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Expanding the Impact of Practical Scientific Concepts for Low-literate Learners through an Inclusive and Participatory Virtual Knowledge Ecosystem

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Abstract: Extension materials for low-literate learners are often developed as part of specialized projects for specific regions or groups. In some cases these materials are inaccessible to other development organizations during the project's life or are lost at the end of the project. More recently, such development materials are typically placed on individual websites for the purpose of preserving the content beyond the scope of any given project. However, such materials are (i) often challenging to find and (ii) those individuals that are able to find and adapt these materials for local use cannot return these local adaptations to the World Wide Web without creating new, often separate, websites. We propose an Internet-based virtual knowledge sharing system for development materials for low-literate learners that allows users to easily access the materials and to contribute their local adaptations and local solutions. The site we envision is similar to a "wikipedia" in terms of ease of use but contains materials that will be peer-reviewed before publication. The site also will allow for post-publication online reviews and updates as mechanisms to assist in the improvement of content and to facilitate the localized adaptation of content.

Keywords: Extension Documents, Developing Nations, Low-literate Learners

Introduction

THE SCALABILITY OF "printed" material has improved dramatically in the last two decades due to technological shifts, most notably the World Wide Web (WWW), that have changed the way literate learners access information. The Internet has resulted in an explosion of access to knowledge and online learning tools for literate learners. Although literacy inherently allows for a certain level of scalability, technical articles are often written by and for those literate in the specialized field that the article focuses on. Even so, such content can be rewritten into a more accessible language that allows most literate members of a population to understand some aspects of the concepts (*e.g.*, science in the popular press) and how the concepts may impact their lives. Regardless of the target

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audience within the larger population of the literate learners, these materials can in many cases be repeatedly accessed, and this accessibility can be scaled to reach a large number of people.

Practical scientific concepts are no less important to the one billion people in the world who are low-literate learners than they are to literate learners. As is the case with literate learners, enabling low-literate and often low-income learners to understand basic concepts and to access relevant information can be extremely important in their daily lives (Souter, Scott, Garforth, Jain, Mascarenhas, & McKemey, 2005). Such concepts can be used for practical purposes such as improving health, increasing access to water, increasing the productivity and well-being of their livestock, applying better control methodologies for local crop pests, and learning to participate more effectively in the marketplaces as consumers and as entrepreneurs. Such learning is increasingly relevant as communities around the world create innovative solutions to a range of issues that matter to their local livelihood, health, and ecology.

Access to relevant scientific information/knowledge has substantial potential to create social and economic mobility for low-literate and low-income populations in the developing world. Despite the apparent benefits, however, this section of the population has largely been excluded from the information revolution. Reasons for this exclusion are lower penetration of information-access infrastructure, socio-cultural diversity, as well as the low levels of literacy and income in these regions. Although information and communication technology (ICT) interventions have been recognized as important for medical issues in developing nations, non-medical areas, such as agriculture, business-skill development, and environmental sustainability, have received less attention (Chetley, Davies, Trude, McConnell, Ramirez, Shields, Drury, Kumekawa, Louw, Fereday & Nyamai-Kisia, 2006).

In the following article, we outline a strategy to help local educators easily obtain important concepts from the WWW for dissemination to populations of low-literate learners and to help local educators develop, modify, share, and deploy novel and localized materials. We provisionally have termed this approach the Virtual Knowledge Ecosystem for Sustainable Development (VKESD). The VKESD is an online system in which materials can be (i) accessed in a wikipedia-style format and (ii) downloaded, adapted, and returned to the system in such a way that preserves local adaptations, all in a peer-reviewed manner that makes the content mobile and expandable as local projects contribute their versions. Parameters critical to the development of this system are outlined below.

Increasing Access to the Electronic Information

World Wide Web access and cell phone usage have dramatically increased throughout the globe, though urban areas are typically "wired" long before their rural counterparts. To address the problem of WWW access in rural areas, many non-profit and for-profit organizations are currently developing inexpensive laptop computers that can be used in villages. Although the concept of the "$100 laptop" arose from the One Laptop Per Child Organization, multiple commercial groups have and are continuing to develop inexpensive computers that may, in the coming years, be used in classrooms in developing nations. Regardless of which low-cost laptops become prevalent in developing nations, there will likely be greater access to the WWW in rural regions throughout the world in the coming decades, even if access comes initially (or even in the long-term) through low-cost smart phone technology. In 2009, for

example, Venezuela announced the development of a $15 smart phone with both video and audio capacity (Mossesgeld, 2009). Additionally, smart phones capable of exchanging videos using Bluetooth® are now available in many developing nations, including West Africa (Carvin, 2005). Such devices could allow users to exchange files and other kinds of information within their local communities. Current smart phones such as the iPhone®, which has a voice-activated search engine, prove that at least some of the initial technologies for interfaces useful for low-literate learners are beginning to emerge, with the long-term potential for integration into low-cost devices (Chowdhry, 2008; Plauche, Nallasamy, Pal, Wooters, & Ramachandran, 2006).

