Can teacher-centered community-based conservation programs influence student household sustainable behaviors near a biodiversity hotspot?

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Abstract
Local communities living on the borders of protected areas can be key drivers of environmental degradation. Community-based conservation initiatives seek to use sustainable activities as a strategy for mitigating these degradative behaviors while improving livelihoods but must be scalable to the site and sustainable over time. Teacher training, as a means of information transfer to the broader community, is one technique for implementing long-term sustainable behavior programs. To be effective, sustainability practices must reach beyond behavior change in teachers to influence students and the broader community in which they work. UNITE for the Environment (UNITE) is a community-based environmental sustainability program located along the border of Kibale National Park in Uganda, a site of high biodiversity, particularly for primates. UNITE focuses on conducting teacher trainings with 12 schools within 5 km of the park. We conducted an evaluation of the effectiveness of the transfer of UNITE’s sustainability practices to the broader community. Families of teachers and students from schools that UNITE worked with, as well as control schools, were surveyed to assess their use of sustainable activities promoted by UNITE. Sustainable activities included specific agricultural practices, composting, bee-keeping and fuel-efficient stoves, while controlling for possible confounding variables between households including socioeconomic, spatial, and demographic variables. Results revealed that UNITE households, in comparison with control group households, showed greater use of sustainable practices for 12 of 13 behaviors tested. Wealth was the most influential of socioeconomic factors, with wealthier individuals more likely to implement sustainable activities. UNITE participants had greater value of the environment and belief in their ability to affect the environment than members of the control group. This study demonstrates the ability of teacher training programs to influence sustainable behavior, even while controlling for socioeconomic
1 | INTRODUCTION

Human activities, such as habitat degradation and hunting, are the primary threats to forests and their wildlife inhabitants, especially primates (Hill, 2002; Onderdonk & Chapman, 2000). Local communities living on the borders of protected areas can be key drivers of environmental degradation (Thornton et al., 2020) and thus represent an important area of focus for conservation efforts. As a result, community-based conservation, most simply defined as “natural resource or biodiversity protection by, for, and with the local community,” has arisen as a strategy for wildlife conservation outside of protected areas (Western & Wright, 1994). Sustainable livelihoods is one conservation approach used within community-based conservation that seeks to find win-win solutions by improving livelihoods and minimizing environmental impact (Redford et al., 2008). When centered on the borders of protected areas or in remote biodiversity hotspots, sustainable development can mitigate human impacts in protected areas such as poaching, fuelwood extraction, and erosion. However, the most effective practices for the implementation of community-based conservation merit further study (Davies et al., 2014).

Early approaches to community-based conservation have focused on alternative livelihoods (Berkes, 2007). Such programs attempt to substitute environmentally damaging behaviors with low-impact behaviors, but have been questioned as they depend on the flawed assumptions of substitution (IUCN, 2012). This substitution principle is rarely supported by evidence as new sources of income may simply supplement existing unsustainable behaviors as opposed to extinguish them (e.g., starting poultry farming may not eliminate bushmeat consumption) (Wright et al., 2016). By focusing behavior change efforts on identifying solutions that reduce dependence on the environment, as opposed to alternative livelihoods, it may be possible to improve wellbeing and reduce environmental impact at the same time (Wright et al., 2016). Indeed, more recent community-based conservation efforts have tried to establish a clear link between conservation and local benefits, such as through use of sustainable activities (Berkes, 2007).

For community-based conservation initiatives, like sustainable livelihood programs, it is important to recognize heterogeneity of communities (Wright et al., 2016). These programs may be biased in terms of who is reached based on wealth or proximity to the program center or to the natural resource itself. In general, wealthier individuals, those working for existing institutions such as schools or government, and those who are more educated may be better equipped to shift and diversify their livelihoods (Smith et al., 2001). Conversely, poorer individuals and those living closer to natural resources may be more dependent on the environment and less able to adapt their practices (Kümpel et al., 2010). However, it should not be assumed that dependence on and use of the environment are equivalent. Wealthier individuals may have greater overall use and impact on biodiversity than poorer individuals (Angelsen et al., 2014). There have been limited efforts to account for factors, like wealth and location, when evaluating the success of sustainable livelihood or behavior change campaigns (Nilsson et al., 2020).

