Community-oriented engineering co-design: case studies from the Peruvian Highlands

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The goal of an engineer’s career is solving real problems for social and ecological betterment. At the University of Engineering and Technology (UTEC) in Lima, Peru, this vision is promoted from the earliest stages of a student’s engineering career to enable them to embrace their creativity while developing meaningful solutions for ecosystems in need. In this article, an educational methodology is presented that uses a project-based collaborative learning approach with the aim of evaluating, selecting and developing community-oriented engineering solutions in the Base of the Pyramid (BoP). Communication strategies and evaluation of projects based on co-design methods implemented among engineering students and isolated rural communities in the highlands of Peru are discussed. In conclusion, the process to select a community is analyzed and the most important criteria are determined. In addition, we highlight the importance of defining elements to understand the context (community and place) and to establish future objectives (group and projects) during the exploration period that will help facilitate the decision to select a community.

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Introduction

Despite advances in fields such as human science, engineering and technology, many people do not see material enhancements of their lived experiences or even to access basic needs. Poverty remains one of the long-lasting “wicked” problems of society. Today, more than 4.5 billion people do not have access to products and services necessary to meet basic needs, such as clean energy, water, healthy food or a home suited to weather conditions, among others (OMS, 2017). This portion of the population has been denominated by economists as the ‘Base of the Pyramid’ (BoP), for being the largest sector of the economic pyramid. Although the term reduces the narrative around poverty and the concept of markets, it is useful to quantify and illustrate the large number of opportunities present in BoP environments, some of which exist beyond markets themselves. The design, construction and use of practical solutions through engineering, in concert with local knowledge and expertise, can help to address problems faced locally within BoP communities.

From an economic standpoint, BoP markets, a segment that encompasses the world’s poorest communities in Africa, Asia, Latin America, and the Caribbean, are forecasted to grow to six billion in around 20 years’ time (Prahalad & Hart, 2002). There are numerous factors that can draw back this window of opportunity. It is crucial to establish which factors can enable communities to take advantage of this promising projection or reject participation in exchange for development at a local level. Enacting either of these options must go hand in hand with the integration of appropriate knowledge at the local level, allowing for more comprehensive visions of development.

Nowadays, universities guide their teaching methodology towards the creation of new technologies or the design of products, which they later seek to place in a specific market segment. Most of the time, though, these innovations are not made to take into account or directly include BoP populations. Fortunately, recent shifts within STEM education are changing this notion. Universities are including courses in sustainability and social responsibility to ensure that students understand that an engineer needs to serve the community in a socially responsible and sustainable way (de Vere et al., 2009). At our university, we challenge students to develop interdisciplinary projects as part of an active learning methodology to increase the engineer’s technical and soft skills (Vega & Ortiz, 2018; Murray et al., 2016; Vega et al., 2018). In addition, many people and designers are invoking innovation as the foundation of their projects. In a recent CEO Global Study (Cooper, 2016), 53% of the respondents agreed that R&D and innovation technologies were generating the greatest return in terms of successful stakeholder engagement. This rate gives us an idea of the value of the innovation factor. It becomes apparent that the way to innovate is not the same for each market segment. Many environments where BoP populations live are not suitable for the development of products that require expensive materials or equipment. One of the main differences between innovation at the BoP and at other levels of the economic pyramid is that innovation at the BoP is not about creating new product features, but about adapting existing products, highlighting or remixing local products in accordance to different cultural backgrounds (Anderson & Markides, 2007). In summary, the notion of innovation also needs to be expanded.

Other authors mention how enterprises can be beneficial in order to build fraternal relationships between communities and institutions, capable of providing added value to their production chain and potentially improving the quality of life of the people. Projects aiming to succeed in economically constrained areas need wide community participation, among other things, and should be led by engineering teams through co-design methods (Reynolds-Cuellar & Delgado Ramos, 2020). Following these guidelines has the potential to increase effectiveness in terms of addressing the need or opportunity being approached (Castillo et al., 2012). For this to happen, it is important to identify answers to questions such as: who is the target population? Are the necessary conditions present for collaboration across all parties? Which products/services will be co-designed and offered? How can such products/services be made as cost-efficient as possible? How can we make the process as inclusive as possible?