The use of such voice-activated technology, when combined with content that is appropriate for low-literate learners, may someday allow this segment of the population to interact with the WWW directly and in their own language in order to obtain information and educational materials that will directly benefit their lives. However, the educational and development communities interested in the use of this technology and the deployment of such information must begin to determine how to structure such content in a manner that can be easily accessed through such devices. The technological changes in information deployment are likely to outpace the rate at which educational content can be developed, tested, optimized, and ultimately put into practice for low-literate learners. Consequently, the organization and structure of that content should be addressed and developed before such smart phone devices are commonly in the hands of low-literate learners so as to optimize the deliverability and impact of the educational content locally, regionally, and internationally.

Case studies on the use of cell phones in developing nations have already been conducted, demonstrating both the potential power of using these devices along with the potential pitfalls of the current technologies (Shackleton, 2007). A report by Shackleton (2007), commissioned by UNICEF, summarizes more than 12 such case studies. For example, the SIMpill program in South Africa has used a cell phone-based system to (i) increase patients' adherence to prescribed medications and (ii) allow the healthcare providers to better track their patients' medication-use patterns, such that they could remind the patients of the need to take their pills at a given time. Additionally, the Fahamu-UmNyango Project, also in South Africa, focused on the deployment of human rights information and tracking of human rights violations. Some of the advantages of this program, which used current cell-phone technologies, include the ease by which users could be brought into the program and the relatively simple management of the system. However, one of the limitations of this program was human error that generated misspellings when key words were entered. Although not discussed in the Shackleton (2007) report, the Fahamu-UmNyango Project would have likely been biased for receiving reports from literate learners. As smart phone technologies and interfaces become more accessible to low-literate learners, it is likely that such technologies will become available to an increasing number of people in developing nations.

Need for Educational Materials for Low-literate Learners

Development of materials appropriate for low-literate learners will also require, in some cases, considerable resources and time commitment. The process of developing content should begin well before the devices are in the hands of low-literate learners because expenditures on such technologies are difficult to justify in advance of the content that makes them useful. If an organization were to start developing educational content (*e.g.*, videos,

animations, or audio files) appropriate for delivery on smart phone technology in developing nations, they would likely go through the following general steps: understand the needs of the audience, outline the concept for the video/animation/audio file, create the content, test it with a target group for feedback, develop a final version or versions, and in some cases translate such materials into appropriate languages. If such materials are taken across cultural groups, the content might require adaptation for both language and cultural differences.

Understanding what needs to be done to deal with such language or cultural adaptations will in many cases also necessitate partnerships with in-country organizations that are highly familiar with these local challenges. Thus, depending on the content and the structure of the organizations and partnerships, the development of content appropriate for low-literate learners is likely to require months or probably years. It follows that organizations with a strong interest in creating educational content for low-literate smart phone users in developing nations will likely need to initiate the process of developing such content sooner rather than later to meet such potential long-term smart phone deployment opportunities.

It will be difficult for any organization to argue for the commitment of even a limited amount of resources to develop low-literate-appropriate content until smart phone technology becomes commonplace among most low-literate learners. However, there exists a target community that can immediately make use of such materials and impact low-literate groups with current technologies. This target group includes but is not limited to scientists in developing nations who also do extension work, extension agents in developing nations, NGO employees/volunteers, and Peace Corps volunteers; we refer to this target group as "information deployers". These individuals often have (1) secondary, post-secondary, or a graduate-level education; (2) Internet access and Internet skills; (3) limited or no access to IT staff; and (4) the need to easily obtain, adapt, and share useful content for low-literate learners.