Community-based conservation initiatives, including sustainable livelihood programs, behavior change campaigns, and other conservation education programs, suffer from a dearth of evaluation (Davies et al., 2014; Kuhar et al., 2010; Nilsson et al., 2020). Evaluation efforts also tend to be one dimensional, focusing only on economic, attitudinal, behavioral, or ecological effects and are often single level (looking at an individual, household, or community), which limits the ability of the assessment to detect possible trade-offs (Davies et al., 2014). Previous studies related to UNITE for the Environment (UNITE), the community-based program evaluated here, have demonstrated knowledge and attitudinal improvements in students related to teacher training (Lukas et al., 2017). However, it is well established that environmental knowledge is not the only factor influencing pro-conservation or sustainable behaviors (Kaiser & Fuhrer, 2003; Moss et al., 2017). While studies on the effects of conservation programs on attitudes are 14 times more common than those looking at behavior, there is reason to believe that attitudinal changes do not necessarily translate into conservation action, particularly where economic interests may be involved (Nilsson et al., 2020). In some cases, attitude and behavior may even be unrelated, such that shifts in behavior can occur without changes in attitudes and vice versa (Maynard et al., 2021).
Sustainable livelihood programs also struggle with scalability (Wright et al., 2016). This issue is exacerbated by the lack of systematic reporting and thus replicability of existing programs (Davies et al., 2014). The goal of teacher-centered programs is to expand the reach of community-based interventions from a relatively small number of teachers (120 individuals in this study) to the students that they work with (over 5000 individuals in this study), and into the broader community. Our recent work demonstrated the ability for teacher-centered initiatives to create sustained and multiplicative behavior change in relation to production of fuel-efficient stoves and thus suggests the potential value of this approach as a means to engage the broader community via direct interaction with a relatively small number of influential individuals (Kendall et al., 2021). We explore this idea further in this article, recognizing the importance of assessing not just the direct effects of these programs on teacher behavior, but more importantly the indirect and broader effects at the community level.

Here we evaluate a sustainable livelihoods program centered on teachers, called UNITE, that operates next to a biodiverse, forested protected area, Kibale National Park (KNP), Uganda. This program trains teachers to work with students and the broader community to utilize sustainable activities, most of which mutually benefit community livelihoods and the environment. Generally, the goal of these sustainable activities is not income generation per se, but to provide community members novel ways to conduct existing practices, such as farming or cooking, that reduce the impact of these activities on natural resources. In these communities, teachers are respected authorities with potential to influence the behavior of their students, their families, and indirectly, their broader community. In addition, students who are influenced via their teachers, may indirectly encourage change at the household level. There is increasing interest in intergenerational learning but limited exploration of the role of child to parent directed influence, which we explore here by assessing student households (Zeldin et al., 2013). The behaviors encouraged via this program reduce dependence on natural resources, which in turn reduces habitat encroachment and loss, key threats to chimpanzees and other species found in KNP (Onderdonk & Chapman, 2000). We surveyed families of teachers and students from both schools that UNITE worked with as well as control schools, which are similar in terms of distance to the park, student body, and financial resources.

We hypothesized that families of teachers and students from schools with which UNITE works would have higher implementation of sustainable behaviors compared with those from control schools. In addition, we controlled for confounding variables between households including wealth, family size, student age, and distance from nearest UNITE school, which may affect the ability and desire of households to implement sustainable activities. We hypothesized that wealthier families, with fewer members, older children, and living closer to schools with which UNITE works would be more likely to enact each of the sustainable activities (Angelsen et al., 2014; Kümpel et al., 2010; Smith et al., 2001). We also expected to find greater uptake of sustainable behaviors amongst households of teachers versus households of students. Finally, we expected to see more positive and empowered attitudes about the environment and the ability of individuals to make change amongst families of UNITE schools versus controls schools. This work provides novel insights into the role of teachers as communicators of sustainable practices and the impacts on their students and student households with careful consideration for how socioeconomic factors might influence behavior change. Given limited evaluation work in this field and lack of incorporation of confounding variables in previous studies, this study provides useful insight for practitioners hoping to work with teachers as communicators to promote sustainable practices and thus reduce the impact of local communities on neighboring protected areas.

2 | METHODS

2.1 | Study site

At 795 km², KNP, Uganda, is a biodiversity hotspot, home to one of the largest populations of chimpanzees in East Africa and 12 other primate species (Onderdonk & Chapman, 2000; Plumptre et al., 2010) that is surrounded by rural communities relying heavily on subsistence agriculture and natural resources. The main threats to wildlife in this forested ecosystem are habitat degradation and poaching by the adjacent communities (Chapman et al., 2010; Mackenzie et al., 2011). Population density near the park is greater than 300 people per square kilometer exacerbating pressure for natural resources around and within the park (Chapman et al., 2010).

2.2 | Program description

UNITE, founded by North Carolina Zoo in 2002 and operating with on-going support from Cleveland Metroparks Zoo, works with 12 schools (11 primary or elementary schools and 1 secondary or middle/high school) that are within 5 km of KNP. The program has focused on
primary schools in part because there are fewer secondary schools in the area. The program trained approximately 120 teachers to deliver content to their students about environmental science and sustainable behaviors. Further information can be found about the program in Kendall et al. (2021) and Lukas et al. (2017). From 2015 to 2019, the project focused on sustainable practices by providing guidance for implementing specific behaviors of interest during teacher training. When requested, UNITE staff also provided additional support to teachers or school groups for implementation of these behaviors. For example, one UNITE staff member could be called to provide technical support in construction of fuel-efficient stoves if needed. At times, a metal frame or other minimal materials might be supplied if requested. The UNITE program also supports conservation clubs at each school and would provide a small amount of funding to implement their annual work plans, which often drew from activities discussed in teacher training. The present study measured the impact of the teacher communication with the students and their families by collecting survey and direct observation from the UNITE schools’ student households and from households of students in control group schools.