In this context, collaboration with BoP communities can lead to the development of products and services that are both effective and respectful of local dynamics; when there are no attempts at collaboration the exercise can prove futile. Even this comprehensive approach to products and service development is not enough to completely avoid risk. Therefore, it is important to emphasize that all stakeholders should be involved at every stage of development, from need/opportunity assessment all the way to the deployment of outcomes. Such designs should focus not only on technological application but should also take into account a variety of cultural, ecological, and societal nuances (Manzini & Vezzoli, 2005). These steps are necessary so that new engineers can provide feasible pathways for long term impacts (Anderson & Markides, 2007). Therefore, it is important to understand the current situations of BoP communities in order to identify variables that will allow a diagnosis of their current context and the main needs that each community may have. Fortunately, the co-design process allows all parties to be involved and, in this way, helps to ensure and adjust the needs to build a better project and/or service.

In this paper, we propose a framework for the development of projects in collaboration with members of BoP populations. We illustrate it using a case study in Peru, introducing a model that takes into account a set of factors to identify, select and execute co-design projects. It sets a concrete foundation of contemporary themes and challenges for future research in BoP communities. The goal of these co-design projects is two-fold: (1) to expose engineering students at a Peruvian university to the practice of community-based projects, and (2) to use these projects as a concrete avenue for students to effect positive change in historically marginalized populations. Achieving these goals will provide engineers with methodological tools to engage in grassroots, low-cost cultures of innovation, while producing a net-positive outcome in society. This is fundamental in order for the engineers of the future to see themselves as agents of change in their own communities.

Case studies: Peruvian Highlands

For this research, we gathered information from three communities around the city of Tarma, which is part of the department and region of Junin: (1) Sayancancha, (2) Acshuchaca, and (3) Rayampampa (Fig. 1). Tarma is located 232 kilometers northwest of Lima, in the Andes Mountain range. Its most important economic activities pertain to the service sector (commerce, tourism) and the public sector (public administration, health, and education). Trade depends on local agricultural products.

Most of the families in the communities live in “adobe” (mud bricks) houses, with a few exceptions of constructions involving noble (concrete) materials. The roofs are made of zinc corrugated roofing sheets. The windows are made of glass or plastic sheets, and the doors are made of wood. As these houses were built without any technical supervision, there are holes in the walls, doors, windows and ceilings (Fig. 2). Each house has a kitchen made from stones and clay, which has three burners: one at the front and two at the back, with an entrance for firewood and another for cleaning the ashes. The kitchen is used to cook a
diet rich in carbohydrates, with a notable absence of protein. Likewise, the stove is also used to dry clothes and firewood and serves to heat the indoor environment and help with raising guinea pigs. It is common for families to eat produce that they grew themselves, such as potatoes (the main agricultural product in the area).

The communities are organized by community leaders, who are elected every 2 years and have monthly general meetings to discuss various issues associated with the community. Among the main issues on the agenda are often land disposal and the maintenance of access roads. In the culture of Andean communities, these leaders have an important role since they are the ones who decide on the activities to be carried out. The evaluated communities are the following:

- **Sanyacancha** (−11.4712, −75.7753) is located 1 h and 30 min by truck from Tarma. The community has 30 families and averages ~150 people: 80 women and men, 16 children in primary school and eight children in secondary school. The rest leave the region to study, and few return to the town. There is a primary school and a medical post that is open once a week.

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**Fig. 1** Map of Peru and the selected communities near Tarma, Department of Junín. This figure shows the map of Peru and the location/proximity of the three communities in Tarma, in the central highlands.

