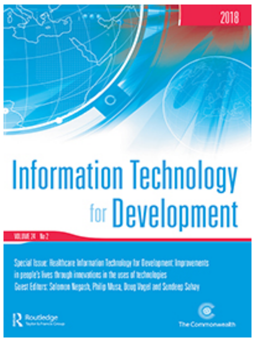

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An assessment of learning gains from educational animated videos versus traditional extension presentations among farmers in Benin*

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ABSTRACT
This study compared the efficacy of linguistically and dialectically localized animated educational videos (LAV) against traditional learning extension (TLE) presentations for learning gains of knowledge around agricultural- and healthcare-related topics within a rural population in Benin. While both approaches demonstrated learning gains, LAV resulted in significantly higher test scores and more detailed knowledge retention. A key contribution of this research, moreover, involves the use of mobile phone technologies to further disseminate educational information. That is, a majority of participants expressed both a preference for the LAV teaching approach and a heightened interest in digitally sharing the information from the educational animations with others. Because the animations are, by design, readily accessible to mobile phones via Africa's explosively expanding digital infrastructure, this heightened interest in sharing the animated videos also transforms each study participant into a potential a learning node and point of dissemination for the educational video's material as well.

KEYWORDS
Educational animated video; cell phones; multimedia learning; malaria; cholera; neem; Benin

1. Introduction

There are upwards of 800 million to 1 billion illiterate to low-literate learners globally, most of whom live in developing nations, and many living in rural areas and speaking diverse local languages. Given that literacy is generally a direct result of access to formalized education, the decreased or under-resourced availability of education in rural areas tends to decrease rural literacy; and national language teaching policies also affect the level of literacy, since local languages are often prohibited or unsupported in what fewer rural schools there are. As such, delivering life-improving knowledge to this linguistically and

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culturally highly diverse and often economically challenged group has been deemed a highly costly and logistically daunting task. Additionally, even for those people who are literate and live in rural areas in developing nations, technological and infrastructural issues have made access to life-improving education difficult.

One path for deploying education to these groups has been through traditional government-based agricultural extension programs. Lately, however, these programs, both in the developed and in the developing world, have generally been in decline for want of funding. In many countries, this has meant fewer extension agents for the numbers of farmers. In Benin, agriculture extension agents are not always available for every farmer, and the resources these extension agents have to do their work is becoming more and more limited. For example, they will often no longer have the resources to create printed materials in local languages or even to have the money for gas to visit villages in need of extension information.

In Benin, an added challenge is its 55 spoken languages (Lewis, Simons, & Fennig, 2015). To supply needed extension materials in many, much less all, of these languages quickly becomes cost-prohibitive, and assumes reading-literacy as well in its recipients. Such materials, in addition, need to be in a format usable across a myriad of cultural groups and levels of access.

In view of these difficulties, over the past decade, there has been a considerable increase of interest in the potential for the use of information and communication technologies (ICTs) as a way to address the aforementioned challenges and concerns, particularly in the face of decreasing funding. ICTs, in general, rely less on traditional means for information dissemination (i.e. institutions, printed materials) and more seek to leverage emergent information technologies (e.g. telecommunications, the Internet) to deliver life-improving materials.

One such ICT initiative is Michigan State University's Scientific Animations Without Borders (SAWBO). SAWBO represents an academically based exploration for connecting global experts in a virtual manner in order create educational content for use by low-literate learners; an exploration that aims to produce tangible educational content that is both testable, useable, and effective in the field. By design, SAWBO animations utilize carefully crafted, cross-culturally acceptable visual images amenable to translation and description in potentially any local (or locally accented) language. Each SAWBO educational video addresses specific diseases, value-chain limitations or agricultural challenges and proposes effective and simple techniques that can be adopted in the field. The videos are provided free of charge and for educational purposes only.

Creating the animation is half the picture; delivery is the other half. To date, SAWBO has explored several different delivery approaches using mobile technology, in part because cellphone use is currently widespread and still increasing all across Africa. As such, SAWBO's Deployer Application (App) allows anyone with an Android phone and access to the Internet to access SAWBO animations. The animations, in turn, can be downloaded onto an Android device through the Deployer App and then played at any time, including when the device has no access to the Internet.

In this way, an extension agent or aid worker can use such a device as a portable video-viewing device for individuals or groups in the field, easily affording them access to educational animations either on a specific, relevant topic and in a specific, relevant (or locally accented) language as well as the local country accent for that language (where available) or at least the closest useful animation and language/accent. Additionally, the animation can be shared and transferred onto other devices using Bluetooth® technology, allowing the animation to spread "virally" between phones, even those without an Internet connection, thus making it a highly efficient and accessible system of sharing knowledge.

Shuler (2009) describes how the increasing functionality of mobile technology has created a potential for learning that comes with breaking down barriers otherwise prohibiting access to and the processing of information. Even in remote areas, mobile phones presently afford opportunities for users to access information and to learn from that information. The popularity of mobile phones across Africa seems to be making them increasingly more effective and less expensive. Soloway et al. (2001) and Zurita and Nussbaum (2004) point to the low cost as one of the major advantages of mobile phones as an educational/knowledge-sharing device among poor, remote, and underserved populations.

Visuals combined with verbal narration demonstratively enhance learning (Mayer, 2002). Traditionally, radio played a major role in delivering information to rural areas in Africa (Chapman, Blench, Kranjac-Berisavljevic, & Zakariah, 2003; del Castello, 2002). Today, the Internet has revolutionized access to information even for people living in rural areas. Mobile phone technology similarly has the potential to secure itself as *the* key player in the area of extension information. This stands in contrast to other forms of educating farmers, such as extension learning presentations in villages, which can be costly due to resources, as well as travel time and distance for extension agents (Ramamritham, Bahuman, Duttagupta, Bahuman, & Balasundaram, 2006).