2.3 | Survey methods

Surveyors randomly selected households around KNP based on registries from both UNITE (n = 12 schools, 254 households) and control (n = 4 schools, 45 households) schools. Random selection was accomplished using a random number generator that determined what households to select based on their order in the registry. Heads of each household were asked to verbally complete the survey in local language with one of four local staff surveyors from UNITE. Questions were designed by a mixed team of Ugandans and Americans and underwent multiple iterations to improve on clarity and word choice. Furthermore, there were no additional concerns raised after pilot testing of these questions with community members. At the time of the survey the staff read a written consent statement and received consent from the head of household for participation in the survey. Each of the staff had received training in human research ethics from the Collaborative Institutional Training Initiative (CITI) program as part of the IRB process. Visits were done without prior notification to the households. Most interviewees would not have known the UNITE staff surveyors, particularly as the actual student or teacher linked to the UNITE schools were never interviewed, but rather another member of their household would have been surveyed. GPS coordinates of the household were collected, and where possible, practices of the specific behaviors that were indicated in the survey were also verified (i.e., existence of fuel-efficient stove or kitchen garden). Surveyors collected information on tablets using CyberTracker. All data were collected in December 2020 and January 2021.

2.4 | Assessment of socioeconomic, spatial, and demographic variables on sustainable activities

Distance between the home and the nearest UNITE school was determined in ArcGIS 10.6 using the Spatial Join tool. Wealth of household was measured based on size of farm plot, presence of permanent housing, livestock ownership, water access, ownership of radio and mobile phone, and transportation (bicycle, motorcycle, or other vehicle). A wealth index was created based on these characteristics. This wealth index assigned a quantified value for each of the previously listed factors such that possession of free range poultry or rabbits received a score of 0.5; ownership of a mobile phone, radio, goat/sheep, pig, bicycle and presence of a rainwater tank or gravity system (purchased at household level) scored a 1 for each; the presence of farmed poultry (or combination of free range and farmed poultry) or cattle and ownership of a motorcycle scored a 2 each; and permanent housing and ownership of a vehicle scored a 3 each. In addition, size of land was categorized such that properties of greater than 2 acres received score of 3, those of 2 acres received a score of 2, those of 1 acre scored 1 and those less than 1 acre received no score. Scores were summed across all factors providing a scale varying from 0 to 18.5.

2.5 | Evaluation of sustainable behavior for program and non-program participants

We surveyed households about 17 different sustainable behaviors, which have been the focus of the UNITE program over the last 5 years. For all participants, these included presence of fuel-efficient stove, waste separation, tree planting, use of kitchen garden (vegetable garden near household), banana growing, and beekeeping. In addition, for those participants that had a farm, we evaluated sustainable farming practices, including microcropping, agroforestry, rotating crops, mulching, drip irrigation, use of water retention ditches, keeping garden records, and the use of organic fertilizers and pesticides versus chemical ones.

For each sustainable behavior, we assessed how behavior varied between households of UNITE students and households of control students using a GLM with...
binomial distribution in RStudio Ver 1.3 (RStudio Team, 2020) using presence or absence of the behavior as the response variable. To accomplish this for each behavior, we ran one model with UNITE versus control as a fixed factor and one model without that variable and compared the AICc values, selecting whichever was lower. In addition, all models included as fixed effects student age, distance to closest UNITE school, family size, and wealth based on the index described above. Distance to closest UNITE school was log-transformed to improve model fit. We checked for collinearity among continuous variables and all correlations ($r^2$) were less than .23. We then looked at confidence intervals of other variables within the final models for overlap with zero to assess the impact of distance to closest UNITE school, family size, wealth, and student age. We had four households for which we lacked GPS coordinates and one student who was considerably older than the rest of the sample and thus these data points were excluded from the analysis.

Ultimately, only 13 behaviors were included in the analysis because of the requirements for binomial GLM. For use of binomial GLM, the sample size is equal to the lesser of the number of people who do, or do not do, a given behavior since this was the response variable. To avoid overparameterization, where sample size was less than 50, we did not run models as we were including five parameters in the final model; this applied to banana growing, drip irrigation, keeping garden records, and multicropping.

In addition to households of students, we interviewed a small number of teacher households ($n = 37$). Because sample size for the teacher groups was small, we only looked at differences between teachers and students descriptively and compared the proportions of households of UNITE teacher, UNITE student, control teacher, and control student doing each of the sustainable behaviors tested.

To assess relationships between sustainable behaviors, each behavior was categorized as 1 or 0 if it was being conducted by a given household. We then summed across all non-farming sustainable behaviors and all farming sustainable behaviors. This allowed us to assess patterns in frequency of sustainable behaviors between households.