**Fig. 2** Community housing with different types of roofs (zinc corrugated roofing sheets and “Ichu” peruvian natural fiber) and indoor cooking stove. This figure shows the current conditions of the communities, as the houses were built without any technical supervision, there are holes in the walls, doors, windows and roofs.
Achuchara (−11.153, −75.5815) is located 3 h and 30 min from Tarma. The community is small and has an average of eight to nine families and it is described as the following: 12–15 community members, five children, nine women and 20 men. There is a very large migration effect since many men do not want to work harvesting potatoes and go to Lima when they are 25–30 years old. There are hamlets, also called annexes, that have to hire labor from Huancavelica for the harvest season.

Rayampampa (−11.2188, −75.5441) has up to 40 families (68 adults out of 110 inhabitants approximately) scattered over 22,000 hectares. This community is located 1 h and 30 min by truck from Tarma. The access route is a paved zigzag trail, where landslides occasionally occur during the summer season, due to heavy rains. Rayampampa has three buildings for education: one of prefabricated material and two of concrete material. Currently, only two are in operation, the oldest being dedicated to alternating secondary education. The second of the two operating buildings was opened in 2015 for pre-school and primary education.

Regarding the climate, the average temperature in Tarma (−11.418611 −75.690833), is 20 °C during the day and 5 °C at night, with intense rains and preponderant fog. The lowest temperatures occur between the months of May and June, when there is also a humidity level of ~85%.

Framework: Engineering for Social Change
In the following sections, we introduce our framework for establishing collaborations with BoP communities. We start by describing the criteria involved in the framework (Smith & Leith, 2015) and provide examples connected to the case studies described in the previous section. The criteria for selecting a community are crucial to the projects’ success. More often than not, developing criteria for establishing successful collaborations is replaced with technology transfer processes that look for under-resourced populations to provide with technologies that cannot feasibly be sustained over time. The complexity of developing criteria for successful collaborations comes from the fact that simple actions or decisions can deeply affect the success of a project. Therefore, it is important to account for as many factors as possible in connection to the decision-making, deployment and sustainment of projects. Regarding ethical approval, the Declaration of Helsinki was not relevant because we have not made an ethics diagnosis of the human being from the community, only living observation to improve community members’ quality of life (Fig. 3).

For example, working with an NGO can provide relatively easy access to communities as well as connections to ongoing projects. It can also allow access to funding through larger organizations. However, given that NGOs often have very specific goals, this interaction could lead to a reduction in the number of pathways a project could take, leaving out potentially impactful and interesting projects stemming directly from communities. When working with NGOs, it is crucial to maintain balance and leave space for local visions of the future to develop. Ultimately, creating solutions for the BoP requires a systemic approach based on a variety of community-based work strategies that introduce not only new technologies but also new meanings to end-users (Castillo et al., 2012).

Here, we present a set of basic criteria and factors for community-based needs assessment prior to project selection. These factors were used as part of the aforementioned case studies and later improved following lessons learned gained throughout the process. It is important to highlight that the goals of each project may affect the importance of each criterion. We illustrate this with examples below.

Community selection criteria. Relationship building with communities began almost 6 months before the international team traveled to the selected territory. The project head contacted community leaders and NGOs, and travel arrangements were made to visit a group of communities. The goal was to seek consensus from multiple independent evaluators (three local/national and one international) with regards to which community group to select. The relationship building period was done during a week in which two communities were visited each day. At the end of this period, evaluators reduced the list to three finalists and a final choice was made.

Proper community engagement involves an analysis of the conditions, advantages, disadvantages and limitations of any potential collaboration. This allows all parties to establish and define clear objectives for the proposed project as well as to develop contingency plans to mitigate the effects of unwanted events. This stage is very important, as sustainability is key to success after the first 3 weeks following a project’s launch. Furthermore, it is important to follow up on projects by returning to communities both 6 months and then 1 year after to evaluate impact. In this case, at the time of returning to the communities for the second stage of the project, there had been changes in community leadership that made it difficult to work collaboratively again. The overall project was developed over a period of 18 months (relationship building and project development, plus the six and 12 month follow-up monitoring) for the first stage of

![Fig. 3 Rayampampa community involvement through different talks and educational workshops in order to collect and transform insights to key projects. This figure shows the participation and involvement of the team with the community, children and adults, and how we support different talks and workshops for the development of the projects.](https://example.com/fig3.jpg)
sustainability. The second stage was planned to focus on product development and corporate social responsibility.

