LEARNING, SOCIAL CAPITAL AND SOCIAL NETWORKS, AMONG PRODUCERS OF THE MIXTECA ALTA, OAXACA

Bersaín **Ortiz-Jiménez**[1*], Filemón**Vásquez-Ortiz**[2], Carlos **Ramírez-Cuevas**[3]

[1]Universidad de Chalcatongo. Chalcatongo de Hidalgo, Oaxaca, México. 71100.
[2]Instituto Tecnológico Superior de San Miguel el Grande. San Miguel el Grande. Oaxaca, México. 71140.
[3]Quiego, A. C. El Camarón. Nejapa de Madero, Oaxaca, México. 70530.
*Corresponding author: ortiz.bersain@colpos.mx

ABSTRACT

In Mexico, small-scale farmers lack knowledge and organization to effectively take advantage of natural potential and social capital, which can be used to transfer technology for productive systems, even though the government and other organizations have implemented training programs. Research was carried out in two very marginalized rural communities; participants included: fourteen producers selected by non-probabilistic sampling and the criteria for participation was that each of the participants were dedicated to cultivation and that they grew peach trees on their land. It was evident that the teaching-learning effects derived from rural colleges (RC's) for the management of milpa interspersed with fruit trees (MIFT), influenced neither social capital, nor the formation of social networks for technological diffusion. In conclusion, despite RCs using certain strategies to fortify learning, they require a methodology that initially implements studies to assess the interests, attitudes and abilities of producers.

Keywords: knowledge, rural colleges, MIFT, small-scale producers.

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INTRODUCTION

Rural Colleges (RCs) work to improve socioeconomic needs and take advantage of the producers' potential natural resources. In Mexico, the RC's approach has its origin in the communes of the last century, which supported the vulnerable majority of the population, also known as refuges, rural schools and cultural missions for the populace that promoted necessary changes or improvements for the people (Martínez and Padilla, 2010).

Examples in Asia include agroecological practices to improve food security and family nutrition (Global Alliance for the Future of Food, 2021); in Africa, the management of soil, water, seeds, agrochemicals, etc., and in Latin America, the fortification of organizations, management of maize cultivation, fruit trees, cocoa, coffee and food products, among others (FAO, 2015). In regions of Mexico, some projects and programs were implemented that directly impacted producers (Noriega *et al.*, 2019).

In the literature, it is apparent that different organizations have been established throughout the world and in this country to provide producers with limited resources or in marginalized areas with access to knowledge to improve productivity and sustainability (Adamsone-Fiskovica & Mikelis, 2022). However in real terms, productivity in rural areas has diminished (OCDE-FAO, 2017), income is low and insufficient to buy inputs, or for purchasing basic raw materials for subsistence milpa. Lately, hillsides have become susceptible to erosion, as very substantial runoff occurs during the rainy season. Thus, the management strategies implemented by producers in the Mixtec region, remain unknown. This situation leads us to ask the following questions: What has become of technological learning that was disseminated in some instances? What has become of systems for transferring technology, although these have been constantly modernized? What is the situation of those producers, who participated in these methods and what is their productive potential?

RCs have different perspectives; this investigation has primarily perceived a method of learning-by-doing, that is, the application of experience and experimentation; a context which helps create awareness, and improve knowledge and experience (Kenya *et al*., 2017), through reflection and dialogue. It represents a place where knowledge is processed and where mutual collaboration helps disseminate technological information about crops (Carlberg *et al.,* 2014).

In RCs a variety of participants with egalitarian dialogues interact. Noriega *et al*., (2019) ascertain that in these theoretical and practical sessions, there is interchange between one producer and another, with constant monitoring from professional service providers. Therefore, the concept of organization is essential, because the process of social exchange occurs in a context of trust that enables the producer to participate collectively with the group to which he belongs, in order to improve family well-being and personally transcend in economic terms.

Concerning social capital, three concepts are closely related to RCs and social networks: the values of trust, solidarity and reciprocity. Sedana *et al.,* (2014) presented an analysis showing that high levels of mutual trust, norms and social networks facilitate participation in cooperative activities. Gero *et.,* (2020) stress the need for participation in taxing human situations. Besides analysis of these concepts, the social reality and productive activities in the study region relate to ethnic groups, where traditions and personal traits prevail, such as mother tongue, friendship, respect and community work; but they are also producers, who lack participation and knowledge for taking advantage of their natural resources and strengthening ties.

This situation has lead us to investigate whether the learning processes for the transmission and acquisition of knowledge that are obtained in the RCs augment social capital, thus strengthening functional organization with resulting impact on rural development.

