Development of Pictograms to Communicate Technological Solution Instructions (Labeling) Among Low-Literacy Users

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FEATURE AT A GLANCE
Conveying information for appropriate use of devices is uniquely challenging in low-resource settings. Drug makers have previously developed culturally meaningful informational pictograms to, for example, convey timing of doses, among low-literacy patients. We tested a similarly structured process among Ugandan smallholder farmers. Over 67% of the pictograms scored a passing grade after the second round of testing, meeting our overall success criterion. The process is efficacious in developing instructional/teaching (labeling) pictograms. These findings can help solution/device developers for low-resource settings to provide correctly interpretable pictograms and thus eliminate misuse-driven low uptake.

KEYWORDS:
technology in society, human-centered design, smallholder farmers, user instructions, picture-based cognition, visual literacy

Smallholder farmers in sub-Saharan Africa raise livestock and crops on small-acreage land. Despite the sizes of their landholdings, smallholder farmers are contributing 70% of the food calories consumed by sub-Saharan Africans (Samberg et al., 2016). With the projected increase in the world population, especially in Asia and sub-Saharan Africa, smallholder farmers have to increase their productivity to meet the increasing food demand (Thornton et al., 2018). To facility the increased productivity, many actors are developing technology-based interventions, such as labor-reducing devices (e.g., Kisaalita et al., 2016; Teutsch, 2019).

On scales of simple reading and writing tasks (Posel, 2011), as well as calculation tasks (Adkins & Ozanne, 2005), most smallholder farmers score in the low-literacy range (White, 2011). As such, these farmers have poorer understanding of the written device user information due to their inability to process and critically analyze the information (Rothman et al., 2006). Most times, smallholder farmers are trained and given verbal instructions on how to operate technology-based interventions, in addition to manuals written in foreign (mostly English) and local languages. These farmers find it difficult to read and understand such instructions (Kapeleka & Mwaseba, 2017). The few who can read are not able to interpret and understand the instructions to be able to execute them properly.

Use of pictograms in the manuals might be the best way to convey information to users or consumers (Joshi & Kothiyal, 2011). This is because humans have a cognitive preference for picture-based, rather than text-based information, the so-called "picture superiority effect" (Katz et al., 2006). Pictogram is a collective term used to describe both "symbols" and "pictorials," and it is a form of a universal language since it can be recognized by all as meaning is conveyed with supposedly little or no dependence on language. The advantage of pictograms is that they can easily be recognized and recalled than words, and there are higher chances of being interpreted more accurately and quickly than words. The factors considered critical for pictograms to be a successful communication tool includes comprehensive design and testing to have a clear and culturally acceptable pictograms and appropriate verbal reinforcement strengthening of the conveyed message (Joshi & Kothiyal, 2011).

In order to facilitate comprehension, pictograms should be simple with little details. Pictograms should be locally and culturally relevant to facilitate easy comprehension, accurate interpretation, and recall (Arbuckle, 2004). Arbuckle (2004) used picture-based educational materials among low-literacy people and found that not all forms of pictures were equally effective. It was realized that a cognitive visual literacy skill is needed for someone to understand certain visual pictorial conventions, since exposure to pictorial signs among low-literacy population is very low. The result from the Dowse and Ehlers (2001) study showed that participants demonstrated more accurate interpretation and recall for locally

developed pictograms, since they contained visually familiar constructs.

Pictograms have been widely used in the pharmaceutical industry to convey instructions for proper handling and taking of drugs (Joshi & Kothiyal, 2011). Studies of pictogram-based information have informed the development of efficacious graphic symbols toward desired medication-taking behaviors (Katz et al., 2006). Dowse and Ehlers (2003) reported that pictograms are useful for conveying timing of doses and adherence to taking pills among low-literacy patients. The general findings from these pharmaceutical industry studies/literature suggest that pictures can help low-literacy population to better understand messages and instructions. However, users can interpret picture-based materials differently, so it should not be used as the only mode of instruction. Houts et al. (2001) reported that spoken instructions plus pictograms is the best way to help people with low-literacy skills to recall large amounts of medical information for a period.

