# The Connected Learning Model of Scratch Online Community

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***Abstract.*** *This paper presents the modes of participation in Scratch online community based-on Connected Learning. To reveal how Scratchers are learning from their social interactions online and what model of learning is embedded in Scratch virtual community, this research uses social network analysis and contingency analysis to collect and present data from 113 Scratchers in 759 interactions online. The data was collected from 2015 to 2016, using the network and content from eight different discussion forums. As results, this paper presents the Scratch learning model within its modes of participation, such as collaborative, democratic and academic-cognitive.*

## 1. Introduction

Scratch is a free programming language hosted in scratch.mit.edu that helps learners from all ages to create games, presentations, storytellings and other media through coding. By the time this paper is written, Scratch has more than 13 million members and calls itself a community, which puts together youth and educators to understand more about computational thinking and programming, using both online - through the website - and offline environments like schools and public libraries.

Connected Learning (CL) is a theory that understands education through the principles of interest-based, academically oriented and peer-supported [Ito et al 2013]. Authors say that CL unites learning in academic spaces - like school - and the one that is considered informal - like spending time in social media, playing video games or training sports. CL focuses in helping kids and youth to learn by building empowerment and equality through learning. This paper looks into Scratch online community scenario to understand which are the network modes of participation that can be based-on this theory.

## 2. Method

To understand the Scratch online community learning model, we collected data from eight different discussion forums published in the website, in two different periods: from August to September of 2015, and in the same period in 2016. Intending to present this learning map, the research goes to the community forums to collect data from interactions between Scratchers - users of Scratch - and uses social network analysis (SNA) to visualize its network and content structure. The data resulted into the total of 113 actors (Scratchers) and 759 interactions (messages).

**Table 1. Number of interactions according to collected period**

| Data from | Interactions | Collection |
|---|---|---|
| 2015 | 130 | 08/20 to 09/05 |
| 2016 | 759 | 08/20 to 09/05 |

Both periods of data extraction were needed so it would be possible to investigate the following features: how does the network behaves in both moments, which means, what are the actor's parts and the relations between them; what is the network discussing about in both periods, analysing the content of words and themes found on it; what can be revealed from qualitative data, when it is a complement of network and contingency data; and, finally, what is the connected learning model in online communities of Scratch, and what modes of participation are composing it. The actors names - which were anonymised and are shown as pseudonyms in this paper - and number of interactions of each one of them are important data so it's possible to understand the community network, such as knowing the Scratchers who have more social capital and what kind of influence they can apply to the others. Furthermore, collecting their interactions through messages helps us to investigate the content of conversations these groups are having as a network.

**Table 2. Data collection method for network and content**

| Period | Network | Content |
|---|---|---|
| 2015 | Collection of all actors participating of the forums and its connections: *Actor A directs message to Actor B Actor A directs message to Actor C Actor B directs message to Actor A Actor C directs message to Actor A* | Collection of all text messages published in the eight forums: *Message 1/ Message 2/message 3/message 4/message 5/message 6/ message 7* |
| 2016 | Same as 2015 | Same as 2015 |

The qualitative data collection, though, was made only in 2016, after the network and the content analysis, to analyse it comparing to the first results like main discussion themes and higher social capital for some participants.

**Table 3. Qualitative data methodology**

| Collection Period | Method |
|---|---|
| 2016 | Finding analysis points in network and content data |
| | Searching for correspondent fragments (20) in the forums |
| | Fragmentation and its inclusion to the discussion |

The network and content analysis were both based-on social network analysis (SNA) tools and concepts to be used in this research.

### 2.1 Network Analysis

The SNA puts together methods to understand the processes of social networks [Kosorufoff 2011]. Through SNA, it's possible to understand the role of individuals when they are part of a network, *"mapping the relationships between individuals and social networks"* [p. 77]. It's an analysis that focuses the *"understanding of these structures and its part"* [Recuero, Bastos and Zago 2015, p. 39]. As a result, SNA is a method to understand the connections between members of a network, taking in consideration not only the individual characteristics but also the ones that are related to the whole community. This kind of analysis is helpful to understand how some actors influence the process of information flow, depending on its interactions with others. For its visualisation, the network is represented by a graph, that is a representation of connected objects by links [Kosorukoff 2011, p. 62]. The objects - actors, Scratchers - are shown by a mathematical abstraction called vertex, or node. The links that represent these connections are known by edges, or lines.

