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"Energize my business": towards a social appropriation of solar technology

"Energízame el negocio": hacia una apropiación social de la tecnología solar

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Abstract

This article proposes a strategy for social appropriation of solar technology through a workshop called "Energize my business" which was based on educational design research. The workshop was based on the assumption that appropriation implies both obtaining solar technology equipment and training in energy literacy. The goal was to enable the beneficiaries to self-identify their energy demand and solar solutions as a way to empower their businesses. The sample was a group of three women between 48 and 53 years of age with businesses: tamalería, fonda and handicrafts in soaps and candles. The workshop followed 4MAT's instructional design.

Keyword: social appropriation, energy education, educational design research, solar technology, community work.

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Resumen

Este artículo propone una estrategia de apropiación social de tecnología solar por medio del taller llamado "Energízame el negocio" el cual se basó en una investigación de diseño educativo. El taller se cimentó en el supuesto de que la apropiación implica tanto la obtención del equipo de tecnología solar como el de una formación en literacidad energética. El objetivo fue que las personas beneficiarias pudieran, por ellas mismas, identificar su demanda energética y sus soluciones solares como una manera de empoderar sus negocios. La muestra fue un grupo de tres mujeres entre 48 y 53 años de edad con negocios de: tamalería, fonda y artesanías en jabones y velas. El taller siguió el diseño instruccional de 4MAT.

Palabras Clave: apropiación social, educación energética, investigación de diseño educativo, tecnología solar, trabajo en comunidad.

Introduction

"Energize my business" was one of the products generated by project 70 of the Mexican Center for Innovation in Solar Energy (CEMIE-Sol), entitled "Validation of a strategy for empowerment through solar energy use". The objective of the project was to empower women who live and have their own business in peri-urban areas through solar energy. The study community was the Rubén Jaramillo neighborhood in the municipality of Temixco in the state of Morelos, Mexico. The selection was due to the characteristics of peri-urbanity in the social impact area of the Instituto de Energías Renovables, the leading entity of the project, located in that colony. The project was developed in a transdisciplinary way with the community; and internally, it was formed by a multidisciplinary team of thirteen people.

There is a problem with projects, such as this one, in which solar technology is installed in peri-urban communities. This is that the donation and installation of technology does not go hand in hand with the way in which the community appropriates it. In the worst case scenario, the equipment lies discarded in a vacant lot as a piece of junk; in the best case scenario, the beneficiaries have sold the "hardware" believing they have benefited more from the money than from the technology; or they have used it for other purposes in their daily lives, for example, using a solar panel as a board to cover or separate areas in a chicken coop. These failures in projects developed in marginal or vulnerable communities are due to the fact that there is no solar energy training program aimed at the beneficiaries to help them appropriate the technology so that they are aware of the advantages they can obtain from it, as reported by Álvarez, Tagle and Romero (2018).

This deficiency is a reflection of the academic or institutional prescriptions to which the community is subjected, in which technology decisions and implementations are made vertically, without considering the end users. Vertical decision making forces people to transition to renewable technologies without training them to be aware of their usefulness and benefits. On the contrary, on the one hand, when there is an appropriation and follow-up, there is a lack of project documentation as in the case of Azamar and Ríos (2020) or the Iluméxico (K. Cedano, personal communication, May 15, 2021) and Concentrarte (K. Cedano, personal communication, June 8, 2021) projects. This implies that having an ownership program there is no information on the implementation mechanism, whether it was successful or not; it also prevents replication and adaptation to other contexts to obtain similar results or improve results. On the other hand, there are few implementations of solar technology to peri-urban or vulnerable areas accompanied by documentation in basic energy training for beneficiaries. An example is the report by Buendía, et al (2018) in which the social adoption of solar eco-technology was demonstrated in a federal elementary school for which an educational program was developed for students. However, this is the exception, mostly the look of the projects is only from Solar Engineering without considering the recipient communities. The lack of a research approach denies future solar ecotechnology implementation programs to start from a fieldwork base.