Kapeleka and Mwaseba (2017) studied the effectiveness of labels in pesticide handling among smallholder farmers and found that most participants had never used labels for learning pesticide use procedures. The few participants who used labels misinterpreted the intended symbol and pictogram information. Studies of efficacy of pictograms in communicating instructions for agricultural productivity interventions, such as labor reducing tools, among rural smallholder farmers are rare. Therefore, the purpose of this project was to test the effectiveness of a pictogram development process inspired by successful used of pictograms in the pharmaceutical industry.

STUDY LOCATION

The study was carried out in Mubende district of Uganda. Mubende is located at 0.5773°N, 31.5370°E with an average elevation of 1,209 m above sea level. Mubende shares borders with Kiboga, Kyankwanzi, Mityana, Gomba, Kyegegwa, Kibaale, and Sembabule districts. The main economic activity in the district is farming and mining (particularly gold mining). Crops grown include coffee, tea, maize, sweet potatoes, beans, and banana. We chose Mubende because, in additional to being a rural agricultural district, it was also logistically close to Kampala, providing smallholder farmers who are representative of many other districts in the country. Within Mubende district, the study sites were in Bukuya subcounty in the villages of Kabosi and Ncwamazi, as shown in Figure 1.

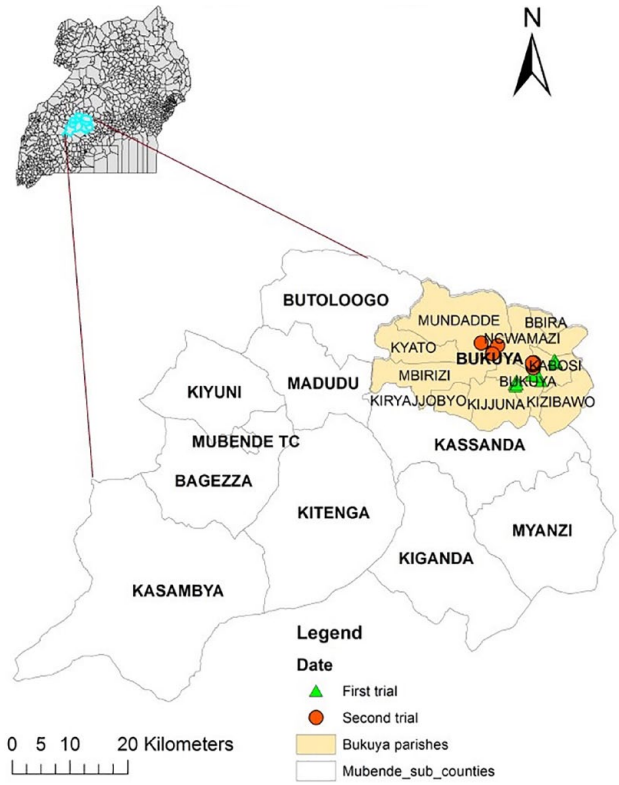


Figure 1. Study sites from Mubende district of Uganda.

PICTOGRAM DEVELOPMENT AND ASSESSMENT PROCESS

We conceptualized a five-step pictogram development process outlined in Table 1. Briefly to create all the messages to communicate and their associated contexts and adopt an established pictogram acceptance criterion (Step 1); to engage an artist to create corresponding pictograms (Step 2); and to test the pictograms among a sizable number of target customers (Step 3). If some pictograms do not meet acceptance criteria, to reengage smaller group of the participants in Step 3 for input on how to improve the failed pictograms (Step 4). To assemble all the pictograms and retest among a new target customer group, but of similar background to the first test group (Step 5). If all pictograms meet acceptance criteria, they are ready for use. If some pictograms do not meet acceptance criteria, go back to Step 4 and keep iterating between Steps 4 and 5.

The actions in the use of two devices, the EvaKuula (Kisaalita et al., 2018) and the IzeChurn (Kisaalita et al., 2016) by low-literacy smallholder farmers informed our choices of communication messages for which to develop pictograms. EvaKuula is a renewable energy (biogas and wind) powered device for keeping smallholder farmers milk fresh overnight so it can enter the cold chain the next day. These farmers have no access to grid electricity, and it is unsafe to transport the milk at night. IzeChurn is a hand-operated churner that separates butterfat from fermented milk toward making ghee. It reduces labor or increases productivity eightfold, in comparison to traditional churning methods/tools.