In this investigation, an analysis of network methodology attributed importance to basic human values. Rendón *et al.,* (2009) present a matrix of five levels of relationship, depending on participant: recognition (acceptance), knowledge (interest), collaboration (reciprocity), cooperation (solidarity), and association (trust). Analysis of networks makes it possible to recognize processes of technological diffusion. Rodríguez-Aguilera *et al.,* (2016) analyze networks as a whole. Baer *et al.,* (2015) assure that when individuals are focused, there is a great variety of ideas and opportunities for resolving group problems. In this sense, individuals are fundamental when learning processes are required for group innovations. Cartoni *et al.,* (2013) found that the process of knowledge diffusion through social networks is incipient. In this regard, a factor that directly impacts each of the groups is individualism and personal interest, a situation that is perceived by producers in general and that affects learning channels for dissemination.

In network analysis, the concept of relationships or interactions are globally defined as the flow of communication, knowledge and products exchanged by producers, as part of the trust and awareness obtained as a result of certain learning processes. People, as well as the links and flows that make up networks are considered as a relational structure that forms in response to shared situations (Rendón *et al.,* 2007). The network is understood as a group of individuals that, either as a group or individually, relate to each other for a specific purpose. For this reason, the following concepts were analyzed in the investigation: The network's degree of centrality (*centrality degree*) is the capacity of an individual to contact a certain number of participants by means of direct and indirect relationships (Rendón *et al.,* 2007). The centrality indicators (Velázquez and Gallegos, 2005), proposed for the research were: incoming degree (*in degree*) represents the number of times that other participants refer to an individual. Outgoing degree (*out degree*) represents the number of relationships that a specific individual claims to have with other participants.

The two concepts of degree of centralization indicate where the information flows to, following a learning process. A producer who learns new knowledge may have the tendency to request more information, thus continuing to accumulate knowledge, a situation which is effective, because in the long term this would usually be forgotten.

Another important analysis deals with the centralization of the network, which is defined as the level of information that exists in the network as a whole; this is a function of the concentration of relationships between the nodes. An indicator of centralization that was considered in this research is that of network density, comprising relationships between producers in the network and their access to information.

This investigation intended to evaluate the effect of teaching - learning that is carried out in the RCs, in terms of social capital and the formation of social networks, among small-scale producers in rural areas.

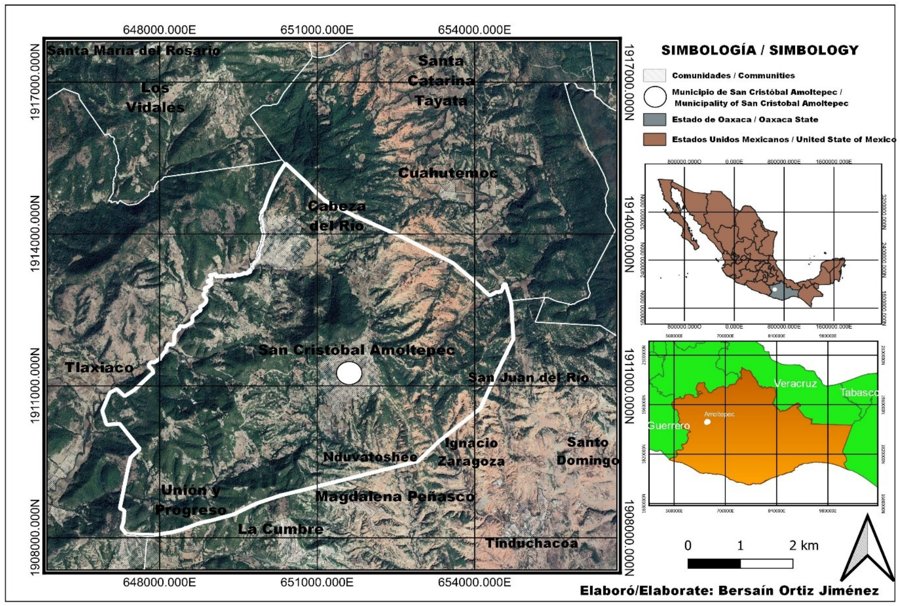
METHODOLOGY

Subjects

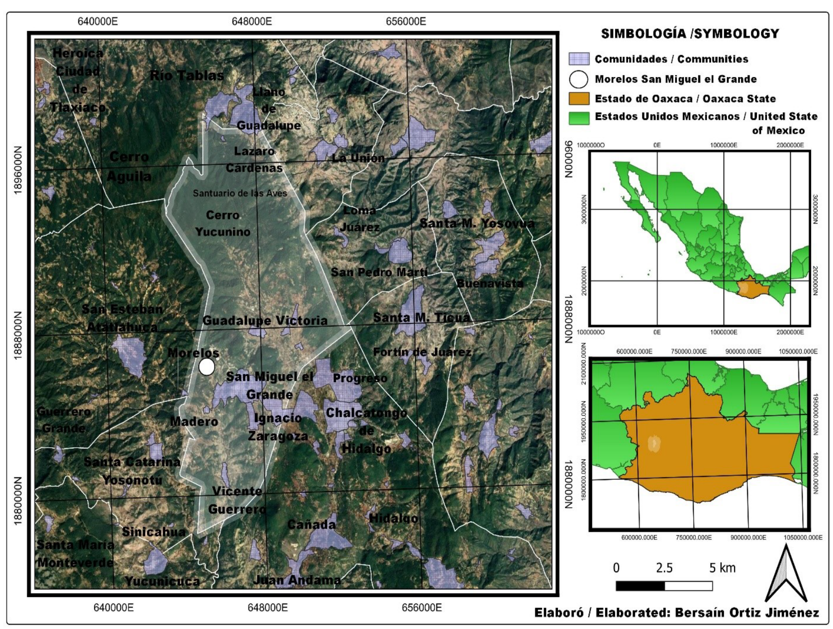
Milpa owners were from the Mixteca Alta region, Oaxaca; 14 producers from the community of San Cristóbal Amoltepec (Figure 1), and 14 producers from the Morelos organization, San Miguel el Grande (Figure 2, undertaken by means of directed samples. In each of the communities, the producers were divided into two groups of producers: a) participants who attended all the sessions at RCs, and b) producers who participated in less than 50% at RCs.