These "information deployers" are currently limited in their ability to obtain new ideas and materials from a centralized source where content can be (i) easily accessed, (ii) easily downloaded, (iii) easily adapted for local use, and (iv) subsequently shared with the rest of the community. A traditional peer-review process like that of a scholarly journal would result in the material becoming "static" once published, and would not allow for the continual adaptations that are essential for increasing the impact of such extension materials. In contrast, Wikipedia has been a highly successful and dynamic system for making information easily accessible to users across multiple languages. However, its lack of rigorous, content-based peer-review has resulted in a debate about its usefulness from an academic perspective (IBM Collaborative User Experience Research Group, 2003; Giles, 2005; Encylopedia Britannica, Inc., 2006). Wikipedia also does not allow academics a system for obtaining credit for their contributions (Forte & Bruckman, 2008). At the same time, the development community has not yet devised a centralized system to peer review specific extension materials for use in developing nations. Thus, there exists a need for centralization such that, in the short term, the "information deployers" can have a system with which to access, adapt, and share development message materials. We propose a system that combines the advantages of these two divergent systems: (i) easy access for the end-user to practical information and (ii) a peer-review process to assist in maintaining the credibility of content and to provide contributors with a mechanism by which they can obtain recognition for their contributions.

Information Sharing Needs

There is an urgent need to make the information revolution more inclusive of low-literate (and often low-income) users both as consumers and creators of knowledge. To achieve the goal of inclusion, virtual knowledge systems must have 8 characteristics: relevant content, credibility, multi-platform support, information delivery formats, bottom-up information sharing, the ability to continuously evolve, open and centralized repository, and intuitive interfaces.

Relevancy of content: As highlighted in the previous section, populations in developing economies are characterized by socio-cultural diversity. For maximum impact, knowledge systems must therefore facilitate the creation and dissemination of socio-culturally relevant content. To be widely useful, knowledge systems must become inherently pluralistic (McLoughlin & Oliver, 1999). As part of the VKESD, existing content can be localized for new regions such that the knowledge is used locally, local input is returned to the system, and both creators of content and adapters of content are credited for their work.

Credibility: Both the WWW and Web 2.0 have led to a remarkable proliferation of content generated by users (Organization for Economic Co-operation and Development, 2006). Although this trend has enabled the capture of individual knowledge from across the globe, it has also raised concerns over the credibility of content due to the lack of appropriate mechanisms for reviewing and validating content. Future knowledge systems must incorporate mechanisms for authenticating and validating content, thereby building credibility. Both the scientific accuracy of the content as well as practical applications of content should be reviewed and validated. As has been demonstrated in case studies involving the deployment of medical knowledge in developing nations, advice networks can be highly influential in dissemination of knowledge (Chib, 2007). Thus, the proposed VKESD system includes a pre-publication peer review process as well as a post-peer review online discussion of the uses of extension materials. The post-peer review process will allow for advice on deployment, feedback on use of content, and suggestions for further adaptations of content.

Multi-platform support: Innovations in the digital hardware industry have spawned numerous devices that are increasingly being used for accessing online content. Conventional PCs are no longer the only devices capable of accessing the WWW (The Wireless Internet Institute, 2003). As a result of this diversity of devices, however, there are significant problems with compatibility of content among various Internet access devices. Incompatibility and platform dependency are critical impediments to scalability of virtual knowledge systems and represent a considerable challenge for current and future deployment systems. However, platform independence (the ability of content to be transferred among all kinds of devices) is a critical requirement for knowledge systems because the adoption rates of various Internet access devices vary immensely across different geographic regions. In Africa, mobile phones have a higher degree of penetration than PCs and therefore could become the preferred device for Internet access (International Telecommunication Union, 2004). Given the current and forecasted trends, the kinds of devices are likely to increase and, therefore, knowledge systems must be built for access across multiple devices, present and future.

Information delivery formats: Instructional design is a fast emerging field that deals with effective delivery of content to obtain enhanced learning outcomes. Modules from such efforts can be created in the form of videos, animations, podcasts, and interactive learning games. Such materials have the potential to enable low-literate learners to understand and adopt

useful scientific concepts. The growing popularity of YouTube® and podcasts underscores the need for content to be delivered in formats that make it accessible for non-specialists so as to expand the reach and impact. Thus, the proposed VKESD will allow for contributions in a diversity of formats.

Top-down and bottom-up information exchange systems: Conventionally, content authoring has been heavily centralized with a few closed groups of experts creating and deploying the content (Figure 1A). This process allows for quality control of deployed material but it inherently suffers from an inability to capture practical and innovative local solutions generated by end users and grass root organizations (Chapman & Slaymaker, 2002). Further, the centralized process leaves little room for informed users to transform the content into formats that are more relevant to their local context. To achieve wider impact, knowledge systems must view end users not only as consumers of information but also as contributors of local solutions and as partners in the localization of the content (Figure 1B). Within the VKESD, we propose that much of the peer reviewing and editing for localized content be conducted within specific countries and regions, with local languages, and/or by local scientific/deployment communities.