To fill this gap, Project 70 asked itself the question: what strategy can be used to promote social appropriation of solar technology among the beneficiaries? A workshop program "Energize my business" was designed based on the assumption that training in solar energy can be a factor in the appropriation of the technology. That is, solar technology appropriation involves both obtaining solar technology equipment and energy literacy training. The objective of the workshop was to enable the beneficiaries to self-identify their energy demand and solar solutions as a way to empower their businesses. The accompaniment of the workshop, of the training, prior to the installation was the main ingredient that marked the difference of project 70 with other similar ones (Molina and González, 2020; Tagle and Álvarez, 2019; Calderón, et al, 2018; López, et al, 2018). The workshop attempted to ensure, following the educational design methodology, the appropriation of solar technology in the entrepreneurship of the women of Temixco. This workshop was the first of three that were provided to the beneficiaries along with one on the use and care of solar devices; and another on entrepreneurship.

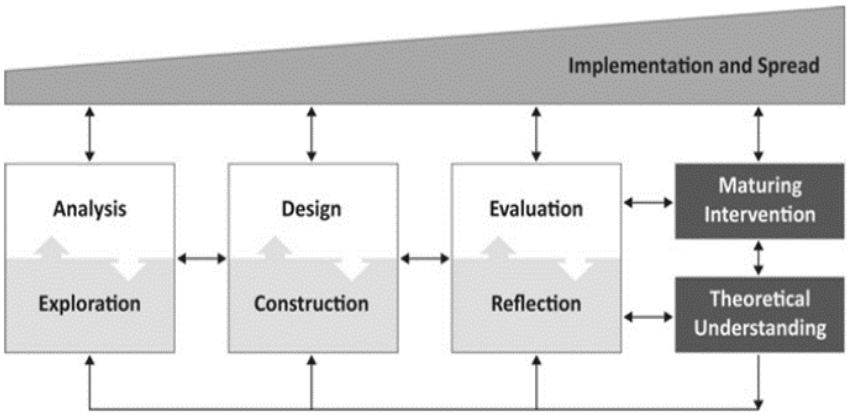
Materials and methods

Since the workshop design was multidisciplinary, a simple approach with a clear and guided application was chosen, therefore Bernice McCarthy's 4MAT (2006)

was selected. The 4MAT model serves as a map to elaborate a teaching-learning sequence structured in eight steps arranged in four quadrants. Step 1 and 2 form the first quadrant in which we seek to connect with the participants' previous experience. Step 3 and 4 form the second quadrant which have in common the formation of the concept, the thematic content. Step 5 and 6 form the third quadrant where the content is practiced and the process of personalization or internalization of the content in daily life begins. Step 7 and 8 integrates the concept or content to applications in daily life and appropriates it to the experience. Quadrant 1 and 4 closes and opens the cycle by what happens in daily life, in the informal context; while quadrant 2 and 3 are the theoretical and practical foundations that are learned in the formal, school context.

The methodology used was Educational Design Based Research (IBD). This methodology tests the design of a program in a real context. In the words of Tjeerd Plump it is, a systematic study of the design, development and evaluation of educational interventions, such as programs, teaching-learning strategies, materials, products and systems (2010, p. 9). IBD is based on the staging of a program in order to refine it as many times as necessary so that it yields the results that satisfy the need for its design. If it is possible to find the principles that satisfy that need then the design is effective, Plump writes that until then a local theory of intervention will have been developed (ibidem) since generality and replicability depend on specific contexts in which the design emerged and is effective. Thomas Reeves and McKenney (2019) propose a generic model composed in three dual phases: analysis and exploration; design and construction; evaluation and reflection which leads to intervention maturation and theoretical understanding preparing the researcher for a new iteration of program design.

Figure 1. Generic model for research based on educational design.



Source: Reeves and McKenney (2019, p. 83).

The researcher's work has two faces, as Reeves points out, he is a detective because he seeks a scientific understanding of the field work; and he is an inventor because he embraces innovation, he seeks creative designs that motivate the active commitment of the participants. Under this double dynamic, phase 1 analysis-exploration has the objective of defining the problem that will solve the construction of a program, which is located in the Introduction section of this document. Exploration refers to the characteristics of the context and the sample, which is found in the Population and Sample section. Phase 2 design-build consists of the requirements and proposition that structure the first design prototype. The prototyping should be reviewed in light of the project goals and incorporation of the program design objectives. Design and construction are interconnected pairs because once the design is built, it transitions between redesign and reconstruction as iterations occur. Phase 3 of evaluation frames the methodological planning, fieldwork or implementation itself in which data collection, analysis and findings are collected, the latter of which is found in the Results section. Reflection corresponds to the Discussion section.