The inclusion of participating male and female producers was implemented according to the following criteria: they belonged to marginalized communities, who cultivated maize and fruit trees in their plots or home gardens, and also that the milpa cultivation areas were irregular or sloping.

The marginalization index in San Cristóbal Amoltepec is high (49.89), whereas in Morelos, San Miguel el Grande it is mid-level (53.14) (National Population Council [CONAPO], 2022), in the case of low-income families, it is thus necessary to maintain food security



Source: self elaborated with information from the National Institute of Statistics, Geography and Informatics (INEGI), and Google, designed using QGIS 3.18 software.
Figure 1. Localization of San Cristóbal Amoltepec.



Source: self elaborated with information from the National Institute of Statistics, Geography and Informatics (INEGI), and Google, designed using QGIS 3.18 software.
Figure 2. Localization of Morelos, San Miguel el Grande.

by cultivating a milpa for self-consumption, similarly, the management and cultivation of fruit trees (peach) is to increase income, especially as the region has a climate that generally favors the cultivation of fruit trees. Likewise, the communities that farm hillside lands have potential for sustainable management. Finally, producers need to be motivated in order to transcend in their productive activities.

MATERIALS AND PROCEDURES

The RC workshops began on May 29, 2015 and ended on December 12, 2015. RC methodology was implemented, establishing a school growing plot per community, where the MIFT system was implemented: 4 maize management sessions, 4 peach tree management sessions and a compost production session. The sessions were monthly, to respect the time of the producers.

Measuring instrument

When the RC sessions ended, a numerical or semi-objective scale survey was applied to measure attitudes towards practical learning in the MIFT system. The questions in the survey consisted of 12 large categories of innovations, which contained 44 variables or minimum recommendations for the implementation of MIFT (Table 1).

Learning Assessment

The value of learning (Table 2) was assessed with reference to the degree of knowledge that each producer developed on the topics of technological recommendations for the management of maize and fruit. For example: a question from the technological recommendations regarding the use of "device A" was: To what extent can you use device A? Explain?; depending on the quality of explanation, the evaluator assigned a percentage from 0 to 100%.

Questions in the survey were generally brief, with easily understood, very simple vocabulary, enabling producers to explain and issue their value judgment on each item. It is important to mention that the evaluator had participated as an instructor and guide in the RC workshops.

Defining instrument reliability

An internal consistency reliability analysis was performed to assess means of gathering information, using the cronbach alpha method for n=14. The calculation undertaken, using the Excel program, gave the following results: San Cristóbal Amoltepec, α=0.977; and Morelos, San Miguel el Grande, α=0.965. Ultimately, the scale used to measure knowledge acquired by producers indicates high internal reliability and is considered acceptable.

Calculation of learning rates for technological innovations

Percentages referring to learning of technological recommendations and the rate that innovations were learnt by category were calculated as follows:

Table 1. Grouping of technological innovations for MIFT on slopes.

I. *Tracing of levels on sloping land*
1. Use of aparatus A
2. Construction of aparatus A
3. Levels on sloping land
4. Distance between points along the contour lines of fruit trees

II. *Management of milpa and fruit trees on sloping land*
5. Knowledge of planting system for fruit trees and milpa on slopes
6. Distance between fruit row level and milpa furrows
7. Alternating fruit trees with milpa cultivation
8. Distance between milpa furrows
9. Reasons for maintaining distance between maize plants that are intercropped
10. Distance required between maize plants

III. *Management of fertilizer for milpa cultivated on slopes*
11. Use of biofertilizer (mycorrhiza) for the treatment of maize grown on slopes
12. Amount of chemical fertilizer used for maize fertilization

IV. *Management of pests and diseases*
13. Pest and disease control on hillside milpa
14. Biological substances for pest management
15. Use of chemicals for pests common to hillside maize fields

V. *Production of organic fertilizer for the management of maize fields and fruit trees*
16. Materials used for the production of organic fertilizer
17. Frequency of use of organic fertilizer in the milpa
18. Quantity of organic fertilizer that should be used in the milpa
19. Frequency of use of organic fertilizer for planted fruit trees