Continuous evolution: To remain effective and relevant over time, content must be continuously evolving based on feedback from end users. This can be achieved by creating an "online ecosystem" for multiparty interaction and participation around the content (Anderson, 2007). The interactions capture valuable insights that can inform future modifications or spark new research (Figure 1B); a multiparty interaction around the content will drive and support continuous updates of the content.

Open and centralized repository: Presently, numerous organizations create content that can potentially have significant impact. However, this content is either lost or exists in disparate locations on the web, making it difficult to find and use. Open and centralized online repositories have grown in popularity over the last decade because they provide a one-stop location for users to upload, share, and access content related to a particular subject. The utility of centralized online repositories is demonstrated by the increasing usage of YouTube® and Wikipedia. Existence of centralized platforms for easy and free uploading and sharing of content enables the harnessing of individual knowledge and distributed of individual creativity across the population, which otherwise could have been lost. Centralization and ease of uploading and sharing greatly increase the utility of a platform and are basic characteristics of the proposed VKESD.

Intuitive interfaces: Although content is increasingly being authored in formats appropriate for low-literate learners, considerable skill is still required to find relevant content (Hargittai, 2000). Substantial research has been conducted in the area of interface design to move away from conventional text-based interfaces and toward more intuitive interfaces (Shneiderman, 1999). Currently, there are commercially available voice-based and graphical interfaces that obviate the need to use typical text searches. These intuitive interfaces assist in navigating through the content base and locating appropriate content.

Challenges to Accessing Electronic Information in Developing Regions of the World

Access to technology infrastructure in developing economies has historically been quite limited due to a wide range of factors, including technological and sociological constraints.

Table 1 provides Internet and mobile penetration figures for three developing regions of the world: South Asia, Latin America and the Caribbean, and Sub-Saharan Africa (World Development Indicators database, 2009). This low degree of penetration prevents many low-income, low-literate populations from accessing and contributing to global knowledge (Matthess & Kreutz, 2009). The low historical penetration figures, however, reveal only part of the reality. Although historically low, technology penetration in these regions has been growing very fast in the last few years (Table 2).

Content deployed on the web has grown greatly over the last two decades but the content is primarily created for the educated populations in developed economies. Other regions of the world, such as South Asia, Latin America, and Sub-Saharan Africa, are characterized by socio-cultural diversity, and therefore only a small fraction of the growing Internet content is relevant to these populations. Language is certainly one of the major factors limiting the usefulness of the web for many in the developing world, given that the dominant languages for web content are those of the developed nations (Table 3). Over the long term, however, content will need to be more inclusive in terms of language diversity and more pluralistic and reflective of the socio-cultural diversity and needs of the developing world.

Benefiting from the information and knowledge on the web in its current form requires users to be literate in the dominant languages of the web and also to have sufficient disposable income to access the technology infrastructure. Economically disadvantaged South Asian, Sub-Saharan African, and Latin American and Caribbean countries lag behind the world average. Additionally, these same developing countries have low primary education completion rates (World Development Indicators database, 2009). Because of economic and educational limitations, these populations do not obtain the benefits that practical scientific knowledge could provide to their daily lives.

Proposed System: Virtual Knowledge Ecosystem for Sustainable Development with Peer Review

We are developing an inclusive and participatory virtual knowledge information sharing system that will allow users to upload and access peer-reviewed extension material related to sustainable development. This system is intended to harness the advantages of credibility and inclusiveness. First, the system will include pre-publication peer review in that submitted content is screened for appropriateness for a given category as well as for presentation and for technical merit. Second, the system will include a post-publication online assessment. This may contain information on the use of these materials, constructive suggestions for improvement of materials, and suggestions for how materials can be adapted for other target groups. Third, materials adapted (based on the initial peer-reviewed materials) to new languages or cultural settings can then be contributed back to the VKESD in a peer-reviewed manner, with credit being given to the original document on which the variants are based. Because peer-review processes have inherent flaws, we recognize that the peer-review process in the VKESD system may need to evolve over time to take into consideration the challenges and needs of both contributors and users (Cope and Kalantzis 2009). Like the peer-review processes in academic journals that arose after the Second World War, peer review in the VKESD system must evolve in response to real-world opportunities and constraints (Burnham, 1990).

From the user's perspective, the VKESD will allow individuals around the planet to upload and download extension materials for use in developing nations. Thus, educational materials (and ideas) appropriate for low-literate learners can be made available to local educators, development agencies, or extension systems that can in turn contribute their own local adaptations and materials back to the series of websites. In this way the VKESD database can grow organically with contributions from around the globe. In the short term, the direct target groups will include (1) researchers and academics, (2) government agencies, (3) non-government organizations, and (4) other groups who directly or indirectly deploy information and develop materials for low-literate learners in developing nations. In the long term, systems should eventually emerge that allow low-literate learners to directly interact both with the Internet and such repositories of materials that are appropriate to their needs.