It has been stated that a community is a dynamic social group that has its own history and is culturally constituted and developed (Glisson et al., 2012). In what follows, we introduce a proposed framework of categories looking at key aspects of community collaborations. Information about the following criteria was collected through a variety of methods including interviews, brainstorming sessions and community meetings. We used the User Research Framework methods, developed by the MIT D-Lab (Smith & Leith, 2013), as this manual gives great insight into community practices from all over the world. Using this framework, students evaluated community visit scenarios in order to define field activities and possible future projects. We acknowledge that this list is not exhaustive and that each project may have distinct factors to consider. Our goal is to provide a structure that can serve as a scaffold for engineering projects.

**Willingness to participate.** Properly gauging a community’s willingness to collaborate in co-design processes is one of the most important factors when determining the feasibility of projects. Given that this type of collaboration requires a high level of engagement from all parties, and that the first step for successful collaboration is the desire to exchange knowledge, making sure that communities and other stakeholders see the value of the overall process is essential. It is important to understand that not all communities are interested in collaborating. Many already have systems for self-determination, for governance and for development plans that are the result of long-standing local processes. Determining if such dynamics are in place can mean the difference between a project that fails and one that succeeds. For our co-design process, only engaged participants were part of the project, and no informed consent was necessary because this article does not contain any ethics studies with human participants performed by any of the authors, avoiding the risk of including sensitive information of the participants that could damage their reputation.

**Location.** A key factor to consider when exploring community collaboration is to determine a cost/benefit analysis. This is particularly relevant for projects within higher education where resources could be limited. Working in remote areas could require significant investment in the transportation of both people and infrastructure. It is possible that these costs, in addition to other project-related costs, could outweigh the potential benefits of collaboration. For example, working in remote locations might mean limited access to communications, making the possibility of accessing information over the internet or coordinating logistics cumbersome. This can be further exacerbated by the need to ensure a robust emergency plan.

**Local connections.** As mentioned before, integrating members from local communities into the team is a fundamental step in the co-design process, not only in terms of the development of the project itself, but also in terms of managing the collaboration (Reynolds-Cuéllar, Delgado Ramos, 2020). For example, community members can easily help to make prior arrangements and support logistical activities in preparation for field trips. In Peru, for example, mistrust and a lack of credibility caused by a long-lasting history of crime and violence can make communities wary of engaging with external collaborators. Local connections can help to bridge this trust gap and effectively manage expectations among community members.

**Basic services.** Access to basic services within communities is another important variable to consider, especially throughout the field-based stages of the project. Inadequate infrastructure for key services can put teams at risk. Services such as water supply, proper sanitation facilities, access to electricity, access to food sources and health infrastructure are vital to ensure projects can be implemented as well as to avoid health issues while guaranteeing proper nutrition during field work. This is not to say that communities with no access to basic services should be negatively assessed under our framework. We consider the means to boil water, the presence of latrines and limited local food options as access to basic services. When options such as these are not in place, teams should explore other avenues to remediate these circumstances (e.g., transporting potable water). Health, on the other hand, is a more serious consideration, especially in light of the current state of health infrastructure and assistance in isolated places in Peru. In the case of our communities, we made sure to take this factor into account; each community has a small, basic medical center where a doctor (usually a residency practitioner) visits every 2 or 3 weeks for half a day to treat and diagnose members of the community. Public transportation to and from the community is scarce; only one vehicle (a car or a truck) goes up and down the mountain to the community each day. Because of this, community members who require immediate/specialized medical attention must call someone from the city (Tarma for this specific study) to come to the community and drive them to a clinic. With that said, basic services such as water supply, proper sanitation facilities, access to electricity and access to food sources are not as essential as health infrastructure, although still useful to provide comfort when possible.