VI. *Seed selection for the milpa*
20. Seed selection
21. Plants that should be selected
22. Reason for selecting these plants
23. Selecting a maize cob from a maize plant
24. Selecting a grain from a maize cob

VII. *Pruning peach trees interspersed with milpa*
25. Season for pruning fruit trees
26. Frequency that fruit trees should be pruned
27. Reason for pruning fruit trees
28. Ways of pruning fruit trees

VIII. *Arrangement of peach fruit trees interspersed with milpa*
29. Arrangement of peach fruit trees interspersed with milpa
30. Way of pruning fruit trees interspersed in the MIFT system
31. Height of fruit tree branches in the MIFT system

IX. *Management of pests and diseases in peach trees interspersed with milpa*
32. Common pests in fruit trees
33. Products to combat pests in fruit trees
34. Common diseases in fruit trees
35. Products for combatting diseases in fruit trees

Table 1. Continuation.

X. Treatment for the transplant of fruit trees
36.Treatment for the transplant of fruit trees
37.Profundity and planting method for the transplant of fruit trees
38.Distance of the fruit tree that is transplanted taking into account the soil where it is planted
XI. Reproduction of peach fruit trees
39Selection of seeds for reproduction of fruit trees
40.Treatment of fruit tree seeds, prior to planting
XII. Fruit tree grafting
41.Reason for grafting fruit trees
42.Types of grafts performed on fruit trees
43.Care when grafting fruit trees
44.Dates for grafting fruit trees

Source: self elaborated with information from experts at the National Institute of Forestry and Agricultural Research (INIFAP), experimental section, Santo Domingo Barrio Bajo, Oaxaca. Researchers and consultants participating in topics at RCs.

First, the Category Innovation Learning Index (CILI) was calculated.
For this, we obtained the innovation learning indices for the 44 recommendations, that is, the sum of the innovation recommendations divided by the total innovations for each component and for each producer interviewed (for example: component 1. Tracing of levels entails 4 recommendations (Table 1); the total percentage of the recommendations is divided by 4 to obtain the percentage for each component).

Table 2. Learning Codes.

Codes	Learning level
0 - 1[1]	0
2[2] – 3[3]	0 - 10
4[3]	11 - 21
5	21 - 30
6	31 - 40
7	41 - 50
8	51 - 60
9	61 - 70
10	71 - 80
11	81 - 90
12	90 - 100

[1]A value of 0-1 indicates answers: I can't explain or I don't know.
[2]A value of indicates answers: I think so, but I don't remember.
[3]Values for codes of 3 through 12 indicate: producer transforms status from insufficient to outstanding.
Source: self elaborated.

$$CILI = \frac{\sum_{i=1}^{K} IRnn_i}{NIRnn_i}$$

where *CILI*: Innovation Learning Index for each category (component); *RInni*: Presence of the nth Innovation recommendation, in the *k*-th category (component); *NRInni*: Total number of Innovation Recommendations in the *k*-th Category (total recommendations in each component).

Second, calculation of the learning index by component (CILI)
This is calculated is calculated by adding the CILI for each component for each one of the producers, divided by the total number of participating producers.

$$ACILI = \frac{\sum_{j=1}^{K=12} CILI_j}{TP}$$

where *ACILI*: Average Innovation Learning Index; $CILICP_j$: Innovation Learning Index of the *j*-th Producer in the k-th Category; *TP*: Total participating producers.

To calculate the average of the exact innovation learning index acquired in each component, a rule of three was applied; codes are considered to have values from 0 to 12, and code 12 was assigned a learning of 100% (exceptional level).

Methodology for network analysis

We studied the social networks of the 14 producers: participants and non-participants from each community, in particular to assess the relationships between aspects studied in the RC's. In a second part of the survey, questions relating to social relationships were asked; each producer was questioned about their relationships and the situation regarding people, groups, and organizations. The structure of this part of the survey considered five levels of relationships: recognizes, knows, collaborates, cooperates and associates (Rendón *et al.,* 2007).

Once this information was obtained, data was captured in a matrix in an Excel file. In order to have total knowledge of each producer, the attributes of each producer were described on this sheet, using a catalog of producers by community that included the following information: in the first column the identification code of the participant (ID); in the second column, the name of the producer and other participants; in the third column, the description of the type of producer and in the fourth column municipality and neighborhood.

Another Excel sheet has a file to describe the network of each community, in a matrix consisting of three columns: the first containing the ID of the producer, the second the relationships of each producer (the relationships of the producer were in order: level 1, level 2, etc., you could not go from relationship 1 to 3 or 5), and in the third column the number of relationship levels assigned (1, 2, 3, 4 and 5). Subsequently, from this database, a 2-column matrix was copied into a notepad file, consisting of a two column matrix: the product ID and the relationship level.