We retained a local artist, and he developed corresponding pictograms for each message. The local artist developed the first set of pictograms. The decision to use simple sketches in the pictograms was based on Ngoh and Shepherd (1997), who

Table 1. Five-Step Pictogram Development Process

Step	Comment
Step 1: Create a set of messages to communicate and associated contexts and adopt an established pictogram acceptance criterion. A reasonable number of messages in a set is approximately 30.	Why approximately 30? If too many, it will take long and smallholder farmers may not have the time and may end-up rushing, giving inaccurate answers to just get to the end.
Step 2: Engage an artist to create corresponding pictograms for the set.	What makes an artist good for this "technologically literate" artists? Does he/she get it when you explain how biogas is made from cow dung? Does he/she get it when you explain how ghee is made from milk? Use a set of three or so processes in assessing the artist's fitness for the job.
Step 3: Test the pictograms among a sizable number (e.g., 30) of target customers. If all the pictograms meet acceptance criteria, they are ready for use.	Why is the sizable number 30? All the 30 participants will not be usable in the final analysis, it is not unusual to drop up to 30%, due to factors like too low a technological literacy or too old or not able to complete the set.
Step 4: If some pictograms do not meet acceptance criteria, reengage smaller group of the participants in Step 3 (e.g., 20%) in facilitated focus group "conversations" for input on how to improve the failed pictograms. The artist in Step 2 should be present as an observer. Do more listening than talking. Let the farmers drive the discussion.	Because this is facilitated focus group conversation, it is easier to work with a smaller number. By having the artist as an observer rather than a discussant, the artist does a lot of listening and in a better position to translate what he/she hears into second-generation pictographs.
Step 5: Assemble all the pictograms and retest among a new target customer group, but of similar background to the first test group. If all pictograms meet acceptance criteria, they are ready for use. If some pictograms do not meet acceptance criteria, go back to Step 4 and keep iterating between Steps 4 and 5 until all pictograms in the set meet acceptance criteria.	Why a different group? If the first-generation pictograms that passed the first time also pass a second time, the first passing was not by chance and indirectly there is confidence in the passing of the modified second-generation pictograms.

reported identification with simple sketches illustrating prescription drugs instructions. From usability study testing tradition, methods are available for testing label efficacy (e.g., Addendum/Appendix of ANSI Z535.3, Weinger et al., 2011). However, in our study, we approached the task from a human-centered design tradition (Kisaalita, 2016), where we sought to engage users not only in efficacy testing but also in active design through focus group discussions.

The initial pictograms were reviewed by the coauthors and colleagues mentioned in Acknowledgments section. The artist improved the pictograms (Set 1) using the feedback. With these improvements, Set 1 pictograms were ready to be tested among smallholder farmers. Two criteria for pictogram acceptability come from the ANSI (American National Standard Institute) and ISO (International Organization for Standards) standards of 85% and 67%, respectively. The ISO criterion was adopted for this study, given the low education level and other variabilities among the participants. In absence of guidance from literature, we adopted the 67% overall pass criterion for the cohort of pictograms tested for success of the procedure. In other words, out of a cohort of 100 pictograms, if 67 passed, the effort would be considered successful. Failure to meet success triggered iteration between Steps 4 and 5 (Table 1) until the pass criterion for the cohort was met.

Standards Identification

ISO 13407:1999, Human-centered Design Processes for Interactive Systems.
ANSI Z535.3:2007, American National Standards Criteria for Safety Symbols.
ANSI Z535.3:2011, American National Standards Criteria for Safety Symbols.
ISO 9186-1:2014, Graphical Symbols—Test Methods—Part 1: Method for Testing Comprehensibility

A local community facilitator was engaged to help with the random selection of smallholder farmers for participation in the study. Three key inclusion/exclusion criteria were (1) inclusion – smallholder farmer rearing livestock and crops on a small-acreage land, (2) exclusion – vision-impaired farmers, mostly due to old age, and (3) exclusion – farmers whose education level was below primary five (P5). Preliminary pilot testing, before participant recruitment, showed that farmers with less than 5 years of primary education had difficult in relating to the pictograms in general.