Favorable Trends for Creating an Inclusive and Participatory Knowledge Ecosystem

Rapid adoption of FOSS (free and open source software) will also be important for reducing costs of creating software and content that will be readily accessed by low-income, low-literate communities. For example, Web 2.0 technologies have democratized information authoring and sharing on the web by enabling bottom-up participation. Communities around the world are using these platforms to actively participate in knowledge creation and dissemination. Modern-day platforms, notably Wikipedia, enable content authoring and access in multiple languages and file formats.

Research, in human systems' interactions, has revolutionized the way users interrelate with technology. Most systems are moving toward more intuitive and natural interfaces that make the process of information search and access easier. Many laptops and mobile devices come equipped with screen-reading software and voice-activated systems that deskill the task of information access, consequently making information on the web a lot more accessible to low-literate and non-technology savvy users.

Global access to computing and network infrastructure is increasing rapidly largely because of innovations in technology and reductions in cost. Developing economies are an active part of this growth. The International Telecommunication Union (ITU) estimated 60% mobile penetration by 2008, driven largely by the Brazilian, Russian, Indian, and Chinese economies (International Telecommunication Union, 2008). Numerous ventures, such as Grameen phone in Bangladesh, are providing mobile phone access to the low-income populations of their country (Gajwani, 2006). This has led to the unprecedented growth rate in mobile phone access to low-income populations of the world Table 2.

The growth in Internet access and use has also been rapid, and once again it is the developing countries that have been responsible for much of the growth. Government agencies and NGOs in developing economies such as South Asia, Africa, and Latin America are setting up large numbers of telecenters that provide Internet access to low-income, low-literate communities (Servon & Nelson, 2001). The Government of India alone will create 100,000 telecenters by 2010 in economically disadvantaged rural areas of the country (DIT-GOI, 2006). Table 2 provides Internet penetration growth data for three economically disadvantaged regions and the world average.

These favorable trends will assist in overcoming the problems caused by Access, Availability, and Affordability (AAA), and will increase the availability of usable knowledge in

developing economies and more specifically, will increase the worldwide impact of practical scientific concepts (Chapman & Slaymaker, 2002).

Critical Issues Associated with Low-literate Learners

Perhaps the most significant challenges in designing education for low-literate learners are the preconceptions and assumptions of literate researchers and teachers. Because educators typically do not know what it means to be low-literate and often lack a personal connection with poverty, they must make a concerted effort to understand the constraints that low-literate learners face. These constraints can be roughly categorized into the cognitive and the affective domains. With respect to the cognitive domain, both the research on low-literate consumers in different countries and the experience of entrepreneurs suggest that low-literate learners have difficulty with abstract thinking and often exhibit "concrete thinking" (Viswanathan, Rosa, & Harris, 2005; Viswanathan, Gajendiran, & Venkatesan, 2008a; Viswanathan, Gajendiran, & Venkatesan, 2008b). Concrete thinking manifests itself in such ways as choosing products based on a single, concrete piece of information (e.g., total price) while avoiding abstractions such as the price per unit of the item. Thus, low-literate learners tend to depend on single pieces of information for drawing broader conclusions. Given their difficulties with language and the abstract nature of words representing concepts or information in symbolic form, low-literate learners often live and communicate in the immediate and visual, world of the here and now. Pictographic thinking, another cognitive tendency, is more than a dependence on pictures, which many learners across literacy levels possess. It refers to viewing words such as names of brands as objects or images in a scene. For example, a person engaged in pictographic thinking will visualize amounts of a product to buy by picturing how the product will be used (e.g., picturing sugar being poured while baking a cake). Similarly, a person engaged in pictographic thinking will "count" by visualizing currency bills. Thus, low-literate learners tend to think and live in a world of here and now, and seek to understand how the things they learn can be applied in their daily life. These characteristics highlight the need to create concrete educational materials that low-literate learners can relate to and use.

With respect to the affective domain, a central consideration for low-literate learners is maintaining self-esteem in encounters (Viswanathan et al., 2005). In educational contexts, low-literate learners must be comfortable with their learning environment. Because they are unaccustomed to formal educational settings, ensuring that the setting is conducive to learning requires care, including ice-breaking exercises (Viswanathan et al., 2008a). Problems (e.g., not having enough money to pay at the counter) attributed to mundane factors such as forgetfulness by literate learners, are often attributed to lack of literacy by low-literate learners. Thus, a learning environment that respects the inherent dignity of every human being is crucial to success. Particularly relevant here is the need to leverage inherent social skills that low-literate learners bring to the learning context, thus making them comfortable with the learning method and minimizing anxiety.