In this study, the nodes are the forums participants, who communicate through Scratch online, and the edges are the connections between these actors, that is, their interactions. When a graph indicates high sized nodes, it means that these objects have high degree, depending on the metric that is being analysed. For example, if the metric is indegree, the highest nodes represent actors who have the most interactions in the network, directing messages to other Scratchers. Besides that, the thickness of an edge indicates the communication depht. The more times two individuals talk to each other in the network, more thick is the edge that connects them. To this study, we use the following metrics to analyse the network data: indegree, outdegree, betweenness centrality, modularity and density.

The indegree metric is the one that calculates how many entrance connections has a network actor, that means, how many times other participants directed their messages to this specific individual [Recuero, Bastos and Zago 2015]. This metric helps to understand how popular is a Scratcher in the network, having social capital from others and seeing how this popularity influences the actions taken by this individual while a Scratch participant. Another metric, the outdegree, is about how many times the actor spoke to others in the network, directing messages to them. Specially in Scratch, knowing the outdegree of its members provides the visualization of how actors participate within the community, especially when there's a comparison between in and outdegree results. It's interesting to see, for example, if there's someone in the network who has high indegree and outdegree, what means this person is communicating well in both ways, directing and receiving a high number of messages. Further, we can know more about the reciprocity in the network conversations, and on the social capital distribution, when it happens to be a community with diversity of nodes and popularity. The betweenness centrality degree is calculated by the position a node has when compared to other nodes in the network [Freeman 1980]. It considers not only the directed connections, but also the ones that these directed connections make to other nodes. "This metric reflects the number of people to whom an individual is connected indirectly through direct links." [Kosorukoff 2011, p. 6]. On the other hand, by

modularity it's possible to visualise how the network[1] is shaped by different communities, and how these ones connect to each other to result a single network. This kind of metric indicates the groups or individuals that are clusters (highly connected), the ones who can propagate information easily to the rest of the forum. The same doesn't happen in groups weakly connected. Lastly, the graph density is calculated through the tendency of the network to close it on itself. It's the total number of connections compared to the quantity of connections possible. As we show in the results, more density means more interconnections, and, further, more diversity of nodes and themes.

### 2.2 Contingency Analysis

The content analysis made in this research is build on SNA as well, although this time the subject is not the actors and its network, but the content of their conversations online. Therefore, this analysis is about the more co-occurrent words and the most commented themes. To do so, the research uses the contingency [Osgood 1959] analysis method. The contingency are the co-occurrence of words inserted in messages published by actors in the network. Through the connections observation and the word concepts of the discussions, it's possible to investigate how are Scratchers connected by common interests and their associations to what is being said and to the social capital present in the online community.

The graphs for contingency analysis differ from the network when it comes to what nodes and edges are performing. This time, nodes are for words/concepts, and edges are for the strength these themes have in the discussions. There are also similarities in metrics represented in the graphs. In the scope of this study, the connections degrees were calculated measuring it frequency in the community, using it entrance connections, that is, how many times a word was said in consequence of another.

Finally, the observation of patterns by network and contingency data allied to the qualitative fragments shows us the cognitive engagement found in Scratch online community forums.

## 3. Results and discussion

The analysis across Scratch network and contingency reveals the connected learning model of this online community, based-on the modes of participation proposed by this investigation. The Scratch learning model is divided into three categories of modes of participation: collaborative, democratic and academic-cognitive.

### 3.1 Collaborative mode of participation

The collaborative mode of participation is based-on two slopes found in data: the peer-collaboration [ Ito et al 2013; Reilly et al 2012; Rheingold 2002] and the search for feedback. Through network analysis, it's possible to visualise how Scratch is composed by many high indegree actors - who receive a relevant number of messages - as well as participants with high outdegree - the ones who direct their messages to a great number

[1] To visualize the data as a network, this study used SNA softwares to the setting (NodeXL) and formatting (Gephi) of the graphs presented.

of people in the network, or to the same individual but oftentimes. The actor MarioR is central to the network both in 2015 as in 2016 periods, for its high indegree. In the first period of data collection, the actor has 12 entrance connections, a number above other participants degrees. In 2016, with indegree 28, this subject remains as a node to each other Scratchers direct their messages in the network, thus becoming a relevant social capital [Boyd and Ellison 2007; Putnam, 2000; Rheingold 2013] and influent [Kosorufoff 2011] to others.