Despite this increased use of mobile phones around access to information in less developed countries, few studies examine to what extent farmers *learned* from the information accessed, including learning gains gleaned from watching animated videos on mobile phones. Thus, the following questions about the usefulness of SAWBO educational animations arise: (1) do learning gains occur in populations in Benin with divergent educational backgrounds? (2) are the learning gains with SAWBO animations in target populations lower than, similar to, or higher than traditional learning extension (TLE) approaches? (3) will target populations in Benin be open to learning such information with animations on cell phones? and (4) would they prefer or not prefer learning from animations as compared to an extension agent presentation?

Our work is framed in Mayer's (2002) theory of multimedia learning and Knowles' theory of andragogy (Knowles, 1980, 1984), as these relate to learning from animated videos compared to TLE. To test the above research questions, we assessed learning and information gains within the fields of agriculture and health from three animated videos using a pre- and post-learning questionnaire approach. More specifically, the intention was to evaluate participant knowledge regarding malaria, cholera, and neem plant extracts prior to and following watching a short animated video about each topic in order to measure the knowledge they acquire from this experience (without the intervention of an extension agent providing guidance).

In this way, our paper not only contributes to the field of learning and mobile technologies but also presents an innovative approach linking educational content and mobile technology together for the upwards of one billion low-literate learners with little access to formalized information and knowledge, but significant portion of which who presently have access to mobile phones (Bello-Bravo et al., 2011).

1.1. Background on Benin and the context for the study

Benin is a small country in West Africa bordered by Togo on the west, Nigeria on the east, and Burkina Faso and Niger on the north, and with a short Atlantic coast along the south. The political capital of Benin is Porto-Novo, but the government seat is in Cotonou, the economic capital. Benin covers an area of approximately 112,600 square kilometers with a population of approximately 10,008,749 people as of 2013 (INSAE, 2015).

A tropical, sub-Saharan nation, Benin is highly dependent on agriculture, with a substantial amount of employment and income dependence in subsistence farming. The national language is French, but the indigenous languages of Fon and Yoruba are widespread; in all, 55 languages are spoken in Benin (Lewis et al., 2015). Literacy – meaning reading and writing in the national language – in Benin is among the lowest in the world at 38% (CIA, 2015); literacies in non-national languages are not typically measured. Mobile technology use in Benin, however, is exploding. From 2000 to 2010, mobile subscriptions rose from 0.8% to 79.9%; by 2010, the mobile phone network covered 90% of the population (World Bank, 2014). This elevated percentage of mobile phone usage has decreased the costs of communication and increased ways for the general population to obtain information.

1.2. Rationale for the study

At present, testing the effectiveness of educational animated videos in local languages for learning gains and technological uptake is limited. Technology and learning are part of a social context (Lea & Nicoll, 2002), and social constructivism (Crook, 2002) and cognitivism (Dror, 2008) alike characterize learning as *an active and engaged interaction* that then has an influence on educational development (Driscoll, 2000). Over the years, evaluations of numerous approaches and methods for agricultural extension learning, including traditional video, radio, and viewing clubs, have been conducted. For instance, while video-viewing clubs were used to train women on integrated pest-management for cocoa in Ghana (David & Asamoah, 2011), a small sample precluded determining the effectiveness of this approach.

Besides traditional systems that provide information and training, ICT approaches represent a more recent opportunity not just for training but also as a source of information, particularly around entertainment and education. Mobile technology has been used widely in different ways: text messaging (Kachelriess-Matthess et al., 2011; Parker, Ramdas, & Savva, 2012), market information, for example, prices for agricultural goods in local markets (Aker, 2010), and other services, for example, banking (Mbiti & Weil, 2016).

The widespread use of mobile phones in Benin is growing even in rural areas both in use and coverage; 83.7% of the population was using mobile phones in 2012, up from 7.3% in 2005, with 99% of the population covered by a mobile network in 2012, up from 43% in 2005 (World Bank, 2012, 2014). Alongside this, traditional unwritten communication systems in African countries remain in place (Wilson, 1987; Yankah, 1989); Donner (2007) describes how deliberately unanswered texts and calls can serve signaling purposes, if also motivated by saving on data plans.

Traditional communication systems still provide trusted sources of information to people, especially in rural areas with less technological infrastructure. Mobile technology builds on this traditional foundation and provides an effective tool that can be used for communication and learning regardless of literacy levels. In particular, mobile technology and educational animations represent an excellent combination for training in the areas of agriculture and health where basic education is sorely needed to prevent devastating crop losses and diseases.

Farmers in Benin and other developing nations have the potential to access information through mobile phones, and since they constitute the largest proportion of the uneducated population in rural areas, they should be the main target audience of any exploratory ICT training. As such, the SAWBO program creates and deploys educational animations related to best practices in agriculture, especially for farmers in Africa. Any new approach must first compare traditional ways of learning with innovative strategies that involve mobile technology. By examining this relationship, we can properly evaluate the impact of different approaches and the potential usefulness of novel approaches.

2. Methodology

In order to comprehend some of the problems that farmers face in rural areas, it is necessary to determine what information farmers already know about a problem and its potential solutions. Historically, then, SAWBO has contacted and worked with global and local experts to research and create educational videos addressing three issues often faced by rural farmers: the prevention of malaria, the prevention of cholera, and the use of neem seed water extracts as a natural pesticide (SAWBO, 2016a, 2016b, 2016c). Each video animation is 2–4 minutes in length, deploys a generalized but appropriate imagery around each topic that experience has shown is well-received by viewers (Bello-Bravo & Baoua, 2012; Bello-Bravo, Dannon, Agunbiade, Tamo, & Pittendrigh, 2013; Bello-Bravo, Olana, & Pittendrigh, 2015; Bello-Bravo et al., 2011; Miresmailli, Bello-Bravo, & Pittendrigh, 2015), and that affords “localization” with voiceovers in the local language and accent of participants.