**Safety.** Personal safety is a key requirement for successfully developing projects involving field work. For this reason, during the exploratory phase, it is necessary to identify both internal and external risks. We propose two main aspects of safety to be taken into account.

- **Socio-political internal/external conflicts:** referring to threats from internal dynamics beyond the community’s control, including religious differences hindering communication or political conflicts revolving around territorial, economic or social power. Information regarding local safety can be provided by local authorities. Some of these conflicts, and the risk they pose to work in the field, can be assessed by safety departments within universities through access to global information systems. A good practice is to triangulate information from different sources in order to avoid misinformation.

- **Natural disasters:** remote areas are often susceptible to natural disasters due to weather conditions. While the probability of major natural disasters is low, some areas can experience repeated weather phenomena during particular seasons of the year. Therefore, the timing of projects should take this into account.

**Potential for impact.** Another criterion that should be taken into account has to do with the expected impact of the project. This can be approached in terms of the educational impact for students, community members and other important stakeholders within the project. Some factors to guide this analysis include the potential for livelihood improvement, the ecological advantages, the number of communities that the results of the project can reach and the contribution to the communities’ wellbeing. Whichever dimensions are chosen for analysis, it is important to clearly establish what the project sets out to do, quantify these expectations and transform them into measurable objectives. This point can prove useful when determining the expected outcome of a given project.

**Community partner analysis model.** What follows is the proposal for a weighted matrix to analyze the aforementioned factors
in reference to potential partner communities. Once relevant aspects for a given project are considered and factored into the decision-making process, we propose the use of a scoring model (Table 1). This model allows different actors to explore the feasibility of each community partnership based on these weighted factors. It should be noted that these scores are subjective and may vary depending on research and field work done prior to the project. It is also important to mention that the sum of the ratings should be equal to 100%. The model is highly customizable in that it allows key factors to be evaluated and weighted in function of the risk or importance of the project and its location. In our case, the community’s willingness to contribute to the project and the active participation of a community liaison were crucial in planning projects; therefore, we assigned a 25% weight to the combination of those two factors and gave the project’s potential for impact a weight of 10%. Then, we determined that basic services, location and safety of the team would receive a weight of 15% each given they were key factors. Completing the model, local connections had a weight of 20% to make sure that the project was up and running on time.

A 1 to 4 weighted scale (where 1 is poor and 4 the optimum) was proposed to subjectively evaluate how each factor behaves across different communities (Table 2). The weighted score of each item may be relative and can be improved with details and additional weight; however, it was considered a scale for each score factor from 1 to 4. A score of 1 represents a range from 0 to 25%, 2 from 26 to 50%, 3 from 51 to 75% and 4 above 75%. The weight ranges can also be moved up and down within a 10% margin. In addition to the weights for each item, it was decided (according to the scouting made 6 months beforehand) to add a description of each item that allows for two objectives: first, to evaluate each community under the same parameters/conditions and second, to quantify and standardize a ranking between 1–4, where 1 is the lowest and 4 is the highest score. At the end of an evaluation, most evaluators will have a similar perception of the basis score weight.

Using the model. Table 3 shows the evaluation of the proposed scoring factors for the three partnering communities. This evaluation was done during the scouting and evaluation process. It is important to mention that, prior to this part of the process, other communities were considered. However, since two of the key criteria for this collaboration were that transport to the location would not exceed 4 h (some of these communities are located less than 4 h from Tarma, but transportation time could potentially be increased due to difficult road access) and that no strong internal conflicts were present, these communities were not included in the evaluation stage of the collaboration.