Table 2. Group 1 and Group 2 Participant Farmers' Profile

Demographic	Group 1, *n*(%)	Group 2, *n*(%)
Gender		
Male	12 (60)	12 (60)
Female	8 (40)	8 (40)
Age (years)		
20 to < 30	2 (10)	3 (15
30 to <40	5 (25)	5 (25)
40 to <50	11 (55)	9 (45)
50 to <60	0 (0)	1 (5)
60 to <70	2 (10)	2 (10)
Education		
Primary	8 (40)	6 (29)
Secondary	8 (40)	13 (62)
Tertiary	4 (20)	2 (10)

The facilitator recruited two groups of 34 (Group 1) and 32 (Group 2) smallholder farmers. Farmers were met at their homes at times of their convenience. The task was to look at each pictogram and tell the message being communicated. Pictograms were presented one at a time. A pretest questionnaire was administered to record gender, age, and level of education. We tested Set 1 pictograms with the first group (Group 1) of farmers in the village of Kabosi (Figure 1). We compensated the participants with cash payments between $2 and $3.

A focus group consisting of four individuals from Group 1 (two males and two females) was randomly selected to provide feedback on Set 1 pictograms that did not pass according to ISO criteria. We started the focus group conversation by sharing the context and intended communication message from Table 3. We next shared the misinterpretations from Table 4 and suggested the group wonder aloud about why the pictogram did not work and come up with suggestion how the pictogram could be improved for further testing. We asked a volunteer from the group to write down all ideas, after which the group distilled those ideas into concrete recommendations shown in Table 4. The comments/suggestions from the focus group were used to develop a new set (Set 2) of pictograms. Set 2 included the improved/new pictograms and pictograms that passed the first time. Set 2 pictograms were tested with (Group 2) farmers from Ncwamazi village (Figure 1).

Pictograms were awarded a score of one if the intended message was identified by the framer and a score of zero otherwise. The total score of each pictogram was expressed as a percentage of the number of farmers that provided the message behind the pictogram, as they understood it. Our research complied with the American Psychological Association Code of Ethics and was approved by the Institutional Review Board at the University of Georgia. We obtained informed consent from each participant. Below, we present and discuss results of the efficacy of the process described.

PARTICIPANTS

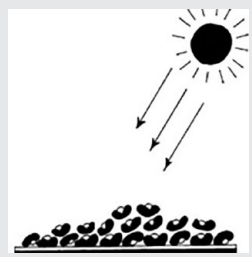
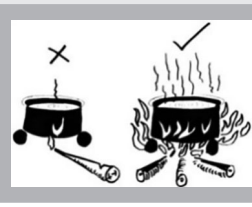
After applying the education exclusion criteria, the number of participants reduced to 20 per group. As shown in Table 2, the cohorts were gender balanced (60% males/40% female). The most common age bracket was 40 to 50 years. Eight and 13 participants in Groups 1 and 2, respectively, had some years of secondary school education. As already mentioned, participants with primary school education had at least 5 years of education. Preliminary testing underscored the importance of 5 or more years of primary education. Potential participants with less education were uncomfortable with technology and/or visual interpretations. Standard education has been reported to be a significant influence in interpretation (Dowse & Ehlers, 2003). This significance can be explained by a social cognitive theory of self-efficacy, defined as, "one's judgement of one's capabilities to organize and execute course of action required to achieve designated types of performance" (Bandura, 1986, p. 391). Education enhances self-efficacy. Low education comes with lack of tools to organize the pieces in a pictogram for interpretation. The cutoff for the cohorts recruited for the study was around 5 years of primary education.

Wogalter et al. (1999) describes mental activities as a sequence of stages, in the Communication-Human Information Processing (C-HIP) model, popular in designing medical device labels. In this C-HIP model, the participant or receiver attends to the information. The information must be understood. To be believed, the information must fit in the participant or receiver's belief system to be motivated, for example, for behavioral change. There is a difference between label and labeling. A label is a

> display of written, printed, or graphic matter upon the immediate container of any article, any word, statement, or other information [that] appear[s] on the label shall not be considered to be complied with unless such word, statement, or other information also appears on the outside container or wrapper, if any there be, of the retail package of such article, or is easily legible through the outside container. (Federal FDA, 2009, cited by Wiklund et al., 2016)