Finally, the data from the notepad was imported into UCINET software for the analysis of social networks, where graphs were prepared and the indicators for the analysis of social networks were obtained: density and the centralization Index for producers and other participants (Rendon *et al.,* 2007).

Calculation of network indicators Density:

$$D = \frac{r}{N(N-1)} * 100$$

where D is the density of a network expressed as a percentage, r represents the existing relationships and N the number of nodes in the network.

Centralization Index is calculated by applying the following equation:

$$C = \frac{\sum(D-r)}{(N-1)(N-2)} * 100$$

where D is the density of a network expressed as a percentage, r represents the existing relationships and N the number of nodes in the network.

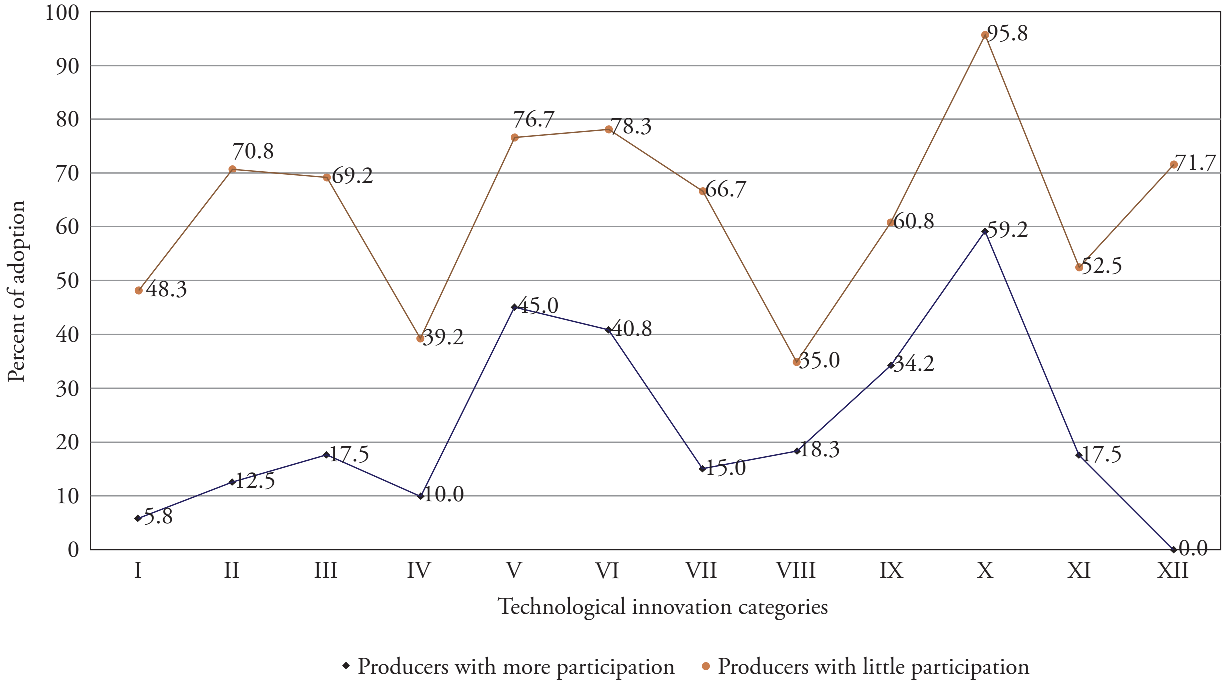
A centralized and 100% trending network is dominated by one or very few central nodes. A network with a tendency to 0%, presents no individual with these characteristics.

RESULTS

Learning acquired in the RC's of San Cristóbal Amoltepec

The learning index for the participating producers was 64 % and those with limited participation, obtained a general learning of 23 % (Figure 3). There is a gap between participants and non-participants; it is important for any institution to recognize this, as this generally occurs in initial event situations, as producers have different interests that lead them to behave in this way and over time motivation and responsibility decline. These circumstances are not suitable for strengthening certain aspects of social capital and even less for forming lasting groups. Danso-Abbeam (2022) found that farmers, who adopt most information, do so due to the importance of access to and use of techniques, as well as their management.

In learning processes, relationships between people are necessary, mainly for the formation of networks and exchange of information. In San Cristóbal Amoltepec, the analysis of social networks was as follows: level 1 (acknowledges), had a network of 41 participants, with an intensity of 37 relationships, the stronger the relationship levels, the less relationships (Table 3). The aforementioned is reaffirmed by the density indicator at the level recognized,



Source: Self elaborated from information provided by the producers.
Figure 3. Learning indices by component in San Cristóbal Amoltepec.