Population and sample. The study population was the Rubén Jaramillo neighborhood in Temixco, Morelos, which is a peri-urban area. It is characterized by the accelerated urbanization process, the displacement of primary activities such as the cultivation of roses, rice, sugar cane by tertiary activities of commerce, mostly informal, of the settlers, chain stores such as OXXO or CFEmático, presence of universities such as IER-UNAM, UAEM, an elementary school named after the colony and a general hospital. Most people work in plumbing, masonry, haircutting and domestic service. The role of women has changed, given the lack of income, from being only a housewife to working outside the home, often informally. The population has primary and secondary schooling, and there is a problem of teenage pregnancy and domestic violence. The selection of the area was based on the university's social impact area.

The sample consisted of three women between 48 and 52 years of age who live in the Rubén Jaramillo neighborhood and who have a business that has become a family business, because they all run it together: a tamalería, a pozolería and soap and candle handicrafts. The schooling of two women is basic education and one has a higher education; they have not been part of a formal education for more than 20 years. Their interests were to save on electricity and gas costs, improve the manufacturing process of their product and protect the environment. The selection of the sample was made after a series of snowball interviews with the study population, considering that: they had a business, that it was their own, that they were willing to invest time in the courses (workshop, entrepreneurship and care of solar technology), that they would authorize modifications in electrical installations, put stairs, etc., if necessary. The

implementation was carried out at the IER-UNAM, on July 31 and August 7, 2021.

The instruments used were: checklists by activity, oral testimony of the participants, a field diary of the researcher and a session observation guide. These are in handwritten format. The written participations were recovered through a workbook composed of the activities and exercises of the workshop. The activity checklist helped to monitor how much of the activities were answered. The testimony of the participants helped to document the experiences on the process of social appropriation of energy issues. The researcher's diary was semi-structured participant observation to evaluate the program design in implementation. The diary and testimonies considered the questions: what have I done, what have I learned, what is significant in my learning and how can I modify my practice, as proposed by McNiff (2005, p. 100).

The workbook was used to collect data on the activities, which was requested at the end of each session. The oral testimony was recorded on the researcher's cell phone, who made a manual transcription. The data collected were organized into the four phases of 4MAT: connect, define, practice and evaluate.

Workshop design. This section corresponds to Phase 2: design and construction. The design of the "Energize my business" workshop was the product of the collaboration of a multidisciplinary team that followed Nonaka's (1994) inspiration. The multidisciplinary design combined different visions on the energy issue and how to approach it in a didactic way considering the requirements of the design, i.e., the characteristics emanated from the exploratory fieldwork. A prototype was designed with a standard Spanish register, clean of technical terms and formulas, the level of thematic content was basic, infocapsules were devised followed by activities to encourage participation and internalization, since the population has not had contact with formal education, and examples from their daily lives were provided with emphasis on their enterprises.

The design of the "Energize my business" prototype consisted of two parts: the identification of energy needs within the enterprise and the different solar technologies. An attempt was made to avoid the failures of other solar technology implementations on three fronts. First, the prototype focused on training people prior to the installation of solar technology in their enterprises. This was because what is important is not that the businesses have the technology, but that the people running those businesses can identify their energy demand and what solar technology can meet it. The design of the

workshop and its implementation tried to avoid vertical decisions from academia to the community, i.e., engineers pointing out the needs of the ventures and proposing the solution, instead the workshop focused on the main actors: the women. The workshop was designed so that the participants would report their needs and propose solutions themselves.

Second, once the beneficiaries had the necessary information and training, they were easily able to identify, at the end of the workshop, the type of solar technology they required. This work dynamic followed a middle-up-down logic, as described by Nonaka (1994, p. 30), in which the beneficiaries are taken into account and not external prescriptions; the fact that they were aware that this was the technology was a great first step. Third, by focusing on their productive activity, the prototype changed their perspective from seeing solar technology as something foreign to seeing it as a tool that activates and strengthens their economy.