2.1. Experimental design

We narrowed our experimental design to address two main questions:

(1) Are educational animated videos more effective in transmitting and promoting retention of knowledge compared to traditional presentations done by extension agents?
(2) Do people prefer to learn via traditional extension agent presentations or educational animations in their own language? The first approach used the traditional method to explain the content of the videos. Before explaining the content verbally, a pre-survey was administered to ascertain baseline knowledge of the participants on the topic. This was followed by the verbal explanation of the content and lastly the post-survey was administered with the purpose of assessing knowledge gains on the topic. The second approach presents the same information via an educational video only.

Both approaches allowed us to test Hypothesis 1:

‘Hypothesis 1’: The traditional extension method of explaining the content will be equally or more effective in conferring learning gains in farmers as compared to the animations.

‘Alternative Hypothesis 1’: The educational animated videos will confer greater learning gains in the farmers than the traditional extension presentation approach.

Using the same surveys, we were able to test Hypothesis 2:

> 'Hypothesis 2': The majority of respondents once they have been exposed to animations as a learning strategy would, on average, prefer to learn using the traditional extension method as compared to the animations.
>
> 'Alternative Hypothesis 2': The majority of respondents once they were exposed to animations as a learning strategy would, on average, prefer to learn using the animations as compared to the traditional extension method.

2.2. Data and methods

2.2.1. General information on the survey location

The current survey was conducted in Benin. Since 2002, Benin has been divided into twelve departments with 77 districts, further subdivided into sub-districts, and sub-districts into villages. In general, Kpomasse is known for a lack of training in agricultural neem product use, and malaria and cholera are perennial problems. Located in southwestern Benin around 60–70 kilometers from Cotonou, the population consists of several ethnic groups dominated by Fon and Sahoue as well as refugees from various African countries. The local population has developed various skills in plant production, fishing, animal husbandry, and small-scale food processing. Schooling reflects a 6–4–3–4 educational system: that is, primary school (6 years), junior high (4 years), senior high (3 years), college Bachelor's (3 years) and Master's (4 years) degrees.

2.2.2. Sample selection

Data were collected in eight villages in five sub-districts within the Atlantic Department's Kpomasse district, as given in Table 1.

Having discussed the purpose of our research with local authorities in each of the eight villages, survey dates were then arranged in consultation with them. One day before those dates, the study was then announced to the community in each village by a village crier, calling them to a meeting the following day. From the people who responded to that call, approximately thirty people were then selected to participate.

Total sample size for this study was 248, with 81–85 participants taking part in each topic tested (malaria prevention, cholera prevention, neem extract use); approximately 30–38 participants per village experienced one of the intervention forms (animated video or TLE). Participants included women and men, all of whom were involved in farming activities, and included traders, small-scale processors, mechanics, carpenters, masons, and students. None had previously watched any of the videos; all had limited knowledge on this study's topics, but expressed interested in these issues. Wanting to increase their knowledge and

Table 1. Experimental locales (Kpomasse District, Atlantic Department, Benin).

Sub-district	Village(s)
Aganmanlome	Lokossa, Kouzounmè, Kougbedji
Tokpadome	Aidjedo-Gbeffadji, Gboho
Kpomasse Centre	Aidjedo-Tchanhoue
Segbeya	Segbeya 2
Dedome	Hinmadou

skills around food security and economic opportunities, they reported wanting to increase their knowledge and to be well prepared for future challenges.

2.2.3. Survey administration

Pre-test surveys of knowledge around malaria prevention, cholera prevention, and the use of neem as an insecticide were administered in the local Fon language at locations as detailed in Table 2. This was followed by either localized animated video (LAV) or TLE interventions on the specified topics, and then post-tests at all locations.

All data were collected, both pre- and post-intervention at all locations, by questionnaires administered orally in Fon. That is, researchers read the questionnaire to participants and marked down their answers; this, in order not to require lower literacy participants to have to fill out questionnaires they could not read but also to avoid embarrassing anyone and for the sake of consistent data collection. These data also included demographic information such as educational level, Likert-scale data on preferences about the form of intervention experienced, and participant literacy, that is, reading and writing ability in Fon; this last in order to assess the potential or feasibility of disseminating written educational materials in this language.

2.2.4. Data analysis

Survey responses were coded and analyzed in SAS using descriptive statistics. Chi-square tests compared respondents' percentages on the various topics. Correct answers by each participant were calculated as a percentage for each of the three educational topics, that is, malaria prevention, cholera prevention, and neem use; percentages were also calculated on a five-point Likert-type scale (strongly disagree, disagree, neutral, agree, strongly agree) as preferences for intervention form, that is, animated video versus TLE. All data were followed by an analysis of variance (ANOVA) and the Student Newman Keuls test for means separation.

3. Results

3.1. General demographic information of respondents

3.1.1. Neem

The average age of participants was 43 (18–70) years in the TLE group and 38 (19–70) in the LAV group, respectively (Table 3), with only 1.7% of the respondents being

Table 2. Intervention types and topic by location.

Location (Village)	Topic(s)	Intervention form
Gboho, Lokossa	Cholera prevention, neem extract use*	TLE**
Kouzounmè, Kougbedji	Cholera prevention, neem extract use*	AV***
Aidjedo-Gbeffadji, Segbeya 2	Malaria prevention	TLE*
Hinmadou, Aidjedo-Tchanhoue	Malaria prevention	AV**

*To avoid confounding effects on the question of whether participants preferred to learn by extension agents (TLE) or by localized animations (LAV), we only asked these questions about the neem animation assessment, not the cholera animation assessment, at these locations.

**In order to keep the TLE presentations consistent, presenters used a set of notes that outlined the main points discussed in the LAV.

***The 2–4-minute long animations were shown twice to participants using a laptop.

literate in Fon in the TLE group and 8.3% being in the LAV group. Additionally, 68.3% and 53.3% of the TLE and LAV respondents, respectively, had no formal education. A higher percentage of the TLE participants were married (46.7% monogamous against 31.7% polygamous for the TLE group, versus 66.7% monogamous against 25.0% polygamous in the LAV group). The principal occupation for participants was farming, with 88.3% and 96.7% in the TLE and LAV groups, respectively. A large percentage belonged to farmers' associations (93.3% and 96.7% in the TLE and LAV groups, respectively).