In the design of a marketplace-style literacy educational program for low-literate learners, concretizing, socializing, and localizing educational content are considered essential (Viswanathan et al., 2008a; Viswanathan et al., 2009). Concretizing educational content relates to the need to use pictorial, audio, role-playing, and face-to-face interactive tasks that minimize the abstractions. Socializing content enables low-literate learners to draw from

their inherent social and oral language skills and learn from others. Thus, learning modules should emphasize interactions among individuals through audio-visual means and should use face-to-face assignments rather than the traditional lecture mode. Localizing content refers to relating the content to the day-to-day lives of low-literate learners. For increasing marketplace literacy, for example, the learning modules should use local dialects and should depict local marketplaces.

Conclusions

We recognize that the VKESD represents only a partial solution for the overall problem of increasing the ability of low-literate users to obtain and contribute useful content. In the short term, the VKESD deals directly with producers, adapters, and deployers of content for low-literate learners and only indirectly with the low-literate learners themselves. However, the needs of content produces, adapters, and deployers are real, and systems like the VKESD have the potential to significantly impact those who deploy appropriate concepts and technologies to low-literate learners in developing nations. Any such system will likely need to address the eight key concerns raised in this article: relevancy of content, credibility, multi-platform support, information delivery formats, development of bottom-up information exchange systems, continuous evolution, open and centralized repository, and intuitive interfaces. In the long-term, as Internet access increases (and its cost decreases) in developing nations and better interfaces are developed for low-literate learners, the content of the VKESD (or some similar system) may be used directly with low-literate learners. Until these technologies emerge, however, the short-term goal of sharing such content through the VKESD will assist in some of the current challenges faced by those who deploy materials to low-literate learners.

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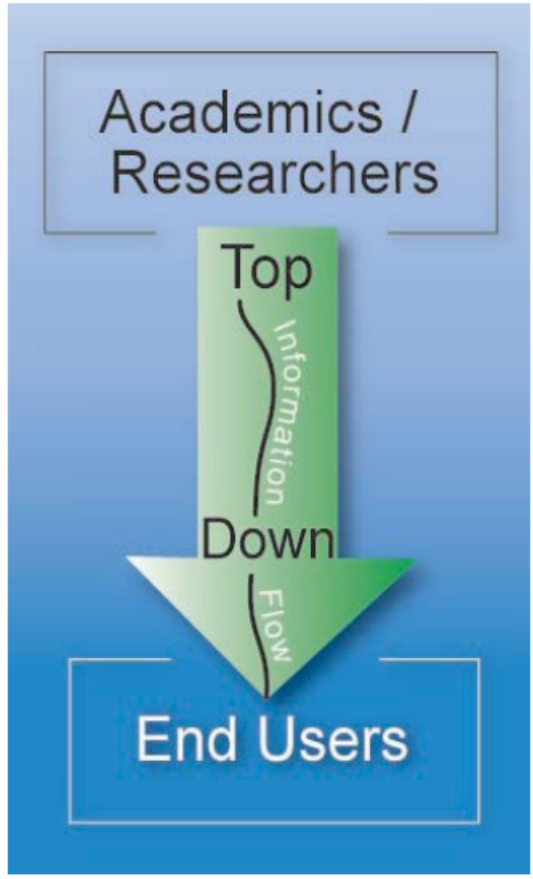
Academics / Researchers
Top
Information
Down
Flow
End Users