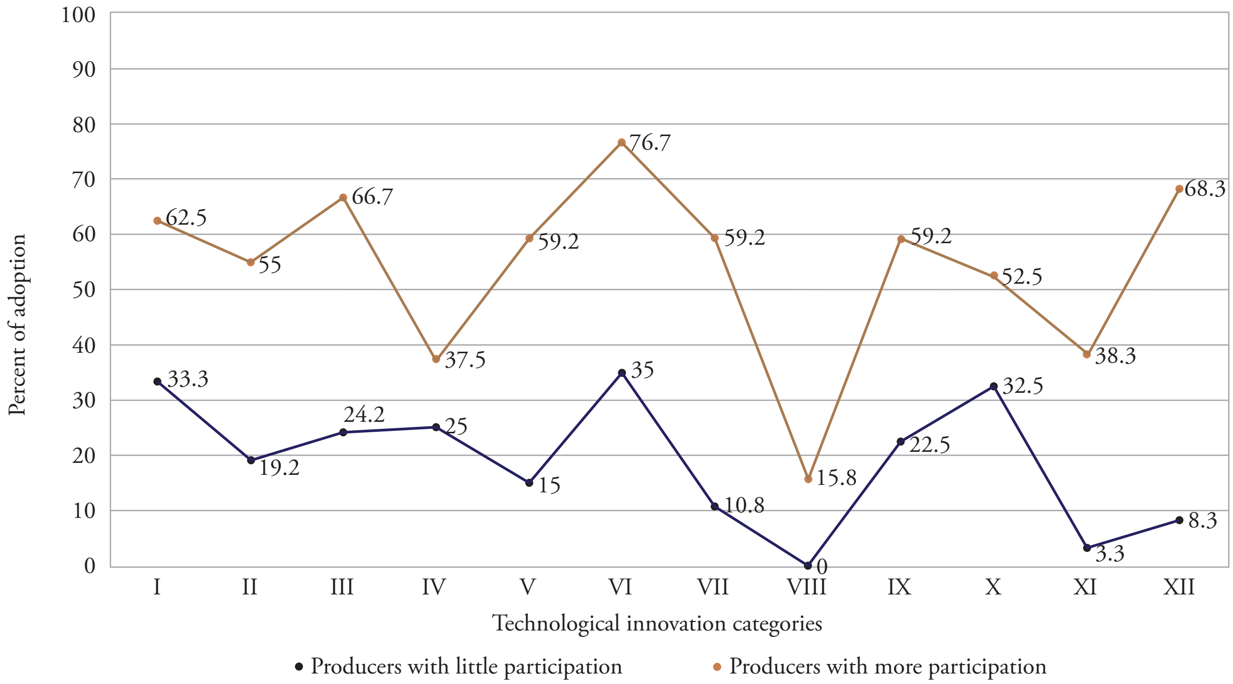
the percentage is 2.3%, which indicates that, out of 100 relationships, only 2 are possible and the strongest level is that of association, meaning that no relationships exist (Table 3). Learning results from RCs in Morelos, San Miguel el Grande, maintained the same trends in terms of the gap mentioned in San Cristóbal Amoltepec, however in Morelos, the learning rates of the participating producers decreasing by 10% and number of those attending also decreased, so that generally, learning focused on management of the MIFT was 19% (Figure 4).

Analysis of producer networks in Morelos, San Miguel el Grande (Table 4) shows that despite the fact that the community has greater communication with other participants in the municipality and from other municipalities; in the RC sessions, the same number of producers participated as in San Cristóbal Amoltepec. In the analysis of the network

Table 3. Relationships and indicators of Centrality in San Cristóbal Amoltepec.

Indicators	Levels of relationship				
	Recognizes	Knows	Collaborates	Cooperates	Associates
Relacionships	37	21	7	2	0
Density	2.3%	1.3%	0.4%	0.1%	0

Source: self elaborated from information provided by the producers and analyzed using Netdraw 2.168 software.



Source: self elaborated based on information provided by producers.
Figure 4. Learning indices by component in Morelos, San Miguel el Grande.

at initial or recognition level, participants show 44 relationships, at the second level of knowledge they decrease 10 units, later, and for levels involving greater organization, they drastically reduced down to zero relationships (Table 4). Also, low participation on the part of producers has a lot to do with attitudes towards learning and on forming associations between producers.

With respect to these situations and in similar studies, Stephenson *et al.,* (2004) concluded that in a broader social context, the bases must be established to better analyze individual actions, social limitations and opportunities.

Thus, in Morelos San Miguel el Grande, density indicators were low; out of every 100 relationships, only approximately 4 are possible, in general, the network is not centralized

Table 4. Relationships and indicators of Centrality in Morelos San Miguel el Grande.

Indicators	Levels of relationship				
	Recognizes	Knows	Collaborates	Cooperates	Associates
Relacionships	44	34	6	2	0
Density	3.9 %	3%	0.5%	0.2%	0

Source: self elaborated from information provided by producers and analyzed using Netdraw 2.168 software.

towards a single participant. The producers also present personal interests in terms of learning and social networks, at the first level of relationships.