3.1.2. Cholera

The respondents' age averaged 40 (19–70) and 45 (24–74) years, with 1.7% and 3.3% Fon-literate in the TLE and LAV groups, respectively (Table 4). A high percentage of the participants had no formal education (50.0% and 66.7% of TLE and LAV participants, respectively), most were married (66.7% monogamous and 25.0% polygamous in the TLE group, and 46.7% monogamous and 33.3% polygamous in the LAV group), and 80.0% and 98.7% farmers, respectively. Here, only 43.3% and 21.7% of the respondents belonged to a farmers' association in the TLE and LAV groups, respectively.

3.1.3. Malaria

The average age of participants was 43 (18–70) years in the TLE group and 39 (18–78) in the LAV group (Table 5), with only 3.3% of the respondents in both groups literate in Fon; 68.3% and 45% had no formal education in the TLE and LAV groups, respectively. Half or more were married (68.3% monogamous vs. 18.3% polygamous in the TLE group; and 28.3% monogamous vs. 21.3% polygamous in the LAV group). Farmers represented the main occupation of 71.7% and 60.0% in the TLE and LAV groups, respectively, with only 21.7% and 31.7% belonging to an association in the TLE and LAV groups, respectively.

Table 3. Demographic information for neem groups.

	Percentage of respondents	
Parameter	TLE	LAV
Mean age (years)	43 (18–70)	38 (19–70)
Sex		
Male	55.0	36.7
Female	45.0	63.3
Literate in Fon	3.3	1.7
Formal education		
None	66.7	53.3
Primary school	8.3	35.0
Junior high school	5.0	3.3
Senior high school	18.3	6.7
University	1.7	1.7
Marital status		
Polygamous	31.7	25.0
Monogamous	46.7	66.7
Separated	0.0	0.0
Widow	2.3	6.6
Divorced	3.3	0.0
Single	15.0	1.7

Table 4. Demographic information for cholera groups.

Parameter	Percentage of respondents TLE	LAV
Mean age (years)	40 (19–70)	45 (24–75)
Sex		
Male	38.3	46.7
Female	61.7	53.3
Literate in Fon	1.7	3.3
Formal education		
None	66.7	53.3
Primary school	8.3	35.0
Junior high school	6.7	5.0
Senior high school	18.3	3.3
University	0.0	3.4
Marital status		
Polygamous	33.3	25.0
Monogamous	46.7	68.3
Separated	0.0	0.0
Widow	0.0	5.0
Divorced	3.3	1.7
Single	16.7	0.0

3.2. Assessment of knowledge on neem extract use comparing TLE to LAV

Here, we discuss specific findings around TLE and LAV interventions with respect to neem extract. While both groups answered a similar number of questions correctly on the pre-test (Figure 1) ($F_{3,153} = 385.67$; $p < .0001$) and both showed significant learning gains regardless of intervention type, post-test scores for the LAV group showed greater learning gains and significantly more correct answers compared to the TLE group.

In both the TLE and LAV groups, very few respondents reported using synthetic insecticides; none reported applying neem extract to control pests in their crops, although approximately half already knew that neem could be used for various purposes (53.3% and 46.7% in the TLE and LAV groups, respectively). At the same time, a very low

Table 5. Demographic information for malaria groups.

Parameter	Percentage of respondents TLE	LAV
Mean age (years)	43 (18–70)	39 (18–78)
Sex		
Male	55.0	53.3
Female	45.0	46.7
Literate in Fon	3.3	3.3
Formal education		
None	68.3	45.0
Primary school	5.0	16.7
Junior high school	8.3	18.3
Senior high school	16.7	20.0
University	1.7	0.0
Marital status		
Polygamous	18.3	21.7
Monogamous	68.3	35.0
Separated	3.4	0.0
Widow	5.0	8.3
Divorced	0.0	3.3
Single	5.0	31.7

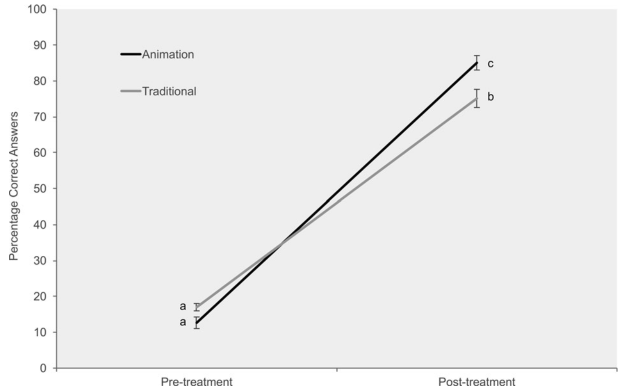

Figure 1. Percentage (±standard error) of correct answers pre- and post-treatment (educational intervention) for use of neem as a natural insecticide. The two interventions were traditional extension presentations (traditional) and a video animation (animation). Means followed by the same letter are not significantly different with ANOVA followed by SNK ($p < .05$).

percentage of participants had knowledge about processing neem extract, about the preferred seed color of the neem seed to be used, or the waiting time before application of the extract as an insecticide (see Table 6).

After the interventions, in both groups, participant knowledge significantly improved regarding both the use of neem extract for insect control ($\chi^2 = 6.5$; $p = .01$ and $\chi^2 = 11.6$; $p = .006$ for the TLE and LAV groups, respectively) and processing ($\chi^2 = 22.7$; $p < .0001$ and $\chi^2 = 41.9$; $p < .0001$ for the TLE and LAV groups, respectively), as well as around the preferred seed color ($\chi^2 = 50.3$; $p < .0001$ and $\chi^2 = 27.7$; $p < .0001$ for the TLE and LAV groups, respectively) and the waiting time prior to application ($\chi^2 = 9.6$; $p = .002$ and $\chi^2 = 24.8$; $p < .0001$ for the TLE and LAV groups, respectively). Only a third of the participants

Table 6. Pre- and post-intervention neem extract use knowledge assessment for TLE and LAV approaches.