Figure 1 A

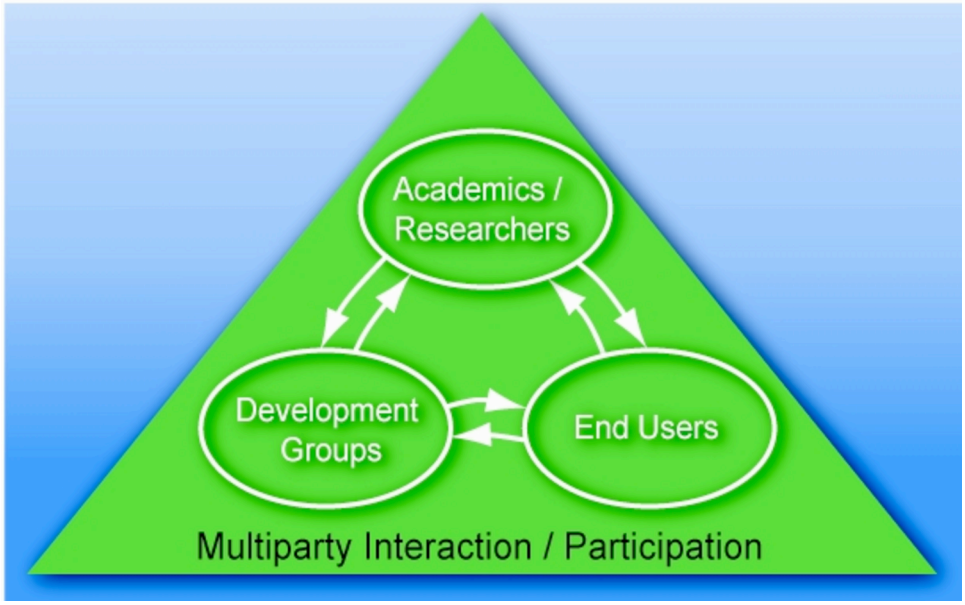

Figure 1 B

Figure 1: (A) Highly Simplified Explanation of the Conventional top-down Approach for Information Flow from Academic/Research Community to End users (with end user being Inclusive of Development Groups). (B) Multiparty Participation Model for Interactive Information Flow between the Academic/Research Community, Development Groups, and end Users

Table 1: Internet users and Mobile Cellular Subscriptions per 100 People in Sub-Saharan Africa, South Asia, Latin American and the Caribbean, the United States, and Europe (World Development Indicators Database, September 2009; Data for Year 2007)

Region	**Internet Users (per 100 People)**	**Mobile Cellular Subscriptions (per 100 People)**
Sub-Saharan Africa	3.8	22.8
South Asia	6.6	22.8
Latin American & Caribbean	26.6	67.4
United States	74.0	87.0
Europe	59.0	>90.0