Using this tool, we were able to highlight the potential for collaboration with the Rayampampa communities in regards to this particular project. Having collected all of our information through the usage of methods such as interviews, community gatherings and collective ideation allowed us to build strong relationships with community members in order to explore a variety of projects. For example, it allowed us to play an active part in leadership processes surrounding the communities’ current issues. In the following sections, we expand on our decision-making process based on the results of the weighted matrix. The next section presents the qualitative analysis of each of the factors, referring to the advantages and disadvantages of partnering with each community. In this way, it seeks to show

| Table 1 Ranking factors table. | Community “A” | Community “B” |
| --- | --- | --- |
| Factors | Weight | Score | Weighted score | Score | Weighted score |
| Willingness to participate | 25% | 3 | 0.75 | 4 | 1 |
| Basic Services | 15% | 3 | 0.45 | 3 | 0.45 |
| Location | 15% | 3 | 0.45 | 3 | 0.45 |
| Local connections | 20% | 4 | 0.8 | 3 | 0.6 |
| Safety | 15% | 3 | 0.45 | 3 | 0.45 |
| Potential for impact | 10% | 3 | 0.3 | 3 | 0.3 |
| Final Score | 100% | 14 | 14 | 13 |

| Table 2 Proposed key factors and component weights. | Score | Willingness to participate |
| --- | --- | --- |
| 1 | Nobody from the community wants to collaborate |
| 2 | There is a small percentage of people willing to contribute to the project |
| 3 | Approximately 50% of people willing to contribute to the project |
| 4 | The majority of the community supports the project |
| Score | Basic services |
| 1 | The community has no basic services |
| 2 | The community has a small number of basic services |
| 3 | The community has all of the basic services except for health centers |
| 4 | The community has available toilets, electricity, food, safe water and health centers |
| Score | Location |
| 1 | Access roads are dangerous with high rates of accidents |
| 2 | Access roads are difficult, and transportation is limited |
| 3 | Access is somewhat complicated but safe |
| 4 | The place has safe and easily accessible roads/infrastructure |
| Score | Local connections |
| 1 | There are no community contacts/liaisons to establish dialog with the community |
| 2 | The community requires more than one contact person as part of the collaboration |
| 3 | The contact person has direct communication and influence within the community |
| 4 | The contact person is a community member |
| Score | Safety |
| 1 | Community experiences serious internal political and social issues; community members are not open to collaboration |
| 2 | Community experiences serious internal conflicts; community members are open to collaboration |
| 3 | Community with manageable conflicts and with people who share the group’s thinking |
| 4 | Community without any conflict and with people who share the group’s thinking |
| Score | Potential for impact |
| 1 | The beneficiary population is just one family |
| 2 | The beneficiary population is a small group of people from different families |
| 3 | The beneficiary population is the entire community |
| 4 | The beneficiary population is greater than a single community |
how the decision was made to select one community and not the others.

Willingness to participate. First, we took into consideration the amount of effort and engagement a community could provide to the project. This was determined based on a variety of factors internal to the community related to governance, availability of time and trust, among others. We adhered to the communities' processes as we regarded this part of the process as fundamental to the success of the proposed project. From the beginning of the work (scouting), Rayampampa and Acshuchacra community members showed great openness and initiative towards partnering. On the other hand, the director of the Sayancancha school did not show the same interest due to previous problems with NGOs. This history created mistrust, which made it difficult to continue collaborating with this community.

We also considered the number of families in each community and the availability of natural resources in the surrounding areas. These two factors were key as the initiative sought to reach a large group of families and emphasize the importance of working with surrounding ecosystems. Taking this into consideration, Rayampampa (about 20 families) turned out to be a larger community than Acshuchacra and had the availability of natural resources necessary to carry out the project. Acshuchacra, on the other hand, is a very small and isolated community with a maximum of 10 families and did not have the necessary support to develop the project. Rayampampa, in addition to having many community members willing to participate in the project, also had local officials willing to collaborate with us. These two factors made the difference for our decision, as they signaled strong community commitment.

The desire to participate, collectively design and coordinate a program is key when selecting a community. It legitimizes local knowledge and the right of the community to self-determination while allowing external teams to provide support and partnership to explore solutions together. This virtuous cycle also allows for external teams to stay engaged, eager to learn and producing research work (Charca et al., 2015; Mori et al., 2019).