	Percentage of respondents			
	Pre-intervention		Post-intervention	
Knowledge	TLE	LAV	TLE	LAV
Use of synthetic insecticides	10	1.7	–	–
Use of neem as insecticide	0.0	0.0	–	–
Various purposes for neem use	53.3	46.7	93.3*	100*
Knowing people who apply neem extract (yes percentage)	21.7	16.7	–	–
How to prepare neem extract	6.7	11.7	55.0*	100*
Dark brown seeds preferred (highly agree percent)	3.3	15.0	93.3*	100*
Waiting time (24 h) for neem use of extraction (highly agree per cent)	33.3	25.0	75.0*	95.0*
Neem extract highly recommended (highly agree per cent)	35.0	33.3	75.0*	95.0*
Spraying of green plant parts (highly agree per cent)	–	–	80.0	96.7
Knowledge sharing (highly agree per cent)	–	–	88.3	98.3
Neem cheaper than chemicals (highly agree per cent)	–	–	85.0	100
Getting new information (highly agree per cent)	–	–	100	100
Appropriate learning method (highly agree per cent)				
Traditional	–	–	66.7	30.0*
Animation	–	–	33.3	70.0*

– indicates unavailable data.
* indicates significant differences within a method (i.e. TLE before versus after, LAV before versus after) with chi-square test ($p < .05$).

in the TLE group (who were not exposed to the videos) selected the video animation as an appropriate dissemination tool; in the LAV group, approximately two-thirds of the participants chose the video method as an appropriate information dissemination tool.

For most of the parameters, no significant differences were observed between the TLE and LAV groups; the significant differences, rather, were found between the two groups in knowledge retained on neem extract processing ($\chi^2 = 7.8$; $p = .005$) and the appropriateness of video animation as a dissemination tool ($\chi^2 = 7.8$; $p = .005$), with the videos performing better on both of these issues. After the interventions, a high percentage of respondents claimed that neem extract should be highly recommended and sprayed on green plant parts. Most expressed that neem extract was cheaper than chemicals and that they had received new information that could be shared with non-participants. Similarly, more LAV participants (70%) thought that this intervention was an appropriate way to disseminate information compared to the TLE groups' opinion about TLE. Indeed, most of the LAV respondents underlined how the animations provided not only a voice but also a visual demonstration of the processes helped them to retain information.

3.3. Assessment of knowledge on cholera disease comparing TLE to LAV

Here, we discuss specific findings around TLE and LAV interventions with respect to cholera prevention. While both groups answered a similar number of questions correctly on the pre-test (Figure 2) ($F_{3,153} = 365.04$; $p < .0001$) and both showed significant learning gains regardless of intervention type, post-test scores for the LAV group showed greater learning gains and significantly more correct answers compared to the TLE group.

The pre-test knowledge assessment for cholera prevention revealed that a low percentage of respondents were aware of the disease pathogen, knew people that suffered from cholera, or knew how to prevent the malady (see Table 7). After both TLE and LAV interventions, significantly higher percentages of the participants demonstrated knowledge on the disease pathogen ($\chi^2 = 24.6$; $p < .0001$ and $\chi^2 = 7.0$; $p = .008$ for the TLE and

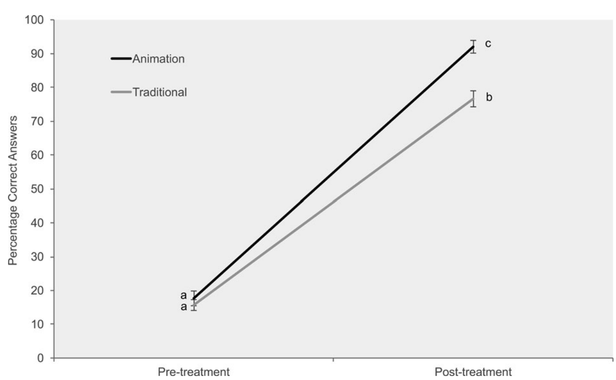

Figure 2. Percentage (±standard error) of correct answers pre- and post-treatment (educational intervention) for concepts related to cholera. The two interventions were traditional extension presentations (traditional) and a video animation (animation). Means followed by the same letter are not significantly different with ANOVA followed by SNK ($p < .05$).

LAV groups, respectively), recognition of cholera symptoms ($\chi^2 = 33.0$; $p < .0001$ and $\chi^2 = 16.5$; $p < .0001$ for the TLE and LAV groups, respectively), water treatment to prevent the disease ($\chi^2 = 33.9$; $p < .0001$ and $\chi^2 = 6.1$; $p = .01$ for the TLE and LAV groups, respectively), the waiting time after water treatment with bleach ($\chi^2 = 22.4$; $p < .0001$ and $\chi^2 = 26.9$; $p < .0001$ for the TLE and LAV groups, respectively), and how to seek information at health centers for treatment ($\chi^2 = 27.7$; $p < .0001$ and $\chi^2 = 11.6$; $p = .0006$ for the TLE and LAV groups, respectively). A significant difference occurred on the *waiting time after water treatment with bleach* ($\chi^2 = 43.3$; $p < .0001$) item; that is, a significantly higher percentage (81.7%) of people in the TLE group answered this item incorrectly on the post-test.

3.4. Assessment of knowledge on malaria disease comparing TLE to LAV

Here, we discuss specific findings around TLE and LAV interventions with respect to malaria prevention. As with the other topics, both groups answered a similar number of questions correctly on the pre-test (Figure 3) ($F_{3,177} = 128.34$; $p < .0001$) and both showed significant learning gains regardless of intervention type, post-test scores for the LAV group showed greater learning gains and significantly more correct answers compared to the TLE group.