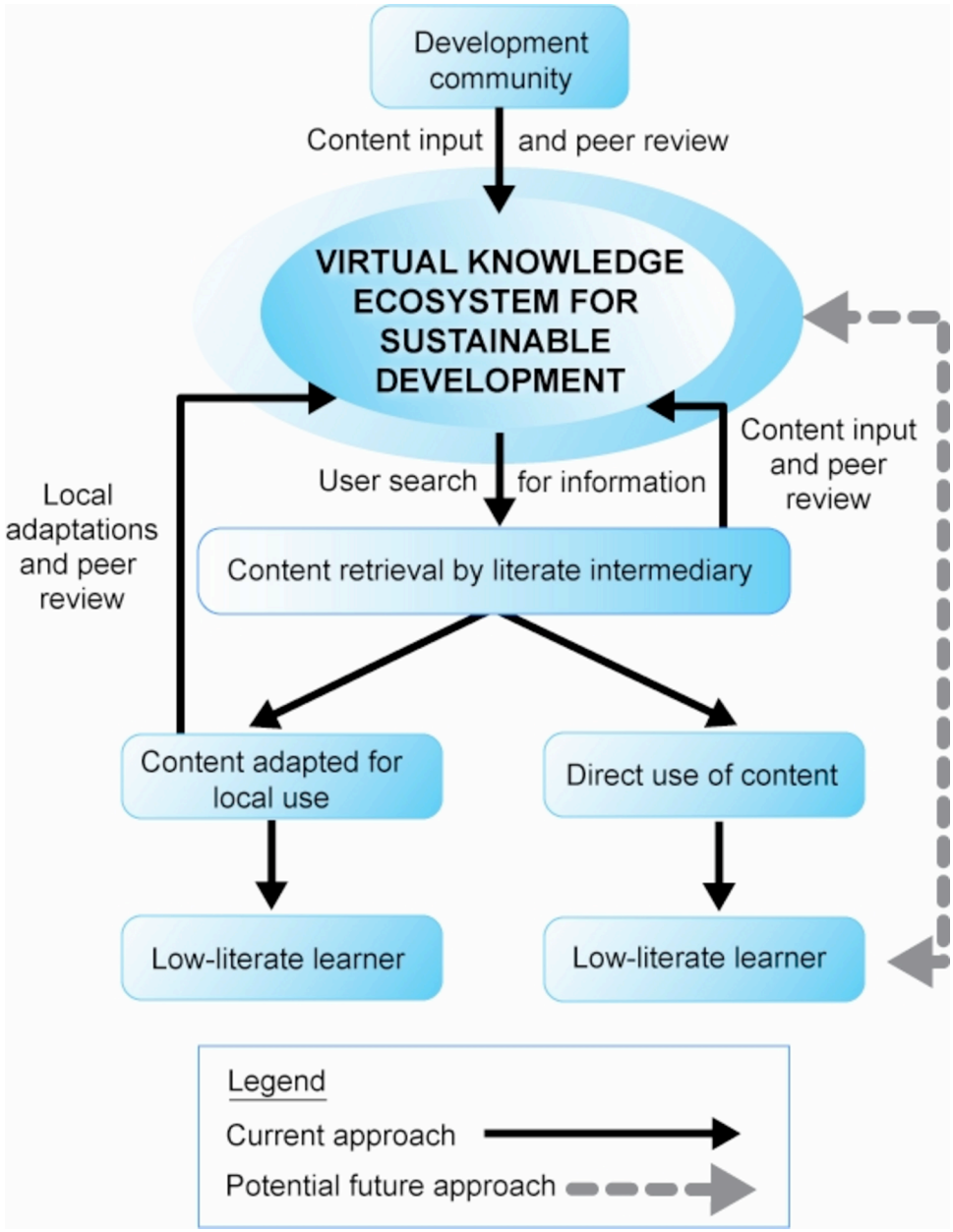

Figure 2: Proposed Current and Potential Future Information Flows for the Virtual Knowledge Ecosystem for Sustainable Development (VKESD)

Table 2: Internet user Penetration and Growth in Latin America, Asia, and Africa, and the Overall World Average (Internetworldstats 2009)

Region	Percent of the World Population	Percent Penetration	Percent user Growth (2000-2009)
Latin America	8.4	30.7	884
Asia	56.3	19.3	546
Africa	14.6	8.6	1392
World	100.00	25.6	380

Table 3: Percentage of Web Content by Language in 2009 (out of 313 Billion Websites)

Language	Percentage of Websites
English	68.4
Japanese	5.9
German	5.8
Chinese	3.9
French	3.0
Spanish	2.4
Russian	1.9
Italian	1.6
Portuguese	1.4
Korean	1.3
Other	4.6
Source: Vilaweb.com, as quoted by eMarketer.com	

About the Authors

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Dr. Bello is part of an international team of educators and scientists focused on developing novel extension strategies for developing nations. Dr. Bello's current work focuses on issues in Niger, Nigeria, Burkina Faso, and Mali as they relate to specialty crops. She also works on issues of how to increase inclusiveness of under-represented people in educational networks and systems.

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Ricardo Diaz presently works for the University of Illinois in Urbana-Champaign in the Office of Extension. His specific duties include developing outreach models to Spanish speaking communities, grant writing, helping county offices strengthen their presence and programs amongst Latinos, and developing software to disseminate key projects in developing

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Srinivas Venugopal has a background in social entrepreneurship and is currently pursuing his MBA at the University of Illinois, Urbana Champaign. Prior his MBA, he was leading a technology-based social venture focused on delivering education services to low income consumers in rural Tamil Nadu, India. His venture was acquired by a USD 3 billion business house in December 2008. He is the founder-president of a non-governmental-organization called "Diya" (http://diya.org.in) which focuses on providing supplementary education in the urban slums of Chennai, India. At the University of Illinois, Srinivas is engaged in a number of research projects under the "subsistence marketplace initiative" and is a teaching assistant for a module on "Sustainable Businesses for Subsistence Marketplaces" under Prof. Madhu Viswanathan. Srinivas is the co-curator of TEDxUIUC (www.TEDxUIUC.com).

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Madhu Viswanathan is Professor of Business Administration at the University of Illinois, Urbana-Champaign, where he has been on the faculty since 1990. He earned a B. Tech in Mechanical Engineering (Indian Institute of Technology, Madras, India, 1985), and a PhD in Marketing (University of Minnesota, 1990). His research programs are in two areas; measurement and research methodology, and literacy, poverty, and subsistence marketplace behaviors. He has authored books in both areas: Measurement Error and Research Design (Sage, 2005), and Enabling Consumer and Entrepreneurial Literacy in Subsistence Marketplaces (Springer, 2008, in alliance with UNESCO). He directs the Subsistence Marketplaces Initiative (www.business.illinois.edu/subsistence) and has created unique synergies between research, teaching, and social initiatives. He teaches courses on research methods and on subsistence and sustainability. He founded and directs the Marketplace Literacy Project (www.marketplaceliteracy.org), a non-profit organization, pioneering the design and delivery of marketplace literacy education to subsistence communities. He has received teaching, social entrepreneurship, humanitarian, and leadership awards.

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