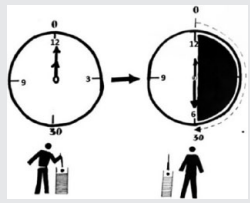
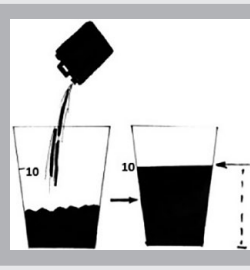
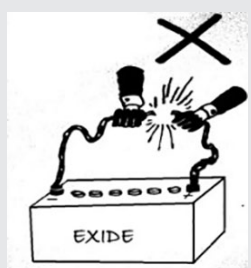
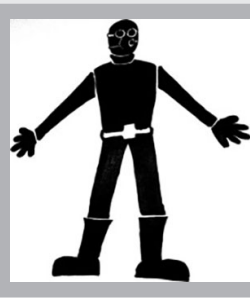
Labeling is defined as "all labels and other written, printed, or graphic matters (1) upon any article or any of its containers or wrappers, or (2) accompanying such article." (Federal FDA, 2009, cited by Wiklund et al., 2016). Accompanying material includes user manuals, the focus in this study. While the pictograms can be used in labels, the labeling definition is a more

Table 3. Pictogram Scores From Group 1 Smallholder Farmer Participants

Number	Pictogram context	Intended communication message	Set 1 pictogram	Score from Group 1 participants
1	To minimize milk contamination, workers milking by hand should wash their hands and the udder with warm water before milking.	Wash your hands with warm water before milking.		40 (failed)
2	Before feeding the digester with fresh cow dung, it should be diluted with water and mixed thoroughly.	Mix thoroughly		35 (failed)
3	There are many outputs on the farms that require reducing the moisture content before storage, for example, slurry from a digester may need reducing its moisture content for future sale.	Dry in the sun		95
4	There are operations that require cranking, like the milk churner. At different times in the process churning may be fast or slow.	Churn fast		35 (failed)
5	Same as above	Churn slowly		35 (failed)
6	In the thermization of milk in a can, the lid should not be removed or opened, as this will introduce germs from the air or dust that may fall into the can. The lid should not be opened.	Keep it covered at all the time		60 (failed)
7	There are operations where high heat is required to raise the temperature. For example, water for thermization to be followed by heating slowly to just maintain the required state of hotness until ready for use.	Heat slowly to maintain boiling		80
8	Same as above	Heat to boil fast		75

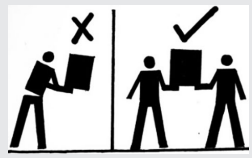
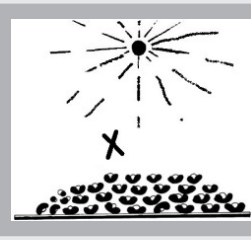
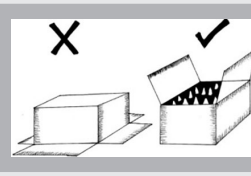
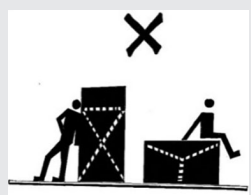
(continued)

Table 3. (continued)

Number	Pictogram context	Intended communication message	Set 1 pictogram	Score from Group 1 participants
9	The length of time required for carrying out a given activity may be important. For example, thermization of milk is carried out for only 30 minutes.	Stop after 30 minutes		65 (failed)
10	To measure volumes, marked containers should be provided.	Fill up to the mark		60 (failed)
11	See context No. 6	Do not open		60 (failed)
12	One of the problems we have at smallholder fortunes farm/facility is plastic litter that has resulted in the death of three of our cows.	Do not bring or drop plastic bags on the farm		50 (failed)
13	We have a solar charged battery with our solar energy-powered fridge that can be unknowingly shorted.	Do not short the battery		40 (failed)
14	There are operations, especially in the workshop, where wearing protective gloves, clothes, shoes, headgear is prudent.	Put on protective gear		85

(continued)

Table 3. (continued)