The pre-test knowledge assessment for malaria prevention showed that a high percentage of the participants had knowledge about malaria symptoms as well as how to prevent the disease (see Table 8). However, a relatively low percentage of them (50.0% in the TLE group and 25.0% in the LAV group) highly agreed that *Anopheles* mosquitoes are the vectors of malaria or that the mosquitos multiply in drinking water that is not protected. A large percentage of the respondents knew how to prevent malaria (70.0% and 76.7% for the TLE and LAV groups, respectively) and all of them had suffered from malaria. A relatively low percentage was not aware of the fact that house sanitization (46.7% and 25.0% TLE and LAV, respectively) could help reduce malaria occurrence. Likewise, less than 50%

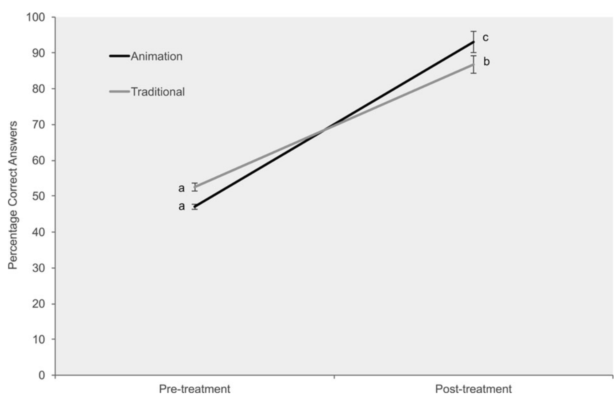

Figure 3. Percentage (±standard error) of correct answers pre- and post-treatment (educational intervention) for concepts related to malaria. The two interventions were traditional extension presentations (traditional) and a video animation (animation). Means followed by the same letter are not significantly different with ANOVA followed by SNK ($p < .05$).

Table 7. Pre- and post-intervention cholera disease knowledge assessment for TLE and LAV approaches.

	Percentage of respondents			
	Pre-intervention		Post-intervention	
Knowledge	TLE	LAV	TLE	LAV
Cholera disease from bacteria attack (yes percentage)	26.7	48.3	98.3*	88.3*
Knowing people who suffer cholera (yes percentage)	6.7	18.3	–	–
Water treatment (yes percentage)	16.7	58.3	96.3*	98.3*
Various water treatment methods (yes percentage)				
Tablet/pills use	3.3	5.0	3.3	1.7
bleach use	3.3	3.3	3.3	0.0
Water boiling	13.3	18.3	16.7	0.0
Combination (tablet, bleach, boiling)	10.0	38.3	76.7*	98.3*
Waiting time (24 h) for water use after bleach treatment (preferred (highly agree per cent) – the correct answer in the video was 30 minutes	20.0	23.3	81.7*	3.3
Health center for cholera treatment (highly agree per cent)	21.7	46.7	95.0*	100*
Diarrhea as cholera symptom (highly agree per cent)	16.7	38.3	95.0*	100*
Washing hand for preventing cholera (highly agree per cent)	20.0	43.3	95.0*	100*
Dirty water and unwashed fruits favor cholera infection (highly agree per cent)	20.0	38.3	95.0*	100*
Knowledge sharing (highly agree per cent)	13.3	31.7	95.0*	100*
Where to get information about cholera (highly agree per cent)				
Clinic	0.0	6.7	0.0	0.0
Hospital	1.7	0.0	0.0	0.0
Both	91.7	88.3	93.3	100

– indicates unavailable data.
* indicates significant differences within a method (traditional method before versus after, animation method before versus after) with chi-square test ($p < .05$).

Table 8. Pre- and post-intervention malaria disease knowledge assessment for TLE and LAV approaches.

	Percentage of respondents			
	Pre-intervention		Post-intervention	
Knowledge	TLE	LAV	TLE	LAV
Malaria symptoms	90.0	85.0	90.0	100
Anopheles as malaria vector (per cent highly agree)	50.0	25.0	100*	100*
Knowing people who suffer malaria (yes percentage)	100	100	–	–
How to prevent malaria	70.0	76.7	100	100
How malaria spreads				
Standing water	78.3	70.0	91.7	100
Trash storing water	21.7	83.3	91.7*	100*
Unprotected drinking water (highly agree per cent)	0.0	40.0	91.7	100*
House sanitization	46.7	25.0	71.7	100*
Health center for malaria treatment (highly agree per cent)	48.3	26.7	81.7	100*
Mosquitoes proliferation (highly agree per cent)	48.3	28.3	88.3*	100*
Adults and children should work together for malaria prevention (highly agree per cent)	51.7	28.3	86.7*	100*
Knowledge sharing (highly agree per cent)	45.0	28.3	85*	100*
Where to get information on malaria				
Clinic	50.0	63.3	100	100
Hospital	85.0	100	100	100
Getting new information	–	–	98.3	100
Appropriate learning method (highly agree per cent)				
Traditional	–	–	40.0	5.0
Animation	–	–	60.0	95.0
Motivation for sharing knowledge	–	–	63.3	100

– indicates unavailable data.
* indicates significant differences within a method (TLE before versus after, LAV before versus after) with chi-square test ($p < .05$).

of respondents in both groups highly agreed that a reduction in mosquito proliferation could lower malaria incidence.

On the pre-test, a low percentage of the participants in the LAV group (25.0%, $\chi^2 = 27.0$; $p < .0001$) did not know that house sanitization could also lower malaria incidence; 100% answered this question correctly after the LAV intervention. In contrast, while 46.7% of the TLE group answered this correctly on the pre-test, only 71.7% answered this item correctly on the post-test, a non-significant learning gain. In both groups, participants were not aware of the fact that both adults and children should work together to prevent malaria disease ($\chi^2 = 5.8$; $p = .02$ and $\chi^2 = 24.01$; $p < .0001$ for the TLE and LAV groups, respectively), although most were motivated to share information on malaria disease ($\chi^2 = 7.4$; $p = .007$ and $\chi^2 = 24.0$; $p < .0001$ for the TLE and LAV groups, respectively). On post-testing, a large percentage of the respondents had increased their knowledge on both the malaria vector and how to prevent the disease (100% for both groups) and disease symptoms (90.0% and 100% for the TLE and LAV groups, respectively).