### 2.6 Evaluation of attitudes toward sustainability

We asked three questions/statements in relation to attitudes about sustainability and its importance including: (1) How important to your livelihood and family is it to maintain a healthy environment?, (2) My choices and actions can affect the environment, and (3) UNITE has influenced our environmental activities. Respondents used a Likert scale from strongly disagree/not at all important (1) to strongly agree/very important (5) to provide their response. For questions related to self-efficacy, other literature has found that specificity of these types of question to the task is important (Chen et al., 2001). Content of our attitudinal questions was specific to the environment as we wanted to understand people's perceptions of their self-efficacy in affecting the environment in particular. Mann–Whitney U tests were used to compare responses from UNITE and control households. Correlations between attitude and number of non-farming and farming sustainable practices done by a given household were also evaluated using Pearson correlation via cor function in RStudio.

### RESULTS

We interviewed 299 student households of which 45 were control households and 254 were UNITE households. The majority of households were those of students from primary school (which goes up to the equivalent of seventh grade in the United States). Where possible, surveyors attempted to confirm presence of sustainable practices through direct observation. This was more feasible for non-farming activities, which are more readily observed. Percent of households where reported behaviors could be confirmed are provided in Table 1. Of these, 292 (249 UNITE households and 43 control households) had farms and were included in the analysis related to sustainable farming practices.

Across 12 of the 13 behaviors considered, the model including UNITE versus control was selected and in all these cases the UNITE households reported greater use of sustainable practices than controls (Table 2). Tree planting was the only sustainable behavior considered where the model including the variable of UNITE versus

| Sustainable practice       | UNITE   | Control |
|----------------------------|---------|---------|
| Fuel-efficient stoves      | 83.2    | 37.5    |
| Waste separation           | 39.8    | 19.4    |
| Tree planting              | 68.5    | 51.2    |
| Kitchen garden             | 62.4    | 39.3    |
| Beekeeping                 | 33.8    | 16.7    |
| Banana growing             | 72.3    | 65.3    |

Table 1. Percent of households reporting implementation that were verified to be engaging in a given sustainable behavior (i.e., households with direct observation out of all households reporting conducting that behavior).
control households was not selected, though it was reported more frequently in UNITE households. Across both UNITE and control households tree planting was a very common behavior. Wealth had a significant, positive effect on the presence of fuel-efficient stoves, tree planting, kitchen gardens, water retention ditches, beekeeping, agroforestry, and mulching. Family size had a positive effect on presence of water retention ditches. Age of student from UNITE or

| Sustainable behavior       | Percent of UNITE households | Percent of control households | Other significant variables |
|----------------------------|-----------------------------|-------------------------------|----------------------------|
| Fuel-efficient stoves      | 49.6                        | 24.4                          | Wealth                     |
| Waste separation           | 74.4                        | 51.1                          |                            |
| Tree planting              | 85.0                        | 75.6                          |                            |
| Kitchen garden             | 69.7                        | 42.2                          | Wealth                     |
| Beekeeping                 | 24.0                        | 11.1                          |                            |

**Sustainable farming practices**

| Sustainable behavior       | Percent of UNITE households | Percent of control households | Other significant variables |
|----------------------------|-----------------------------|-------------------------------|-----------------------------|
| Agroforestry               | 69.9                        | 51.2                          | Student age, wealth         |
| Rotating crops             | 88.4                        | 67.4                          |                            |
| Garden ditch               | 48.6                        | 34.9                          | Wealth, family size         |
| Mulching                   | 78.7                        | 55.8                          | Student age, Wealth         |
| Chemical fertilizer        | 14.9                        | 32.6                          |                            |
| Chemical pesticide         | 46.2                        | 76.7                          |                            |
| Organic fertilizer         | 72.7                        | 44.2                          |                            |
| Organic pesticide          | 16.5                        | 11.6                          |                            |

*Response variables for which model including UNITE versus control household factor had lowest AICc.

**TABLE 3** Comparison of sustainable behaviors between teacher and student households for UNITE and control

| Sustainable behavior       | Percent of UNITE teacher households | Percent of control teacher households | Percent of UNITE student households | Percent of control student households |
|----------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|
| Fuel-efficient stoves      | 60.7                                | 55.6                                  | 49.6                                | 24.4                                  |
| Waste separation           | 96.4                                | 88.9                                  | 74.4                                | 51.1                                  |
| Tree planting              | 89.3                                | 77.8                                  | 85.0                                | 75.6                                  |
| Kitchen garden             | 89.3                                | 100                                   | 69.7                                | 42.2                                  |
| Beekeeping                 | 35.7                                | 11.1                                  | 24.0                                | 11.1                                  |
| Banana growing             | 92.9                                | 100                                   | 93.7                                | 88.9                                  |