Else, there are highlighted nodes specially because of its outdegree, which means the number of times they searched for others in the discussions. In 2016 the data show how there are a lot of actors who joins the network for the first time. Fran - with outdegree 27, joao (26), Helena (26) ze (26) and CodingMarcelo (24) are examples of these actors. Inspired by this data, this paper proposes the collaborative mode of participation grounded in two spheres: the peer collaboration and the feedback request. As peer-collaboration is about a model based-on the Scratchers participation to promote knowledge [Sefton-Green, 2013] and help their peers in the network [Ito et al, 2013; Rheingold, 2002]. Moreover the feedback request is rooted in actors using the network to problem solutions in a collaborative way [Reilly et al 2012].

### 3.1.1 Peer-collaboration

Supported by the contingency analysis, which reveals Scratch as a learning space for thematics related to new projects and support in media, games and music productions, it's understood that the interactions that occurs on the website while an online network take its users to a participation model that focuses in peer collaboration [Ito et al 2013; Rheingold 2012] during their work production.

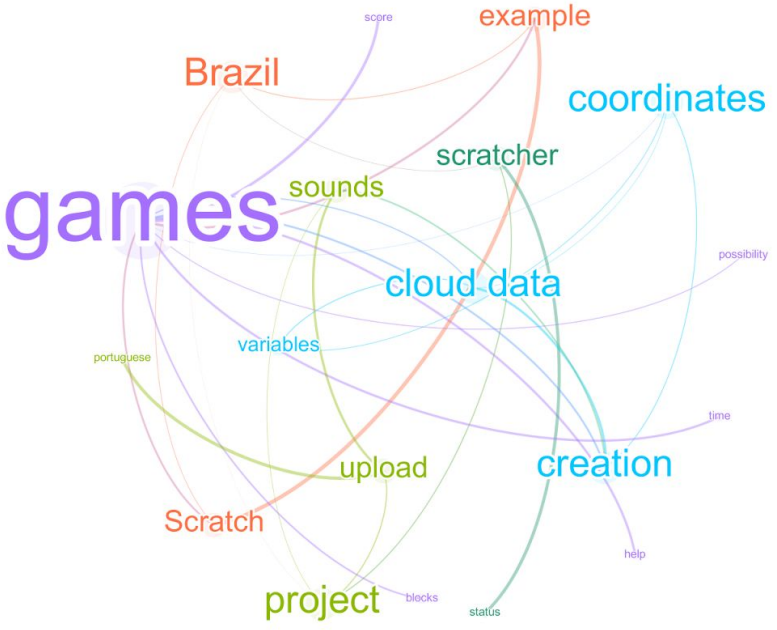


**Figure 1. Contingency graph from 2015 data**

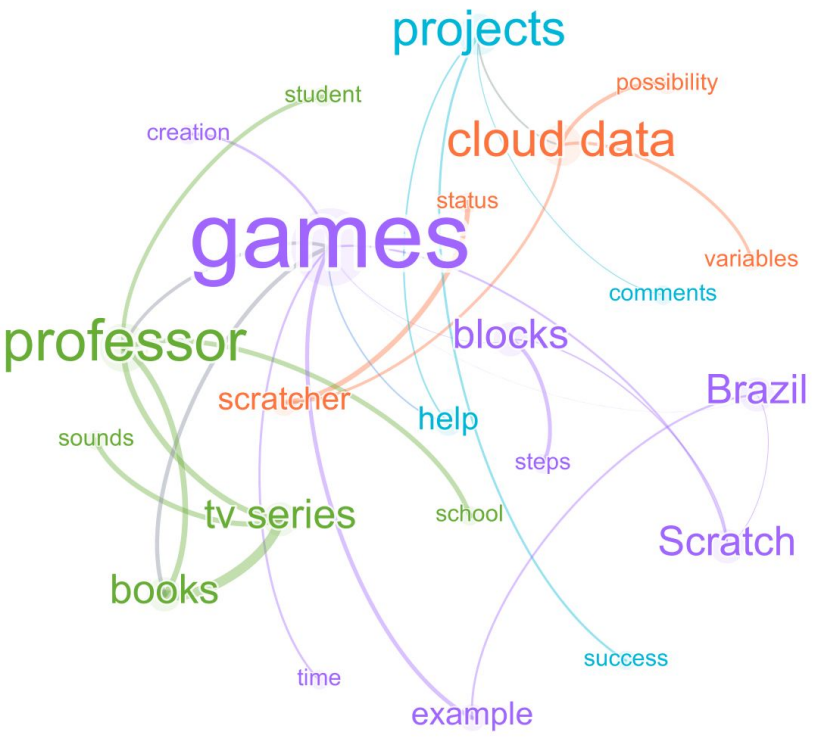


**Figure 2. Contingency graph from 2016 data**

The word "help"composing the theme "games" in 2015 data (figure 1), together with mentions like "blocks" and "possibility"; and, in 2016 data (figure 2), building the subject "projects", with "success", gives us an understanding of the collaborative meaning of these conversations. By also taking in consideration the qualitative data, it's possible to reassert the collaborative mode as a participation in Scratch, thanks to interactions of Scratchers who use the network to present suggestions and problem-solutions to their peers in order to help them with their projects and problem-solving. It's the case of a Scratcher who enters a discussion saying *"Hello! I was seeing some discussion topics and decided to help you!"*, and then offering tips to a user who was having doubts on a project development. Furthermore, even participations without a focus in project production are connected to collaborative participation mode, when Scratchers are available to answer about matters that have no relevance indicative in the network.

### 3.1.2 Feedback request

Specially related to outdegree metric, we realize how some participants have high degree in this category because of their late participation in forums, joining it after intensive interaction from others. These actors join the discussions to ask for help about a theme that is already being discussed by its peers. To reinforce this data, contingency graphs (figure 1 and figure 2) show how feedback request is a constant subject in Scratch, under the high co-occurrence of words including the term "help", that co-occurs in 2015 especially with "games"; and, in 2016, with "projects", taking in consideration the network learning to be a working supportive environment.

### 3.2 Democratic mode of participation

The democratic mode of participation, as it is proposed by this paper, is based-on two facts: the open network and its growth. Each one of these matters, mainly inspired by the network analysis, shows how connected learning is part of this performance.