Basic services. The second relevant factor was access to basic services, such as drinking water, food, electricity and a sewer system. Rayampampa, unlike the other communities, met the necessary requirements because it has access to both basic services and to stores for basic resources including food. However, we recognize and want to acknowledge the importance of not centering on this criterion. Doing so runs the risk of expanding already existing gaps and leaving out partnerships with communities that do not have this infrastructure. Sayancancha and Acshuchacra do not have all the necessary basic services, requiring travel to the nearest city of Tarma for food and other goods, which would have made our stay for this specific initiative difficult.

Rural communities, particularly in the Global South, are among the most impacted groups with regards to access to basic services. Therefore, these services should not necessarily be a requirement for the success of a project. Instead, the improvement of such services can be made a part of the development and growth of a project. This creates a shared responsibility that invites and elicits participation from the entire community (Meirinawati & Pradana, 2018).

Location. As the initiative required participation from different teams and the projects required moving tools in order to manufacture on-site, reliable transportation infrastructure was important. In this regard, the best community was Sayancancha based on travel distances and the condition of the roads between there and Tarma. Rayampampa, on the other hand, is located 3 h from Tarma, while Acshuchacra turned out to be the farthest community (5 h by truck and an additional hour of walking from the city). Since Acshuchacra was the most remote, transportation would be both impractical and potentially dangerous given the lack of infrastructure. This is not to say that these factors would make it unlikely for any project to take place and maybe other groups could still conduct projects with them in the future. On the contrary, when analyzing the potential for impact of the project for both Rayampampa and Acshuchacra, it became clear to us that Acshuchacra was a much better fit given their access, albeit limited to basic services. However, the logistical hurdles related to the equipment and personnel required for this project made it infeasible to consider Acshuchacra as a partner.

The community that had the best infrastructure turned out to be Rayampampa, since it had a new educational building (a primary and secondary school with showers) that had been built by the local state and that would make our stay easier. The other two communities did not have adequate infrastructure and had more rudimentary buildings.

Local connections. Engagement and local connections for the three communities were rather similar. On the one hand, Rayampampa, Acshuchacra and Sayancancha are all within the same geographical area, so there were no significant cultural differences. On the other hand, the contact person who had access to each community turned out to be the same contact in the city of Tarma. Since the three communities were close to Tarma, maintaining this connection was key in order to facilitate community visits, secure resources and build trust with community members. It is very difficult to generate trust and efficiency if you do not have a local contact.

Security. As mentioned earlier, safety was one of the most important factors when evaluating partnerships with these three communities. The main points in this regard were the absence of internal conflict and access to basic safety resources such as a medical post.

In Rayampampa, no internal conflicts were found within the community or at a regional level, and team members could live.
together in the community, allowing them to take part in community activities such as visiting families in their homes in the morning to participate in breakfast and then working with community members in the field during the day. In Sayancancha, as previously mentioned, there was mistrust based on previous engagements with NGOs in the area. Additionally, accommodation arrangements there would have required complicated layouts, which would have made it difficult for teams to have access to working spaces. In regards to Acshuchacra it lacked a nearby medical post, which would have created a risk in the case that any member of the team needed immediate medical attention. The medical post was 3 h away and, due to the rainy season, difficult to access.

Potential for impact. Finally, the potential for impact in each community was evaluated. As mentioned before, having the opportunity to reach a group of at least 20 families was one of the goals of the project. The Rayampampa community had also expressed interest in disseminating learnings from the program to the other potential partners. From the nearly 20 families who received training, a good portion are on their way to share learnings with the Acshuchacra community.

By using this model, and through visits and evaluation, we were able to determine that the Rayampampa community was the best fit for the project. Before wrapping up on site, a plan was co-developed with the community in order to return within the next 6 months after the first stage for follow-up purposes and to ensure the sustainability of the project. The main objective of this model is to provide a tool to assess and evaluate the main conditions of a community with regards to partnering within the context of educational projects. The factors included are tailored to a particular context. These factors, including the priority assigned to each variable, can be changed, especially when different locations are defined.