**Sustainable farming practices**

| Sustainable behavior       | Percent of UNITE teacher households | Percent of control teacher households | Percent of UNITE student households | Percent of control student households |
|----------------------------|-------------------------------------|---------------------------------------|-------------------------------------|---------------------------------------|
| Agroforestry               | 82.1                                | 77.8                                  | 69.9                                | 51.2                                  |
| Rotating crops             | 100                                 | 88.9                                  | 88.4                                | 67.4                                  |
| Garden records             | 28.6                                | 22.2                                  | 7.8                                 | 7.1                                   |
| Multi-cropping             | 92.9                                | 88.9                                  | 87.1                                | 83.7                                  |
| Garden ditch               | 60.7                                | 55.6                                  | 48.6                                | 34.9                                  |
| Mulching                   | 82.1                                | 77.8                                  | 78.7                                | 55.8                                  |
| Drip irrigation            | 25                                  | 22                                    | 8.8                                 | 4.7                                   |
| Chemical fertilizer        | 10.7                                | 33.3                                  | 14.9                                | 32.6                                  |
| Chemical pesticide         | 39.3                                | 66.7                                  | 46.2                                | 76.7                                  |
| Organic fertilizer         | 85.7                                | 88.9                                  | 72.7                                | 44.2                                  |
| Organic pesticide          | 32.1                                | 44.4                                  | 16.5                                | 11.6                                  |
control school had a positive effect on agroforestry and mulching with households with older student from the school being more likely to do these behaviors. Distance to UNITE school was not significant for any behavior.

For the four behaviors for which we did not run GLMs, banana growing and multi-cropping were very common amongst both UNITE and control households (with only 21 and 39 households not doing the behavior respectively). Drip irrigation and keeping garden records were very uncommon behaviors amongst both UNITE and control households (with only 24 and 21 households doing the behavior respectively).

In addition to households of students, we interviewed 37 teacher households—9 from teachers at control schools and 28 from teachers at UNITE schools. While we did not formally test the relationship between teacher and student households, in general, households of teachers from both UNITE and control schools were much more likely to perform sustainable practices than student households, and UNITE teachers were generally more likely to perform sustainable practices than control teachers (Table 3).

We found that for non-farming sustainable behaviors, there was considerable variation in frequency of conducting multiple behaviors with an average of 3.9 (out of
6) behaviors performed per household (Figure 1). Note that these values include all households combined (both UNITE and control, student, and teacher). For sustainable agriculture behaviors, the average number of behaviors performed was 5.3 (out of 9) behaviors per household and there was also considerable variation in number of different behaviors conducted (Figure 2).

### 3.1 Attitudes toward sustainability practices

UNITE households overall and UNITE student households specifically were more likely to feel that (1) a healthy environment was important for their livelihood, (2) that their choices can affect the environment, and (3) that UNITE had influenced their environmental activities, when compared with controls (Table 4). UNITE teacher households also had more positive attitudes than control households, but there was not a significant difference between UNITE teacher and control teacher households for the question about their ability to affect the environment. The relationship between attitude question 1 and the number of non-farming and farming sustainable actions taken was generally weak with correlation of 0.24 and 0.14, respectively. Similarly, the relationship between attitude question 2 and the number of non-farming and farming sustainable actions taken was generally weak with correlation of 0.25 and 0.10, respectively.

### 4 DISCUSSION

Community-based conservation initiatives, particularly sustainable livelihood programs, have the potential to reduce the impact of human activities on the environment, but to be effective they need to be scalable and sustained over time. Because there is significant evidence that knowledge and attitude changes alone may not lead to pro-conservation behaviors, it is critical to evaluate the effect of community-based conservation programs on behavior specifically (Kaiser & Fuhrer, 2003; Moss et al., 2017; Nilsson et al., 2020). Previously we demonstrated the ability of teacher training to lead to multiplicative and sustained behavior change over 4 years in relation to a single target behavior—construction of fuel-efficient stoves (Kendall et al., 2021). Here we demonstrate that a teacher-centered sustainable livelihood program can lead

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**Table 4** Results from Mann–Whitney U for attitudinal questions (∗ indicates findings are significant)

| How important to your livelihood and family is it to maintain a healthy environment? (out of 5) | N  | Mean (SE) | Mann–Whitney U |
|---|---|---|---|
| UNITE | 282 | 4.61 (0.04) | U = 5222, z = –4.287, P < 0.001* |
| Control | 54 | 4.17 (0.11) | |
| Student—UNITE | 254 | 4.57 (0.04) | U = 3798.5, z = –4.122, P < .001* |
| Student—Control | 45 | 4.11 (0.11) | |
| Teacher—UNITE | 28 | 4.96 (0.03) | U = 87.5, z = –2.529, P = .011* |
| Teacher—Control | 9 | 4.44 (0.28) | |

| My choices and actions can affect the environment (out of 5) | N  | Mean (SE) | Mann–Whitney U |
|---|---|---|---|
| UNITE | 282 | 4.07 (0.06) | U = 5284.5, z = –3.796, P < .001* |
| Control | 54 | 3.5 (0.15) | |
| Student—UNITE | 254 | 4.01 (0.06) | U = 3625.5, z = –4.162, P < .001* |
| Student—Control | 45 | 3.33 (0.16) | |
| Teacher—UNITE | 28 | 4.61 (0.13) | U = 104.5, z = –0.905, P = .366 |
| Teacher—Control | 9 | 4.33 (0.27) | |