#### 3.2.1 Open network

The statistics show that the Scratch online community it's less dense [Kosorukoff 2011] in 2016 than in 2015, meaning that the network don't shut down on itself through time but, on the opposite, diversifies the voices of its conversations. From the first co-occurrence period (figure 1), the theme "games" was highlighted from the rest, with 13 events. The second collection period (figure 2), with 29 occurrences, the same subject divided attention in the network with topics like "professor", "projects" and "cloud data". About the words found in the network, in the first period there were strong connections of terms like "cloud data" (17 events) and "creation" (5 events), when in the second period these words were more occurrent with others: "cloud data" - mentioned 22 times in 2016 - appeared more with "projects" (36 mentions), that was part of another group of themes in earlier data; and "creation" (9 events) were strongly co-mentioned with "games" (29 events) in the later period of time. These numbers show a community open to new themes, opinions and ideas - an open network feature [Kosorukoff 2011] - alternating types of participation [Ito et al, 2013] from actors interacting through it, creating part rotation when it's about social capital [Boyd and Ellison 2007; Rheingold 2013; Putnam 2000]. It's also interesting to sight that the participation of a new actor, after a long period of no interactions, is followed by the reactivation of the community discussion when this one is centered in collective-interest [Lévy 1998; Rheingold 2002], bringing new opinions and knowledge [Sefton-Green 2013] about certain topic.

#### 3.2.2 Network growth

The network growth differs from the "open network" because the last one is specially based-on the network density, and this one is about the network tendency of having more members over time. To decrease a network it would be necessary to Scratchers erase their conversation forums or their messages in it. By what was shown in this research, this is not a common practice, since there were no messages deleted from a year to the other. From the eight studied forums, only one actor "ended" the discussion topic, thanking the community for collaborating to the initial issue he proposed. The same didn't happened in other discussions strands in Scratch, which increased its interactions from 130 to 759 from the first to the second analysed period.

Compelling these data, it's possible to realize that one of the factors that serve as base to the democratic participation propelling is the Scratch tendency to receive each time more members in its online conversations. In open network, the same composition tends to have more actors and more connections, building an online community [Rheingold 1993; Roque, Rusk and Blanton 2013] whose adherence is influenced by peers common interests [Ito et al 2013].

As an add to the purpose of considering the network growth a democratic mode of participation sphere, the graphs data reveal how the forums have a high increase of participants from the first to the second period. In the same way, the graphs regarding to

two from three metrics presented show that there was also the increasing of influential nodes in the network. In 2015, MaioR, Oi-Adri, julia and Lia were in the group of nodes with the highest indegree; in 2016, the three main positions for indegree raised to six actors: ProfM, MarioR, julia, rolima, Oi-Adri and Lia. The same occurs with the high betweenness centrality nodes [Freeman 1980; Kosorukoff 2011], that is, the ones who connect nodes that connect to other nodes in the network. In the first period of data extraction, there were three actors in featured positions to this metric - Diogo, Savis and MarioR; in the second period, this number became four, including different actors from the first ones, like Estergamer, rolima and Nick. This data detailing presents a network set by 43 actors in 2015 that, with a growth of 62% in the followed period of collection, gets to 113 participants. Both network and Scratchers' degrees grow among time, when there's active participation in forums. Similarly, some nodes have high social capital in both periods, while new participants appear and stand out only in the second one, changing the nodes who have relevant social capital in the online community.