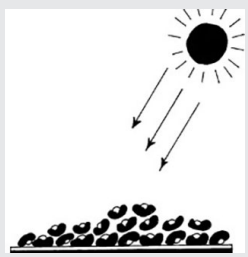
Number	Pictogram context	Intended communication message	Set 1 pictogram	Score from Group 1 participants
15	Sometimes heavy items are delivered on the farm that one individual cannot lift or move.	Do not lift alone		85
16	Some things are sensitive to direct sun heat exposure. It may be necessary to protect the things from direct sunshine.	Do not store in the sun		75
17	Some things may be sensitive to water. For example, feed grain.	Keep away from water		80
18	Boxed equipment might be sensitive to the position of storage, For example the Icy Ball engine.	Keep upright		35 (failed)
19	Same context as the above.	Do not lean or seat on		95
20	During milking, hygiene is essential to protect the milk quality. Therefore, the equipment used (for example cans, jugs and mugs) should be kept clean all the time.	Wash the equipment well before milking		45 (failed)

inclusive and is consistent with the intended use of the pictograms in this study. The participant "motivation" in our study was for him or her to come up with their best understanding of the meaning of the pictograms. In our field experience, the less educated participants had difficulty with the comprehension part of the C-HIP model. They tried to engage the researcher to explain the pictogram more so they could get "the right answer" or what they thought the researcher "wanted to hear."

SET 1 AND SET 2 SCORES

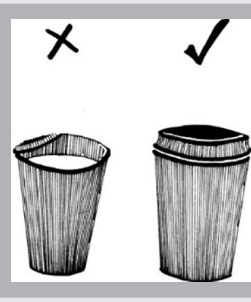
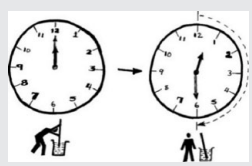
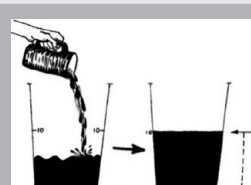
The first set of pictograms and their corresponding scores are presented in Table 3. Using the ISO pass criteria of 67%, less than half of the pictograms (eight out of 20) passed. Literature has not provided guidance to judge whether this was normal or unusual. However, even if it did, probably the setting would be very different from the usual setting (Western counties), where most of such studies are conducted. The pass

Table 4. Pictogram Scores From Group 2 Smallholder Farmer Participants

Number	Misinterpretations[a]	Focus group recommendation	New pictogram included in Set 2	Group 1 score	Group 2 score	% Score change
1	• Warm water is grass • Missed to recognize warm water • Bucket to be rinsed with warm water before milking • Preparing feed for the animal • Cow looking at the man with feed • Wash container before milking	Use three separate segments: (1) pot of water being boiled, (2) *mulalo* (person who milks) washing his hands in boiled/ warm water, and (3) *mulalo* washing udder/ milking		40 (failed)	55 (failed)	37.5
2	• Last individual pulling out water • Missed mixing thoroughly • Two people pouring and then mixing • Continuous mixing • Pouring from the bucket and dipping in a stick • Pouring and mixing but the second individual is standing • Pouring milk and mixing it	Show in the middle segment, pieces added not yet dissolved and mixing with strength		35 (failed)	90 (passed)	157.1
3				95 (passed)	85 (passed)	–10.5
4	• Water in dishes; the first is dirty and the second is clean • People pointing • Pounding • Stay away from mixing hot water • Mixing and the individual has gotten what he wants • Mixing is complete • Mixing well • Mixing concentrated and nonconcentrated milk	Remove the "no"/"yes" markings and instead use the "×" and "√" symbols		35 (failed)	45 (failed)	28.6

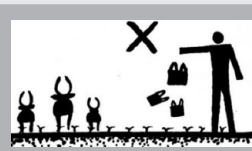
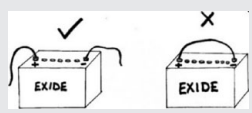
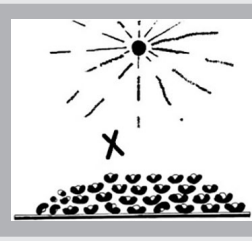
(continued)

Table 4. (continued)