| UNITE has influenced our environmental activities (out of 5) | N  | Mean (SE) | Mann–Whitney U |
|---|---|---|---|
| UNITE | 282 | 3.95 (0.05) | U = 3405, z = –6.729, P < .001* |
| Control | 54 | 2.89 (0.14) | |
| Student—UNITE | 254 | 3.84 (0.06) | U = 1964, z = –7.357, P < .001* |
| Student—Control | 45 | 2.64 (0.12) | |
| Teacher—UNITE | 28 | 4.89 (0.06) | U = 54, z = –3.415, P = .001* |
| Teacher—Control | 9 | 4.11 (0.29) | |
Findings regarding the lack of importance of student age to nearest UNITE school was never significant. Family size and student age were rarely significant in barriers to adoption for poorer individuals. In contrast, of iron rods in the case of the stoves, which may act as a tree seedlings, construction of new gardens, and purchase and mulching. With the possible exception of mulching, kitchen gardens, ditches, beekeeping, agroforestry, included construction of fuel-efficient stove, tree-planting, wealthier individuals were more likely to adopt the sustainable practice adoption. For 7 of the 13 behaviors studied, positive effect of teacher training on student learning and attitude changes has been well studied, including within the UNITE program (Jacob & Lefgren, 2004; Lukas et al., 2017; Ormsby et al., 2002). Here we demonstrated important indicators of success in terms of meaningful adoption of sustainable behaviors may be related to a teacher-centric approach and to the support, both through initial training and during implementation as needed, provided to teachers, students, and households adopting these new behaviors during the last 5 years. In particular, it is important to note that for this behavior change to have occurred, it required teachers to disseminate information from training to students, students to learn this information, and for students and teachers to further adopt these behaviors at a household level or encourage their use amongst other community members. Regardless of whether it is the teachers or the students who act as the main influencers on the broader community, this study speaks to the strength of working with teachers as opposed to students directly. For tree planting and the four other behaviors that we were unable to evaluate, levels of use of the behavior were either very high or very low. In the cases of high adoption, it may be difficult for conservation programs to have an impact. Similarly, for behaviors with very low adoption levels, which were drip irrigation and keeping garden records, it may be difficult to encourage use of such novel behaviors or may simply require more time before meaningful levels of adoption occur.

This consistent adoption of sustainable practices by UNITE households occurred even while controlling for important socioeconomic factors such as wealth, family size, age of students at the UNITE school, and distance to a UNITE school. However, our study also identified the importance, particularly of wealth, in influencing sustainable practice adoption. For 7 of the 13 behaviors studied, wealthier individuals were more likely to adopt the behavior than poorer individuals. These behaviors included construction of fuel-efficient stove, tree-planting, kitchen gardens, ditches, beekeeping, agroforestry, and mulching. With the possible exception of mulching, all of these behaviors require more resources to implement than other behaviors surveyed such as purchase of tree seedlings, construction of new gardens, and purchase of iron rods in the case of the stoves, which may act as a barrier to adoption for poorer individuals. In contrast, family size and student age were rarely significant in terms of their effect on sustainable behavior use and distance to nearest UNITE school was never significant. Findings regarding the lack of importance of student age suggest that teacher-centered programs do not need to focus on teachers working with older students, such as those in middle or high school, but instead that even younger students, possibly with support of their teacher's broader influence on the community, may be able to engage their families in sustainable practices. This supports the potential influence of intergenerational learning, even going from child to parent (Zeldin et al., 2013). Indeed, the UNITE program works mainly with primary school educators and has consistently seen meaningful impact within the community. Lack of effect for distance to school also demonstrates how teacher or even school centered programs can have wider effects, possibly because they draw from students coming from across a wide area.

For sustainable livelihood programs or behavior change campaigns with more than one target behavior, it is unclear if households will be more likely to adopt several behaviors or will select for only a few. Based on our measures of cumulative behavior change, the data suggest that there is a wide distribution of how many behaviors are adopted ranging from 0 to 6 for non-farming and 2 to 9 for agriculturally based sustainable activities. The bell-shaped distribution of the cumulative behavior measures suggests that households may select several behaviors appropriate for their needs. As such, significant results are not driven by a few households implementing many behaviors but rather by different households using a variety of behaviors.

While we did not formally test the relationship between teacher and student households, in general, households of teachers from both UNITE and control schools were more likely to perform sustainable practices than student households. UNITE teachers were also generally more likely to perform sustainable practices than control teachers. For UNITE teacher households this finding is unsurprising as the program is directed specifically at teachers as opposed to students. However for control schools this suggests that teachers in general may be more likely to engage in sustainable practices, which is consistent with other findings from Uganda that more educated individuals and those working with government run agencies are more able to shift practices than other households (Smith et al., 2001). Teachers may thus be early adopters of sustainable behaviors, which provides further support for greater focus on teachers for information transfer as they may act as important influencers for their communities, particularly in relation to sustainable practices.