No other significant differences were observed between the TLE or LAV for method of information dissemination besides the number of the participants highly motivated to share information ($\chi^2 = 4.9$; $p = .026$). All LAV participants selected this dissemination tool as an appropriate method for information sharing.

3.5. Lessons learned

Most of the bed nets used in the villages are not treated with chemicals. Participants learned that bed nets treated with chemicals could be more effective at preventing malaria; the National Program to Fight against Malaria (PNLP) in Benin provides such bed nets to pregnant women. Participants also pointed out that bed nets are useful when you go to bed but the mosquito can bite before you go to bed especially because people do not use screens in their windows. Respondents tended to use traditional medicine for malaria such as neem leaves, which are boiled in water with the resulting liquid consumed to prevent malaria; if they drink it every day malaria can be prevented but respondents rarely reported following daily intake of the neem medicine.

Regarding cholera, the information provided in the video was very new to the participants, generally lacking any previous knowledge about the microorganism as well as how the disease is contracted and transmitted. Participant knowledge in both the traditional and video animation groups significantly improved with regard to cholera disease and prevention, although participants in the video animation groups were able to better retain more detailed information compared to those in the TLE group.

Similarly to cholera, only a few participants had prior knowledge about the various uses for neem extract and its application as an insecticide. Consequently, people had little knowledge about how to process neem extract or what seed color was suitable for such a preparation. While both types of intervention increased participant knowledge, not only did video animations more significantly increase participant knowledge about neem processing compared to participants in TLE groups, but also a larger number of participants identified video animations as an appropriate way to disseminate the information.

Besides being reported as the preferred learning method, LAV are also designed to be easily downloadable, shareable, and re-playable on video-enabled mobile phones or other digital technologies (desktops, laptops, or from the Internet). This presupposes access (either loaned, owned, or rented) to such technologies. Despite very rapidly expanding digital infrastructures in Africa, however, no participants reported access to desktop computers. Similarly, only 3.3% of participants in the TLE neem extract groups – in the villages of Gboho, Lokossa, Kouzounmè, or Kougbedji – reported access to laptops, while only 1.7% and 3.3% in the TLE and LAV groups in the same villages reported access to the Internet. In contrast, at least 68.3% or greater of all groups reported access to mobile phones.

4. Discussion

Overall, the results of this study support both alternative hypotheses that video animations would foster greater learning gains than traditional extension presentations and that, once exposed to video animations, people would on average prefer them as a learning approach as compared to the traditional extension learning presentations. For all three topics, the learning gains were equal or better with video animations compared to the TLE approach.

With respect to learning gains around malaria preventions, the following trends emerged. While both TLE and LAV approaches showed learning gains, the LAV gains were greater. That is, with the TLE intervention, only four questions showed statistically significant increases in correct answers; with the LAV approach, five questions showed statistically significant increases in correct answers. The lack of statistical significance for many of the other questions may be due to relatively high levels of prior knowledge in the participants. Malaria is a very common disease, and all of the participants had suffered from it previously. Interestingly, for the animation group, 100% of the respondents answered all of the questions correctly post-treatment, which was not the case for the TLE group.

Statistically significant differences were also obtained between the groups for the choice of the appropriate dissemination tool. The percentage of the participants citing the intervention method as an appropriate information-disseminating system was much higher for the LAV group compared to the TLE group (Table 9), suggesting that people who watched the video animations were more engaged by that tool. More LAV participants also stated that they were motivated to share the information compared to TLE participants.

These results parallel the findings for the neem extract use and cholera prevention as well: while both groups experienced significant learning gains from both types of intervention, LAV group learning gains were greater, and LAV participants more numerously identified animations as an effective information-disseminating approach for neem use. We do

Table 9. Participant access to types of information technologies.

	Percentage of respondents by educational topic and intervention type					
	Neem extract use		Cholera disease		Malaria disease	
Parameter	TLE	LAV	TLE	LAV	TLE	LAV
Mobile phone	68.3	76.7	68.3	68.3	76.7	86.7
Desktop	0.0	0.0	0.0	0.0	0.0	0.0
Laptop	3.3	0.0	0.0	0.0	0.0	0.0
Internet	1.7	3.3	0.0	0.0	0.0	0.0

note, however, that 81.7% of TLE participants post-test answers on the *waiting time after water treatment with bleach* for cholera prevention item were incorrect compared to 3.3% on the same item for LAV group participants. Although the TLE error was not statistically significant, the wide post-test difference suggests that video animations may better foster information retention. We discuss this possibility more below.

The results from this study echo and extend on previous studies (Bello-Bravo & Baoua, 2012; Bello-Bravo et al., 2011, 2013) conducted on the reception of SAWBO animated videos among a variety of rural and suburban populations across several African nations (Benin, Burkina Faso, Niger, and Ethiopia). SAWBO videos have been introduced to groups of farmers, traders, students, and technicians with a range of educational backgrounds and literacy levels. Data from these studies show that, across the board, the videos are well received, with most viewers suggesting that they would use and share the videos with their communities (Bello-Bravo & Baoua, 2012; Bello-Bravo et al., 2013, 2015). Part of this is due to convenience and frequency of access; once saved to widely available cell phones, the information is easily shared with others and generally constantly on-hand (compared to always carrying around printed/pamphlet information). But another part is the consistency and integrity of the information; that is, learning gains "saved" to individual memory are subject to degradation, modification, and being received as less authoritative by others. Instead, to replay a video animation on a cell phone to a new learner almost perfectly reproduces the opportunities for gains that the person sharing the video previously experienced.

This speaks to the great potential of these animated videos for addressing not only persistent health and agricultural issues that plague much of the developing world but also critical disaster relief needs (Miresmailli et al., 2015) and the needs of underserved populations in more industrialized nations as well. These findings, moreover and coupled with this previous work (Bello-Bravo & Baoua, 2012; Bello-Bravo et al., 2011, 2013, 2015), strongly suggest that the same animated visuals can be effectively used across diverse cultural groups, modified only by voice overlays in appropriate, locally accented languages.