Number	Misinterpretations[a]	Focus group recommendation	New pictogram included in Set 2	Group 1 score	Group 2 score	% Score change
5	• Same as 4 • Already cooled after mixing • Only the second individual is mixing • Mixed and did not achieve what the individual wanted • Mixing the wrong way	Remove the "no"/"yes" markings and instead use the "×" and "√" symbols		35 (failed)	50 (failed)	42.9
6	No meaningful misinterpretations, as reflected in the close to a passing score.	Keep the same pictogram as before. You can remove the lid from the first container.		60 (failed)	95 (passed)	58.3
7				80 (passed)	85 (passed)	6.3
8				75 (passed)	95 (passed)	26.7
9	• Calculating time before night • Waiting for the right time • They are weighing • It is 30 minutes • I see the clock, but what is the man doing	Make the minute and hour arms visible separately. Remove the shading, but maintain the arrow. Show the hour arm movement to the half hour point. Dramatize the action/no action images below the clock		65 (failed)	65 (failed)	0
10	• The container has boiled water • Use all the 10 units • Two buckets; one has contents the other is being filled • Pouring something from the can • Never recognized the 10th mark • The can is pulling out water	Show water all the way to the bottom with a person handling the can. Make sure the water comes out of the can.		60 (failed)	70 (passed)	16.7

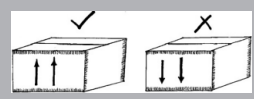
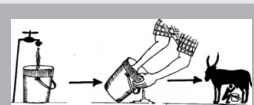
(continued)

Table 4. (continued)

Number	Misinterpretations[a]	Focus group recommendation	New pictogram included in Set 2	Group 1 score	Group 2 score	% Score change
11	No meaningful misinterpretations, reflected in the close to a passing score	Keep the same pictogram as before		60 (failed)	75 (passed)	25
12	• Thought about free range system on the farm • Observed a cow in the garden but not the action • Not good to pour for a cow down • When rearing a cow use a big stick for safety • Man avoiding the cow from spoiling the things • Stopping a cow from eating in the garden	Change to more than one cow. Show many *buveera* (plastic grocery bags or beverage packaging material) dropped (No) Show segment picking up *buveera* (Yes)		50 (failed)	25 (failed)	–50
13	• Don't handle solar battery • Observed the spark as a sun • First aid kit, not allowed to open • Not good to use hands on a battery • Do not light the lab • Work on it while protecting your self • No idea about the battery • Do not touch wires when you are not protected	Make them look like car batteries. They are usually shorted with a tool (metal) dropped on the terminals. Make the terminals (+/–) large.		40 (failed)	50 (failed)	25%
14				85 (passed)	70 (passed)	–11.8
15				85 (passed)	90 (passed)	5.9
16				75 (passed)	60 (passed)[b]	–20
17				80 (passed)	85 (passed)	6.3

(continued)

Table 4. (continued)

Number	Misinterpretations[a]	Focus group recommendation	New pictogram included in Set 2	Group 1 score	Group 2 score	% Score change
18	• Things in the box should be kept open • Don't leave staff closed • Boxed to be opened properly as instructed • When you keep the box upside down, you keep things inside • Don't close the box when you have put your seeds • It's good to open the box for things to get aeration • The box with seeds is allowed • It's good to open a box when it has some things	Use arrows up and down Use two boxes – one (good) and other (bad).		35 (failed)	80 (passed)	120
19				95 (passed)	85 (passed)	–10.5
20	• Collecting water in the bucket • Take water from the tap and wash the udder • Wash hands and milk • Pour water in the bucket and milk	Separate into three segments of (1) collecting water, (2) washing, and (3) milking.		45 (failed)	85 (passed)	88.9

[a]Verbatim translation to capture the response as recorded in the local language. Eight spaces (3, 7, 8, 14, 15, 16, 17, and 19) are intentionally left blank because the corresponding pictograms, shown in Table 3, passed after the first round of testing and were excluded from the focus group deliberations proceeding the second round of testing. [b]Passing of this pictogram under Group 2 scoring was justified on the basis that the pictogram passed under Group 1 scoring, and Group 2 scoring was so close to the pass mark so that the average of the two scores brings it above the pass criterion.

rate did not meet our criterial of at least 67%. Therefore, we implemented a second round as outlined in Table 1. We show the misinterpretations of the first round testing for failed pictograms and the focus group recommendations in Table 4. The misinterpretations were shared with the focus group. The artist interpreted the recommendations into new or improved pictograms, also shown in Table 4. Some of the misinterpretations surprised us, underscoring how developers of pictograms can get it wrong without engaging the intended users as codevelopers. The retesting of the pictogram that passed during the first trial was also included in the second round to increase confidence in their interpretation efficacy. Fourteen of the 20 test pictograms passed – a 70% pass rate, above the 67% criteria. Therefore, according to our goal, the process was successful in two cycles.

