.

Interaction design and participatory design are two major areas of research that are close to the approach specified in this section. However, we believe that having a language through which informal information can be modeled using formal notation is a potential research direction. There are two ways of looking at a modeling language in this context. One perspective is to have a language for modeling information for improving stakeholder C3 and the other perspective is to have a domain specific modeling language for improving stakeholder C3 in instructional software. We believe that an integrated solution will address the challenges of instructional software.

One major challenge with the idea of modeling language is that stakeholders are often reluctant to provide information and in most of the cases often do not update information when changes happen. We plan to tackle this challenge using social networking tools as explained in next section and integrate UML with social networking tools.

III. USING SOCIAL NETWORKING TOOLS TO ENHANCE STAKEHOLDER C3

We have analyzed the profiles of a majority of stakeholders of instructional software on social networking sites like facebook, linkedin, twitter and found that they spend considerable amount of time in using them and are often comfortable to work using information disseminated using these tools. Can we harness the power of social networking to enhance stakeholder C3 during design of instructional software?

The core idea is to make a group of all stakeholders in facebook, linkedin, twitter and so on and use these modes aggressively to enhance C3 between all stakeholders. We found that this mode of C3 will largely benefit the software project because people often react to tweets and facebook hits rather than emails. We have done a preliminary study of how stakeholders react to comments on their documents using social networking tools and we observed that most of the stakeholders seem to react quite positively when replying through social networking tools. We have also observed that certain stakeholders like learners and software developers are geared towards using social networking while non-technical stakeholders like teachers had some trouble. The ALP case seems to be different with many non-technical stakeholders...
in the process. We have observed that some non-technical stakeholders of ALP are keen to get information on their mobiles and handheld devices through SMS. Using social networking for improving C3 in non-technical stakeholders is an open research question. Dealing with unstructured data is another major challenge for the use of social networking. Further, mapping of unstructured data to meaningful structured form requires creation of systematic processes and integration of various tools. Figure 3 shows typical stakeholders in instructional software and some social networking tools that they can use to share information among themselves and about the system.

IV. A PLAUSIBLE INTEGRATED SOLUTION

While there is a consensus that stakeholder C3 is critical to the success of a project, we believe that there are significant research challenges in that direction. The idea of having a modeling language to model information seems to be a right direction however the requirements of such a language as discussed in Section II require further research and often have conflicting requirements. The main challenge is to structure the unstructured information in a form that is easily accessible and manageable to a wide range of diversified stakeholders. Updating the information during the evolution of software with minimal effort from stakeholders is another major obstacle. Essentially, every stakeholder speaks their own language which is often difficult to depict and much more difficult for other stakeholders to understand. We propose that only a modeling language as discussed in Section II cannot be a plausible solution unless it is integrated with social networking and existing tools.

V. DISCUSSION & CONCLUSION

While there are many relevant areas of work like classifying stakeholders [2][6][14] and engaging stakeholder communication using social networking [19], we found that using them for C3 as described in this paper is still an emerging area and is potential research direction especially for CHASE community. One close work by William [20] talks about teaching soft aspects to students of software engineering and discusses about various challenges of stakeholder communication. While there are numerous empirical studies of using social networking to engage stakeholder communication like [4][19], however in the context of instructional software, we found that keeping track of unstructured information especially in Indian context is still an open challenge because of non-technical stakeholders in the process. Two major areas related to this work which are not discussed in detail here are interaction design [8] and community of interest [10].

This paper has essentially discussed the idea that communication, cooperation and collaboration between stakeholders from widely varied backgrounds is critical for the success or failure of a software project based on four and half years of our practical experience. We then presented need for a unified modeling language for a common understanding of information among stakeholders and emphasized that using social networking tools will significantly improve C3 among stakeholders. We plan to design a modeling language and collaborative platform that uses the ideas discussed in this paper for enabling multi-dimensional, multiple-stakeholder perspective of software project information at multiple levels of granularity.

We strongly believe that the contributions of proposed research not only benefit the instructional design community but from a software engineering perspective, there is ample scope for researching modeling languages. This research also contributes largely to the HCI and SE communities as we plan to design collaborative platforms that provide processes and tools that help people from different backgrounds contribute to the software construction essentially teaching us how to design systems for the people by the people of varied backgrounds.

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