The data from this most recent study in Benin show that, in addition to being well received by local communities, those who watched animated videos retained more information than those presented the same information via a TLE agent presentation. These results support theories that multimedia educational tools, such as narrated animation, produce increased retention and comprehension of new skills and knowledge among learners, particularly for learners without much prior knowledge on the topic at hand (Mayer, 2002).

Mayer's (2002) cognitive theory of multimedia learning posits that meaningful learning occurs when audio and visual representations engage five cognitive processes at once; these are (1) selecting words, (2) selecting images, (3) organizing words, (4) organizing images, and (5) integrating new words and images with previous knowledge. Like the topics addressed in the neem, cholera, and malaria videos, Mayer's (2002) studies emphasize problem-solving knowledge and skills in situations where subjects are presented with information on how to do something and are then asked to perform the task or answer problem-solving, open-ended questions.

In general, the SAWBO animations used in this study employ six out of the seven "effects" that Mayer (2002) outlines as supporting this cognitive theory of multimedia learning. These are (1) "the multimedia effect" of using words and images together; (2)

"the temporal continuity effect" of simultaneous presentation of narration and animation; (3) "the coherence effect," that is, a lack of extraneous sounds and information added to the animation; (4) "the modality effect," which uses narration rather than written text; (5) "the redundancy effect," that is, no redundancy of narration with written text (e.g. a lack of subtitles); and (6) "the signaling effect," whereby animations explain a causal chain through the information provided.

In general, Mayer (2002) finds that well-designed multimedia instruction fosters greater learning gains among low-knowledge learners. Our results support this, inasmuch as participants showed greater learning gains in areas (neem use and cholera prevention), they had lower previous knowledge compared to lower learning gains in areas (malaria prevention) of higher prior knowledge. This does not, of course, diminish the fact that learning gains occurred for malaria prevention as well.

Knowles (1980) initially outlined four components of his theory of andragogy and later added two more steps (Knowles, 1984). The theory of andragogy comprises both assumptions about adult learning and a set of guidelines for practice. Its principles include (1) the need to know, (2) the learner's self-concept, (3) the role of the learner's previous experiences, (4) their readiness to learn, (5) their orientation to learn, and (6) their motivation to learn. Andragogical guidelines of practice for learning point to: (1) increasingly self-directed learning, (2) that it develops from problems and life tasks, (3) the circumstance of learning by self and others, (4) that it is task- or problem-centered learning, (5) internal incentives, that is, curiosity, and (6) the learner's own perception about the *what* and the *why* of learning.

Knowles's (1984) andragogical message is that adult learning is most effective when the students are meeting their level of context or knowledge, and that they will learn more rapidly when the topic and content they are studying shows immediate impact on their current life situation. In light of this theory, the deployment of SAWBO animations can become time-critical; that is, showing a neem animation prior to or during the cropping season has more immediate impact; deploying the malaria or cholera animations when it is predicted that such diseases may be a concern for localized contexts makes it more relevant. That video animations can be left behind on the phones of adult learners empowers people to locally access this information when it is most needed, even in the absence of an "expert." Having such videos available thus meets all six principles and practices outlined by Knowles (1980, 1984) for adult learning in affected communities.

5. Conclusion

In this research study, we aimed to compare learning gains delivered by animated videos compared to more TLE methods. We found not only that participants who watched a video animation demonstrated greater learning gains compared to those who attended a TLE presentation of the same information, but also that animation viewers more highly recommended them as a form of information sharing. As such, not only were animated video more effective, because they can be easily shared on widely available mobile technology (cell phones), they are also more likely to be shared amongst members of different communities.

Both points remained true across a wide cross-section of people of varying educational levels, age, gender, and marital status. That is, learning gains were surprisingly consistent across these variations, as can be seen by the relatively small standard errors observed in all the post-treatment tests (Figures 1–3). Given that for most of the groups tested, the majority of participants had little to no formalized education, this holds out the promise that video animations are useable within the widely varying demographic context of rural African villages. Future studies might well focus on more narrowly characterizing learning gains within specific demographic groups.

While these results support the idea that video animations comprise an effective and popular form of information delivery, further studies to determine the most logical pathways for deployment of this approach in Benin – as well as measures around the longer term application of the learning gains attained – still need to be performed.

This research also raises important questions about the challenges of access to and distribution of knowledge among underserved populations. Our findings suggest that there is great potential in creating animated videos, translated into locally accented languages, as educational material that may then be "mobilized" by farmers and other populations on widely available cell phones in Africa.

For countries like Benin where mobile phone use is high, but Internet connectivity remains low (World Bank, 2014), while all SAWBO animations are available for download via the Internet, they remain sharable without it. Animations can be brought into a community on a single device and then spread to other cell phones using Bluetooth® technology or simply viewed by many people on one phone. Such transition points from online to offline deployment may involve actors (such as agricultural extension agents, researchers, educators, librarians, non-governmental organizations, and civil society) who work with farmers.

Further research, including a more qualitative analysis of why the respondents thought videos were a more appropriate way to share knowledge, would shed much-needed light onto how best to harness mobile and animation technology for the kind of educational purposes described above and as a way to address critical health, agricultural, and development issues world-wide. It was not the purpose of this research to explicitly elicit this why through quantitatively extracted data. Nor does this research claim that expressions of such interest in sharing will actually occur; this is an area for future, follow-up research. Nonetheless, inasmuch as changes of behavior must begin with changes of thinking and expressions of intention to change, the results here then are promising and warrant future research. And, lastly, whether participants re-share videos with an intention to educate or simply amuse others – or both, in the spirit of Horace's dictum that art should "delight and instruct" – is less important than the fact of sharing and further disseminating the information in the first place. Since the "authority" of the information in the videos resides in its scientifically developed content, simply to replay the video to oneself or others re-produces the original learning environment on the spot and effectively makes each person sharing the video into a kind of teacher.

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