Two pictograms (Nos. 2 and 18) increased in scores over 100% between Groups 1 and 2. In both cases, there were major changes in the pictogram. For Pictogram 2, a third a middle segment was added. For Pictogram 18, arrows were used to convey the intended message. Focus group recommendations that result in major pictogram change are most likely indicators of the first-generation pictogram completely missing the mark. There is more evidence in support of this view from a very high percentage change with Pictogram 20 (88.9%) in which a third segment was added. The outlier is Pictogram 12; addition of major changes made it worse. The score for Pictogram 12 decreased by 50%. A closer examination reveals that the artist inadvertently failed to represent one of the focus group recommendation of a "Yes" segment of picking up the plastic bags. We did not catch the error at the time of field implementation. We speculate that this explains the spectacular failure of the pictogram in Group 2 testing. If this is correct, the unintended outcome speaks to the quality and value of focus group feedback. Of the six failed pictograms, the majority (four) increased in score, suggesting that an increase in pass rate was possible if a third cycle was implemented.

We attributed the success rate, in only two cycles, on the human-centered design approach of our development

procedure. Mehta (2012) has described the human-centered design approach as, ". . . an approach to design, that grounds the design process in information about people who will use the product" (p. 138). In our approach, we went beyond the information and codesigned with the users through the focus groups. During the focus group deliberations, we listened more than we talked. We gave the "chalk" to one of the participants (Kisaalita, 2020). As mentioned before, the artist was an observer and focused on interpreting the focus group recommendation in improved or entirely new pictograms. This mind-set conveyed to the participants that we were equal partners in this process.

CONCLUDING REMARKS

Although the success of the process proposed in this study has been demonstrated with low-resource agricultural settings, we believe it is applicable in other low-resource settings. In other words, it is independent of industry type. The results in this study support the view that the five-step process, implemented in the human-centered design tradition, is efficacious in producing recognizable pictograms for label and labeling in low-resource settings. Education level of participants is an import inclusion/exclusion criterion to the success of the procedure. The process is likely to fall apart if the education exclusion is not properly applied.

Now that we have validated the interpretability of the pictograms, our next step is to apply these and/or additional similarly produced pictograms as an intervention to assess their educational and behavioral change outcome efficacy. We have an opportunity in a project, where we are using EvaKuula to store guinea fowl eggs before synchronized hatching by surrogate chicken hens (Roothaert et al., 2011). Guinea fowl are highly prized in the Sudano-Sahelian countries, for example, Burkina Faso. However, the birds are poor broody hens in captivity; they do not sit on their eggs for hatching, and the farmers do not have access to grid/solar electricity to power incubators. The twofold aims in this project is to increase guinea fowl egg and meat production and increase consumption among children 2 years and younger. Animal protein consumption (e.g., one egg per day) mitigates stunting (Iannotti et al., 2017). Numerous studies have shown that poultry interventions targeting increased egg intake among infants and young children in low-income countries need to be integrated with nutrition education (Omer, 2020). We will test the efficacy of educational pictograms in this project in a randomized controlled trial design. Evidence in support of the potential for success comes from studies that have shown that adding pictograms to written and spoken language can increase attention, comprehension, recall and behavioral change (Houts et al., 2006), which is consistent with the C-HIP model mentioned under Participants section. The theoretical foundation behind the evidence can be traced to Albert Bandura's social learning theory of identificatory processes, which provide guidelines for behavioral change interventions using modeling (Perry & Furukawa, 1988).

KEY POINTS

A human-centered design approach was used to develop a process to create pictograms to communicate technological solution instructions among low-literacy users.

The five-step approach is effective in producing recognizable pictograms for labeling in low-resource settings.

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