What is stated here as democratic mode of participation involves two segments, specially from network analysis, to point out the context of this participation categorization. By the open network and through the growth of participants number over time, there's the ideal stage to democratic practices in online communities like the one we study for this paper. The data could show the participation of new Scratchers with no interactions to others, or disclose that old community members don't talk to new ones. However, what happens is the bonding of both bases, showing that one of the most frequent modes of participation in Scratch is a democratic one, allowing the constant diversification of themes and social capital on its online conversations. Pursuant to it, this features provide the empowerment [Burd 2007; Ito et al 2013] of its members through a network knowledge exchanging, when the tool is explored this way.

### 3.3 Academic-cognitive mode of participation

The academic-cognitive mode of participation is termed this way because includes two main aspects: the attention to academic sphere and network open to other communities.

#### 3.3.1 Attention to academic sphere

To propose the academic-cognitive mode of participation, this study regards to the contingency and qualitative data, and observes specially the Connected Learning theory on academic sphere as a fundamental element for learning.

With content analysis, Scratch thematics make sense of a community that cares about academic sphere [Ito et al 2013] of learning. Subjects like "cloud data", "games" and "variables" (figure 1 and 2), represent this affirmative when they are linked to topics about helping peers programming fundamentals based-on scholar curriculum disciplines, like geometry - with coordinates x and y, and variables. This result is about the community interactions focusing mainly in projects production. In a particular case, a Scratcher explains how to use variables to alternate commands in a game: he creates an example about the possibility of a player in Africa to have access to what's programmed by another in Brazil, when the codification is build using cloud data. Other community member brings detailing to the explanation he does: this Scratcher explains how to use coordinates x and y to program a pong game. Briefly, learning with peers can be fun [Ito et al 2013; Rheingold 1993] and, while having math, geometry and game

creation lessons by other Scratchers, centering, yet, its learning on projects production [Ito et al 2013; Lévy 1998], the academic-cognitive sphere deserves attention when it comes to informal learning. However, contributing to formal and non-formal educational environments [Sefton-Green 2013].

### 3.3.2 Network open to other communities

The last grounding for academic-cognitive mode of participation is made on the ability of Scratch online community to be open to other communities. At this moment, open network is taken as the connected learning theory, considering the migration from what happens online to other communities [Ito et al 2013], including face-to-face ones.

Through network analysis, it's verified that one of the Scratchers, a school teacher, has low indegree in 2015 and, a year later, in 2016, becomes one of the most contacted actors in the network. This data brings the wonder about why an influential member in the network, taking in consideration his indegree, had so low outdegree, appearing to have no interest in communicating to others. When using the content data, it's known that "teacher", "student" and "school" (figure 2) are strongly connected and composing one of the most relevant thematics by the end of the second collection period. Finally, it's known that the changing indegree level of that actor from a period to the other, the subject around "teacher" and the co-occurrences, were about a discussion forum in which most of members were students from the same school that offers robotics classes with Scratch, and that first actor is their teacher inviting his students to present themselves and talk about their interests in Scratch and life in general.

There are conversations in Scratch that shows interest in themes linked to other online and presential learning communities, like games, languages classes and musical abilities. These factors assemble to the academic-cognitive mode of participation when they integrate Scratch activities being developed in other ambiences, and are expressed as a virtual way in these conversations, where there are other participants with similar interests [Ito et al 2013]. This mode of participation, therefore, understands Scratch online community as a learning space that does not have an exclusive mode of happening. Instead, carries diversity within its performances process.

## 4. Conclusions

In summary, this paper introduces three main modes of connected learning participation mapped from Scratch online community, intending to collaborate to an area that is recent in studies that involves learning through Scratch. First, because it uses Social Network Analysis, something that wasn't a methodology applied to this tool until now. Also, because it’s centered on data from discussion forums of the online community, searching for connected learning specificities. Beyond the typological proposal, this study attempts to education on learning mediated by computational tools. New medias emerge everyday as educational solutions, and this paper confirms the one studied here as empowerment propellant. Scratch is a free-access tool; yet, as other excellent online or face-to-face educational projects, it depends on people, public policies and institutions support to accomplish its inclusion in non-privileged youth and children's lives. Therefore, this study intends to be an inspiration to think and perform further investigations about social interactions while promoters of learning as a community.

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