The theoretical conjecture or proposition underlying the construction of the prototype was that training in solar energy can be a factor in the social appropriation of solar technology to prevent the beneficiaries from stopping using it after its installation or selling it. The objective of the prototype was for the women to identify the energy demand of their business and their solar solution. Given that the time available was two sessions, the construction of the prototype followed two central themes: "What type of energy do I use in my business?" this session had the objective of identifying the energy needs of their business and "What solar solution can I use in my business?" this session had the objective of having the women identify the solar technology that provided a solution to their energy needs, whether it was a solar water heater, solar stove, solar dehydrator or solar cells. The topics followed an instructional model that pursues the social appropriation of knowledge, 4MAT. Each topic was divided into four sections: connect, define, practice and evaluate; presentations were prepared for each session and material was distributed individually. The following images show the planning of the sessions.

Results

This section corresponds to Phase 3 of the IBD model. The connection of the participants maintained a forced relationship. This activity had the objective of talking about activities and tools they used in their enterprises and some situations they lived in a sunny place like Temixco. The women participated in the form of an interrogation, with short, brief or monosyllabic sentences. This was partly due to the fact that it was the first group contact and there was some distrust. In the second session, the participants were more confident in expressing comments they had heard; although their answers were a little

longer, it was not possible to motivate a conversation or debate among them. Although the themes in this connection stage were intertwined with the content, the limited participation made them seem forced.

The definition followed a pattern of simple association. This was reflected in the activities they carried out, in which they appreciated a pairing of meaning from their experiences and specific exercises. The construction of meaning was of a simple associative type, that is, they constructed a referent and its meaning leaving aside detail, complexity, subtleties and differences. In the first exercise they had to distinguish which image used electric or thermal energy; in the image of the iron, which uses both concepts, they doubted whether it was thermal or electric; they also doubted in the image of a book what type of energy it required. This hesitation showed that the participants could not discriminate from a series of elements those that did not belong to the set, that is, those that did not use energy or those that used both.

Similarly, the participants found it difficult to differentiate the varieties of meanings, for example, there was confusion with the words "natural gas" because they thought it was a renewable source due to the fact that the adjective was "natural" and therefore was not harmful. In session 2 they maintained this same type of processing, in the activities they managed to relate the image of solar technology, the concept and the definition, however, it was difficult to remember abstract words such as "advantage", "maintenance" or "precaution". The processing followed a reverse pattern, while the simple association of solar technology was to keep the differences between each technology; advantage, maintenance and precaution had characteristics that the technologies shared and these were vague. This reverse process of specification, differentiation of solar technologies versus generalization of advantages, maintenance and precaution, in the same exercise was a challenge for them. In the "Dear Heart" activity, the written skills of the participants were evident, only one managed to maintain a similar writing style in response to the entrepreneurs; the rest of the participants only wrote the solar solution. In both sessions, the construction of a simple association network was appreciated, which helped them to achieve the objectives of each session.

In the evaluation process, the women were aware of their energy needs and solar solutions. In session 1, two of the participants were able to identify their thermal and electrical needs even though they were not able to reflect on what it was practically useful for them. Delia and Maria identified their needs and were able to classify them as thermal, electrical or both; Paty only identified their uses within her enterprise, but was not able to identify the needs she had. This is evidence that the associations they built in this session were simple and isolated,

i.e. not linked, linked to structures, series or blocks of other associations, in this case to their venture. In session 2, Paty managed to establish the relationship between her needs and solar technology as did the other participants.

The workshop had a double evaluation, one carried out by the participants on their enterprise, detecting needs and choosing a solar solution, and the other by the team of engineers. The evaluation carried out by the team was based on a "Diagram of solar solutions" in which, by means of questions based on the characteristics of their business and energy demand, the ideal technology for each enterprise was identified. In all three cases, the results of the diagram and the technology identified by the participants were the same. In the case of Delia, she had conducted tests on dehydration of leaves, flowers and vegetables months before the workshop, so she had already well defined her need for a solar dehydrator to speed up her production process of candles and handmade soaps. Maria identified the solar cell technology to reduce electricity consumption for the equipment she uses to make tamales. Paty pointed out that the appropriate eco-technology would be a water heater to speed up the pre-cooking of pozole. The coincidence of responses between the Diagram and what the women indicated was a verification that the workshop prototype yielded the results projected in the program design and that the diagram considers all the elements for diagnosing solar technology according to the enterprise.