The positive effect of teacher training on student learning and attitude changes has been well studied, including within the UNITE program (Jacob & Lefgren, 2004; Lukas et al., 2017; Ormsby et al., 2002).
attitudinal changes of not just teachers, but also of households of students with which they work. This included a greater understanding of the link between livelihoods and the environment, greater sense of self-efficacy in terms of being able to affect the environment, and greater value of the UNITE program for UNITE households versus control households. However, we did not find a strong correlation between these attitudes and our measures of behavior, in particular the number of sustainable activities (farming and non-farming) conducted by a given household. This further demonstrates that attitude may not be a good indicator of behavior (Maynard et al., 2021; Nilsson et al., 2020). Future research focused solely on attitude should be interpreted with caution as it may have little bearing on desired conservation outcomes.

4.1 Limitations

Although home visits used in this study allowed surveyors to verify behaviors at times, for some behaviors, such as sustainable farming practices, it was difficult to verify and in general we were often limited to self-reported behaviors. Because surveys were also conducted by UNITE staff, where teachers or student families’ households know the staff, there is potential for bias toward positive reporting. In general, we did not feel this was the case given the large sample size and that households surveyed generally did not receive direct support or benefit from program staff but rather from teachers or other community members.

While this study demonstrates significant behavior change, the effect of such change on the environment, particularly on habitat loss and degradation, are not directly measured. Measuring these direct effects would be ideal but even if a lack of changes in tree cover or other environmental measures could be quantified it would be challenging to demonstrate an exact link between these changes and the program, especially in biodiversity hotspots such as KNP where multiple conservation organizations work.

5 CONCLUSIONS

Finding solutions to conservation threats that benefit local communities should help to lessen important environmental problems like habitat degradation. This study demonstrates the value of teacher-centered programs to change behavior, specifically use of sustainable activities, not only amongst teachers but amongst students and their families as well. In addition, our studies suggest that teachers may be early adopters of sustainable activities, making them strong influencers for the wider community. As a result, teacher-centered programs should be highly scalable as they are able to be implemented with a relatively small number of individuals, but can also affect a large portion of the community. We demonstrated that teacher-centered sustainable livelihood programs can have a positive effect on attitude toward the value of the environment, self-efficacy in reducing environmental damage, and value of the program, which may be lacking from alternative livelihood initiatives that rely on indirect connections between program benefits and the environment (Maynard et al., 2021). Despite this, attitude was not a good indicator of sustainable activities. Wealth did play a role in the ability of a household to implement some sustainable practices and this finding emphasizes the importance of considering socioeconomic factors when conducting evaluations for sustainable livelihood programs. This study demonstrates the ability of teacher training programs to influence sustainable behaviors, even while controlling for socioeconomic factors, suggesting that other programs should consider this approach to community-based conservation.

ACKNOWLEDGMENTS

We appreciate the hard work and dedication of Bruce Ainebyona, Nyawanga Samwel, and Turyagenda Henry during field data collection. We thank the head teachers, teachers, and parents of the 12 UNITE schools and four control schools for support and permission to access the registries and homes during field work.

CONFLICT OF INTEREST

While authors Corinne J. Kendall, John Tinka, and Elizabeth Folta are directly involved with management of UNITE, there are no financial conflicts of interest related to this study.

AUTHOR CONTRIBUTIONS

Corinne J. Kendall, Elizabeth Folta, John Tinka, and Kristen E. Lukas conceived of the study. Corinne J. Kendall, Elizabeth Folta, Sarah J. Carrier, Aimee Fraulo, and John Tinka designed the study and survey used. John Tinka oversaw all data collection. Corinne J. Kendall, Aimee Fraulo, and Austin Leeds completed the data analysis. All authors contributed to the writing of the final manuscript.

ETHICS STATEMENT

This research followed ethical standards and had IRB approval (#23497) from NCSU, did not directly involve the study of animals, and complied with all Ugandan laws.

DATA ACCESSIBILITY STATEMENT

Because data involved human subjects covered through an IRB, information will not be shared through data repository but certain elements could be requested by reaching out to the corresponding author.
REFERENCES

Angelsen, A., Jagger, P., Babigumira, R., Belcher, B., Hogarth, N. J., Bauch, S., Börner, J., Smith-Hall, C., & Wunder, S. (2014). Environmental income and rural livelihoods: A global-comparative analysis. *World Development, 64*, S12–S28.

Berkes, F. (2007). Community-based conservation in a globalized world. *Proceedings of the National Academy of Sciences, 104*, 15188–15193.

Chapman, C. A., Struhsaker, T. T., Skorupa, J. P., Snaith, T. V., & Rothman, J. M. (2010). Understanding long-term primate community dynamics: Implications of forest change. *Ecological Applications, 20*, 179–191.

Chen, G., Gully, S. M., & Eden, D. (2001). Validation of a new general self-efficacy scale. *Organizational Research Methods, 4*, 62–83.

Davies, T. E., Fazey, I. R. A., Cresswell, W., & Pettorelli, N. (2014). Missing the trees for the wood: Why we are failing to see success in pro-poor conservation. *Animal Conservation, 17*, 303–312.