Limitations and direction for future research
Peru does not have a wide culture for Research & Development (R&D). According to De los Ríos et al. (2010), for many years companies have pointed to higher education as the root of this gap. Insufficient preparation for research and creation, excessive theoretical instruction with a reduced practical component, knowledge that is too general without sufficient specialization and updated knowledge and meager preparation for directing teams are among the main deficiencies within university education in Peru. One of the great challenges facing the university system is to demonstrate the capacity for adaptation to the changes and new demands of today’s society, in which the concept of professional life focuses on what are called professional competencies (De Los Ríos et al., 2010).

Another important aspect of the proper execution of projects at the Base of the Pyramid is the selection of the team. The members must be responsible for achieving the initially set objectives, which must be clear, measurable and achievable. Teamwork is a crucial variable for project execution and performance in the real world, and the challenge is to define the variables necessary to create a fit and a holistic approach for team members. There must be a selection process oriented to the research objectives that helps to define the functions to be performed by each member, including the role of the students and the technical skills necessary for the job.

Furthermore, one limitation to developing these projects is the process of carrying out field work, following up and generally building solid relationships with the community. This process takes time, and not all design teams have the opportunity to see it through. To truly connect with people and their problems and generate proposals for community intervention, a strategy involving grassroots work is required. This is achieved through field work, the use of common language, the use of the codes and symbols of a community and a domain of the values circulating on the social network. Therefore, it is also necessary to study the community in order to establish a stable and mature relationship that guarantees the success of the project over time and that allows for the development of projects with few to no complications.

Most companies do have a social responsibility department to generate capacity building for the community. However, companies have to recognize that they have a way to go in terms of creating the capacity to offer opportunities to young engineers or other professionals with a social/community-oriented profile. Additionally, the profile of the student in general should focus on key values such as commitment, motivation and proactiveness. Going forward, companies and universities need to define a marketing strategy and look for project opportunities with a social context. Until the professional sector develops this dimension, even when students are taught social sensitivity, the market will ultimately force them to place themselves in traditional engineering jobs.

Conclusion
In this work, we have presented the criteria for the selection of a community to develop Base of the Pyramid projects. When not working with an NGO, the process of deciding on the criteria to select a community is key to having a successful project. Meanwhile, defining key elements to understand the context (community and place) and establishing future key objectives (group and projects) during the scouting period will help facilitate the decision of selecting a community. None of the defined factors are eliminating factors, unless they put teams in dangerous environments. During this process, we presented a real case of community selection in the highlands of Peru.

It is important to mention that the factors for selection will correspond to a specific context, in this case Rayampampa. Therefore, the factors must be identified, analyzed and evaluated so that they fit, as best as possible, the reality and context of the chosen community. In this way, potential risks are reduced and better controlled. One of the keys to ensuring that the project is a success is precisely to understand the context and basic needs of the community. The factors presented can be taken as a guide; however, a strong relationship must be established with the community in order to ensure the effective execution of the project.

As mentioned before, we consider it of great importance to approach these projects with a sense of a social responsibility. This is to say that, during the process of setting up, developing, operating and continuing these projects, we infused them with a vision of commitment to society through the construction of new knowledge in collaboration with community partners. This process can additionally be extrapolated to solve other problems or take advantage of other opportunities. By approaching projects through this lense, we can improve both the professional and personal experiences of teams and communities while improving the quality of life in communities in a sustainable way.

To conclude, when considering the "potential for impact" factor, one needs to be open-minded in terms of changing variables at any time throughout the duration of the project. Much positive change will come from the experience gained through the challenges and interaction with the community as both "worlds" are connected to improve the lives of their respective members and learn from each other.

Data availability
All data generated or analyzed during this study are included in this published article.
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