In the oral testimonies about what was learned, the change in the understanding and relationship of topics was appreciated. In session 1, it was not possible to connect the topic with the importance of their business, the answers "all knowledge is useful" or "I learned something new" did not give a relevant answer to the question, this reflected that a personal value or application of the concepts was not built. In session 2, the presentation of the different solar technologies created a link between their needs and solutions within their business. The testimonials focused on listing the advantages they would have if they used a certain solar technology. The change in responses in session 2 was due to the link between their needs and the proposed solar solutions, and knowing that they would benefit from a technology gave them enough agency to select the one that best suited their business.

The following modifications to the workshop prototype are recommended. In session 1 it is necessary to separate the types of exercises, it is suggested in activity 1 to keep images that use thermal or electrical energy, to include an activity in which they select whether they use thermal, electrical or both, to include an activity in which they cross out the activities that do not belong to the set of tools that use thermal and electrical energy. It is better to introduce the

topic of energy with the explanation of renewable and non-renewable energy as a context and focus only on identifying the needs they have in their enterprise.

In session 2, it is recommended that after explaining each solar technology, a clear example of how it can be used in a business, what advantages it would represent such as lower gas costs, among others. In the "Dear Heart" activity, all cases should be about business.

The result of the implementation of the prototype workshop was achieved. This result can be attributed to the objectives of the intervention in its two sessions. The prototype designed had the capacity to be taken to the field without a problem. The factor that contributed to the applicability of the prototype at the local level, Temixco, was the sociocultural approach derived from the exploratory fieldwork with the women, one month prior to the workshop. Based on this, a profile was constructed that helped determine the design requirements. Another factor was the women's personal interest in their ventures, which served as the backbone of the workshop and cohesion within the group. There was also an alignment between the objective of the workshop and the knowledge required by the women to make decisions about their solar solutions. In this sense, there was an integration due to the personal interest of benefiting from the right choice of solar technology.

The workshop design was effective because of the alignment between the design requirements, the propositions and the workshop design. The workshop can be replicated with the same results as long as it is carried out in conditions similar to the context and population, that is, it can be analytically generalized. The short-term impact of the intervention was the social appropriation of knowledge of solar technology in the enterprises as they were able to identify the eco-technology they needed. In the long term it will be reflected in the consolidation, care and maintenance of the technology in their enterprises. The appropriation of this technology in their productive life will be reflected in a better use of their economic resources and productive process.

It is proposed to conduct a longitudinal study to determine the level of integration of technology into their productive life. That is, so far, according to the stages proposed by Jordi Adell (2008), the stage of technological access and adoption has been reached. It is necessary to follow up in order to document the process of the adaptation, appropriation and innovation stage. In each of them it will be necessary to point out the challenges they will face; the direct or indirect repercussions of solar technology in their production processes and physical businesses; what they do and how they face a problem with the ecotechnology, in what personal way they come to appropriate it.

Conclusions

The workshop "Energize my business" was a proposal for social appropriation of knowledge, its implementation and analysis leads to the conclusion that a design program that aims to empower women-led businesses in a peri-urban context should have a socially focused fieldwork.

The social appropriation of solar technology in enterprises can be successful as long as it is not seen as a panacea for economic or energy problems within the enterprises. Just as there is a failure in the distribution of gas or electricity, a day with low solar irradiation due to weather conditions may mean that the solar technology does not have enough power to function. This does not mean that it is a failure, it represents an alternative and complement that contributes to take advantage of economic resources more efficiently in the enterprises, without harming the environment, taking advantage of living in an area of high irradiation as Temixco.

It is important to note that the solar technology was granted on loan, thus protecting it from being sold to third parties and emphasizing the responsible use of the equipment. The beneficiaries were made aware that, in the same way that they acquire other types of technology such as a cell phone, they are responsible for taking care of the equipment they received in their businesses, maintaining it and reporting any faults it may present. The fact that the installation was done in their businesses ensured access and maintenance.

"Energize My Business" was the first prototype to be piloted in a peri-urban area. The maturation of the program that was designed as a prototype will depend on the adjustments recommended above. In addition, a first iteration in the Temixco area or similar will show which elements of the design work for the peri-urban population and which can be modified or need to be emphasized, depending on the type of business.

The theoretical understanding of the program will be achieved to the extent that it is implemented repeatedly. Thus, it will be verified whether the assumption on which it was based is valid for any peri-urban area. It should be remembered that the framework in which the workshop was designed was that of empowerment through solar energy. For the time being, in this pilot, the program was optimal because it achieved the proposed objectives.

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