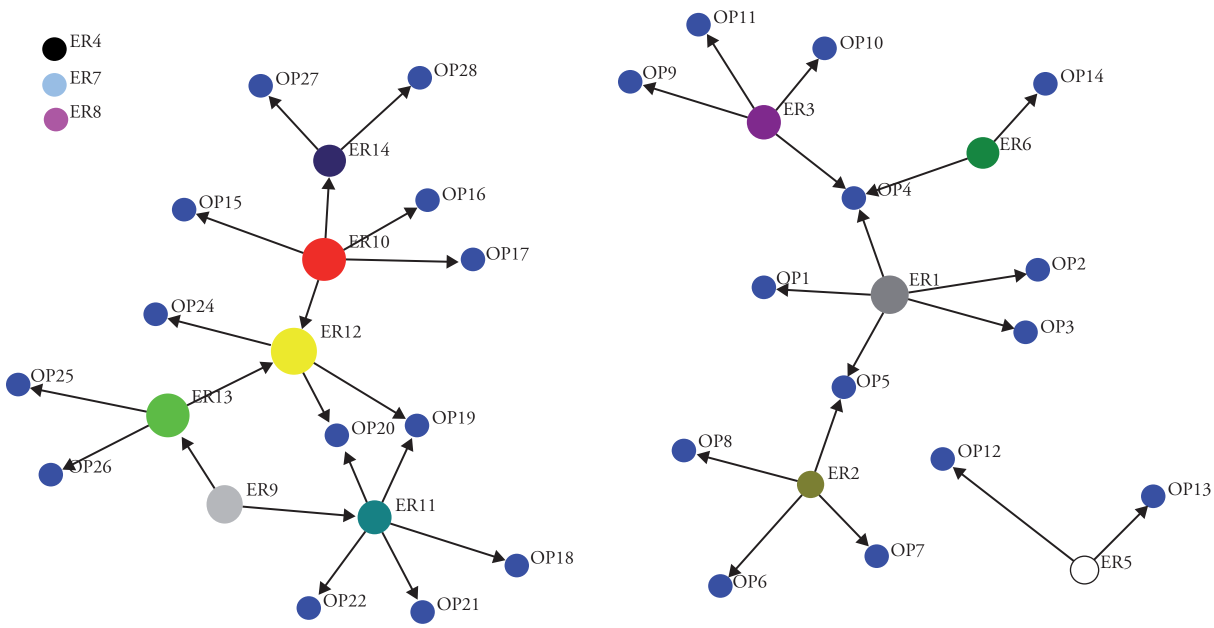
San Cristóbal Amoltepec Network

The relationship network of San Cristóbal Amoltepec (Figure 5) is divided into three independent subnets or clusters; each cluster sharing ties with each other. The link with other producers seeking information to broaden knowledge was one of the main traits of these producers; likewise they obtained greater indices of knowledge in the RCs.

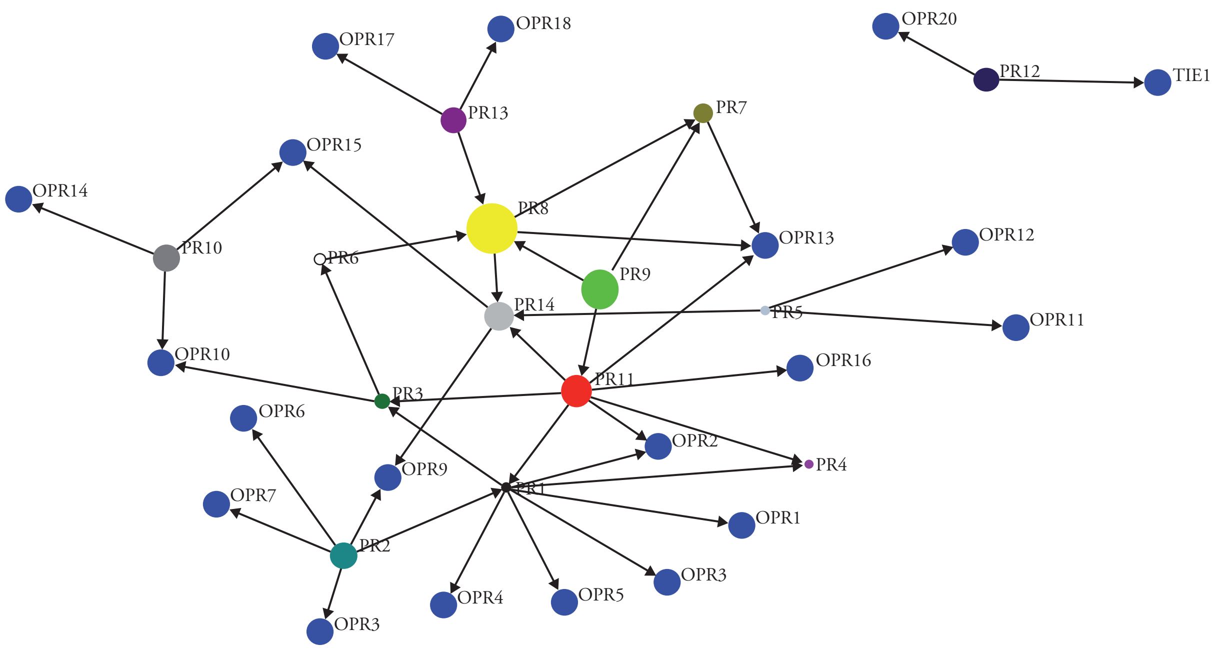
The producers that stand out are: ER1, ER2, ER3, ER11 and ER10, their advantage is that they maintain a relationship and have information, but their disadvantage is that they do not offer to share their knowledge. This situation does not enable strengthening the social capital of an organization. Indeed, Hernández *et al.*, (2014) found that social capital is strongly correlated with organizational learning.