Hill, C. M. (2002). Primate conservation and local communities—Ethical issues and debates. *American Anthropologist, 104*, 1184–1194.

IUCN. (2012). *Resolutions and recommendations: World conservation congress*. IUCN.

Jacob, B. A., & Lefgren, L. (2004). The impact of teacher training on student achievement - quasi-experimental evidence from school reform efforts in Chicago. *Journal of Human Resources, 39*, 50–79.

Kaiser, F. G., & Fuhrer, U. (2003). Ecological Behavior’s dependency on different forms of knowledge. *Applied Psychology, 52*, 598–613.

Kendall, C. J., Leeds, A., Tinka, J., Lukas, K. E., & Folta, E. (2021). Teacher training as a means to sustained and multiplicative behavior change: An example using fuel-efficient stoves. *American Journal of Primatology, 83*, e23193.

Kuhar, C., Bettinger, T., Leinhardt, K., Cox, D., & Cress, D. (2010). Discovering the unexpected: Lessons learned from evaluating conservation education programs in Africa. *American Journal of Primatology, 72*, 445–449.

Kümpel, N. F., Milner-Gulland, E. J., Cowlishaw, G., & Rowcliffe, J. M. (2010). Incentives for hunting: The role of Bushmeat in the household economy in rural Equatorial Guinea. *Human Ecology, 38*, 251–264.

Lukas, K. E., Leeds, A., Slavin, M. A., Tinka, J., & Kendall, C. J. (2017). Impact of teacher training in conservation education on student learning in primary schools adjacent to Kibale National Park, Uganda. *Oryx, 53*, 497–504.

Mackenzie, C. A., Chapman, C. A., & Sengupta, R. (2011). Spatial patterns of illegal resource extraction in Kibale National Park, Uganda. *Environmental Conservation, 39*, 38–50.

Maynard, L., Savage, A., Vega, J., DeWan, A., Díaz, L., Gezon, Z., & Guillen, R. (2021). Can creating sustainable livelihoods with communities impact cotton-top tamarin (Saguinus oedipus) conservation in Colombia? *Conservation Science and Practice, 3*(8), e476.

Moss, A., Jensen, E., & Gusset, M. (2017). Probing the link between biodiversity-related knowledge and self-reported conservation behavior in a global survey of zoo visitors. *Conservation Letters, 10*, 33–40.

Nilsson, D., Fielding, K., & Dean, A. J. (2020). Achieving conservation impact by shifting focus from human attitudes to behaviors. *Conservation Biology, 34*, 93–102.

Onderdonk, D. A., & Chapman, C. A. (2000). Coping with forest fragmentation: The primates of Kibale National Park, Uganda. *International Journal of Primatology, 21*, 587–611.

Ormsby, A., Naiman, T., & Berkovits, A. (2002). Evaluating a teacher training environmental education program in Papua New Guinea. *Applied Environmental Education & Communication, 1*, 91–99.

Plumptre, A. J., Williamson, E. A., Rose, R., Nangendo, G., Didier, K., Hart, J., & Mulindahabi, F. (2010). Eastern chimpanzees (pan troglodytes Schweinfurthii): Status survey and conservation action plan, 2010–2020. IUCN.

Redford, K. H., Levy, M. A., Sanderson, E. W., & de Sherbinin, A. (2008). What is the role for conservation organizations in poverty alleviation in the world’s wild places? *Orx, 42*, 516–528.

Smith, D. R., Gordon, A., Meadows, K., & Zwick, K. (2001). Livelihood diversification in Uganda: Patterns and determinants of change across two rural districts. *Food Policy, 26*, 421–435.

RStudio Team. 2020. *RStudio: Integrated development for R*. Boston, MA: PBC.

Thornton, S., Setiana, E., Yoyo, K., Harrison, M., Page, S., & Upton, C. (2020). Towards biocultural approaches to peatland conservation: The case for fish and livelihoods in Indonesia. *Environmental Science & Policy, 114*, 341–351.

Western, D., & Wright, R. M. (1994). *Natural connections: Perspectives in community-based conservation*. Island Press.

Wright, J. H., Hill, N. A. O., Roe, D., Rowcliffe, J. M., Kümpel, N. F., Day, M., Booker, F., & Milner-Gulland, E. J. (2016). Reframing the concept of alternative livelihoods. *Conservation Biology, 30*, 7–13.

Zeldin, S., Christens, B. D., & Powers, J. L. (2013). The psychology and practice of youth-adult partnership: Bridging generations for youth development and community change. *American Journal of Community Psychology, 51*, 385–397.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Kendall, C. J., Carrier, S. J., Folta, E., Tinka, J., Fraulo, A., Leeds, A., & Lukas, K. E. (2022). Can teacher-centered community-based conservation programs influence student household sustainable behaviors near a biodiversity hotspot? *Conservation Science and Practice, 4*(4), e12648. [https://doi.org/10.1111/csp.12648]