Network in Morelos, San Miguel el Grande

The graph for relationships in Morelos, San Miguel el Grande (Figure 6), shows a more comprehensive network, there are only three isolated participants. The density indicator maintained the same trend, as in San Cristóbal Amoltepec; in the first level of recognition, the density percentage was low. Therefore, there are producers who centralize the network, but unlike the San Cristóbal Amoltepec network, they have a greater advantage because they offer and receive information based on knowledge acquired in the RCs. The producers:



Source: self elaborated with information provided by the producers and analyzed using Netdraw 2.168 software.
Figure 5. Social network in San Cristóbal Amoltepec.



Source: self elaborated with information provided by the producers and analyzed using Netdraw 2.168 software.
Figure 6. Social network in Morelos San Miguel el Grande.

PR1, PR8, PR14 and PR11, can strengthen the relationships of the network and the learning flow of the group of producers, with the added value obtained from the RCs.

DISCUSSION

Teaching-learning is crucial regarding processes for technological transfer. In this research, the learning indices for the producers, who did not participate in RCs were not outstanding and their social network indicators did not strengthen social capital, nor were their relationships significant. Concerning participating producers, learning rates were 50%; they are limited in terms of forming networks and for strengthening capital at the first level of relationships; the neighborhood in each community can influence the level of recognition, but it does not strengthen subsequent levels; mistrust still persists, there is no participation to enable dialogue and reflection among them, nor are the foundations laid for long-term group relationships.

Analysis of networks reveals that one of the problems that arises in the processes for adopting innovation and concerning the levels of relationships, refers to management. Producers also require management, mainly to follow up on practices, to continue receiving support from technicians, to reinforce technology and to access related workshops. Evidently both learning and relationships are long-term processes, which relate to the expectations and desires of each member. Thus, for a project in which many participants are involved, it is important to analyze and comprehend individual and group behavior. Regarding individualism, Villareal *et al.,* (2012) expressed that the emphasis placed by both the producer and the technician is always to strive for the individual and family level first, before attempting to establish the common good.

A factor concerning groups is that over time they disappear. Based on the results from the density indicator, this results in reconsidering intervention strategies for technology transfer at RC events. Although educational and research institutions that promote knowledge for the management of technology and provide professional services represent very important components in the relationship; both specialize exclusively in agronomic themes.

It is also necessary to know of any personal interests, before initiating the RC process, to be aware of any personality traits of participants such as: attitudes and abilities and even be aware who the fast and slow learners are, as well as aspects that have to do with the integration of other disciplines, such as sociology and psychology.

Other strategies that have to do with strengthening groups involve carrying out practical workshops on leadership and other group work. Concerning sustainability adoption practices Reddy *et al.*, (2019) found that the ties created in organizations accelerate learning. After ten years of existence, many foundations have also contributed to the creation of value in the context of productive, commercial and organizational activities of participants in these networks (Muñoz *et al.*, 2007).

At the end of the research study, in the RC experiment in San Miguel el Grande, it was possible to quantify milpa production, showing significant results. In this regard (Noriega *et al.,* 2019) obtained yields with the MIFT system, where RC producers learned how to improve pest and disease management, resulting in improved productivity and income.

CONCLUSIONS

In conclusion it seems that the effects of teaching – learning from technology transfer carried out in RCs, does not influence social capital, nor does the formation of social networks help in the diffusion of knowledge flows. It is possible that RC methodology at the beginning of the sessions should implement issues related to personality, ability and reciprocity of the individuals involved. In this regard, RC methodology employs three training domains: technology, ecological and personal study circles. In this last context only motivational texts are employed, which also imply other problem, such as the language barrier and the need to encourage participation. (Morales *et al.,* 2008).

We recommend that at the beginning of the RC methodology sessions, specialists from other disciplines such as psychology be included to help assess the behavior, abilities and interests of participants. Given this, new questions will emerge in relation to the scope of integrating specialists and personal diagnoses into learning practices - using RC methodology, to impact social capital and the formation of networks.

Finally, we emphasize that one of the main limitations in the research was the monitoring of the project that was implemented, as it ceased to be apparent whether participants continued to apply their assimilated technological knowledge; thus obscuring the long-term impact of technology on productivity, and it remains in doubt, as to whether any of these producers formed groups or established other institutions, where they continue to participate.

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