

BlueFriends

Measuring, analyzing, and preventing social
exclusion between elementary school students

MASTER DISSERTATION

Vítor Hugo Teixeira Belim

MASTER IN INFORMATICS ENGINEERING



UNIVERSIDADE da MADEIRA

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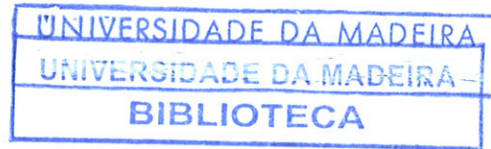
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***BlueFriends: Measuring, analyzing and
preventing social exclusion between elementary
school students***

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(Bachelor)

*Thesis submitted for the Degree of Master
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ABSTRACT

Social exclusion is a relatively recent term, whose creation is attributed to René Lenoir (Lenoir, 1974). Its concept covers a remarkably wide range of social and economic problems, and can be triggered for various reasons: mentally and physically handicapped, abused children, delinquents, multi-problem households, asocial people, and other social “misfits” (Silver, 1995, pp. 63; Foucault, 1992).

With an increasingly multi-cultural population, cultural and social inequalities rapidly ascend, bringing with them the need for educational restructuring. We are living in an ever-more diverse world, and children need to be educated to be receptive to the different types of people around them, especially considering social and cultural aspects. It is with these goals that inclusive education has seen an increased trend in today’s academic environment, reminding us that even though children may be taught under the same roof, discriminatory practices might still happen.

There are, however, a number of developed tools to assess the various dimensions of social networks. These are mostly based on questionnaires and interviews, which tend to be fastidious and don’t allow for longitudinal, large scale measurement.

This thesis introduces *BlueFriends*, a Bluetooth-based measurement tool for social inclusion/exclusion on elementary school classes. The main goals behind the development of this tool were a) understanding how exclusion manifests in students’ behaviors, and b) motivating pro-social behaviors on children through the use of a persuasive technology.

BlueFriends is a distributed application, comprised by an application running on several smartphones, a web-hosted database and a computer providing a visual representation of the data collected on a TV screen, attempting to influence children behaviors. The application makes use of the Bluetooth device present on each phone to continuously sample the RSSI (Received Signal Strength Indication) from other phones, storing the data locally on each phone. All of the stored data is collected, processed and then inserted into the database at the end of each day. At the beginning of each recess, children are reminded of how their behaviors affect others with the help of a visual display, which consists of interactions between dogs. This display illustrates every child’s best friends, as well as which colleagues they don’t interact with as much. Several tips encouraging social interaction and inclusiveness are displayed, inspiring children to change their behaviors towards the colleagues they spend less time with.

This thesis documents the process of designing, deploying and analyzing the results of two field studies. On the first study, we assess how the current developed tools are inferior to our measuring tool by deploying a measurement only study, aimed at perceiving how much information can be obtained by the *BlueFriends* application and attempting to understand how exclusion manifests itself in the school environment. On the second study, we pile on the previous to try and motivate pro-social behaviors on students, with the use of visual cues and recommendations.

Ultimately, we confirm that our measurement tool’s results were satisfying towards measuring and changing children’s behaviors, and conclude with our thoughts on possible future work, suggesting a number of possible extensions and improvements.

KEYWORDS

Social Exclusion;

Interpersonal Behavior;

Connectedness;

Social Network Analysis;

RESUMO

A exclusão social é um termo relativamente recente cuja origem é atribuída a René Lenoir (Lenoir, 1974). O seu conceito abrange uma variadíssima escala de problemas sociais e económicos, podendo ser desencadeado por diversas razões: deficiências motoras ou mentais, crianças vítimas de maus tratos, delinquentes, famílias problemáticas, pessoas socialmente inaptas ou desajustadas (Silver, 1995, pp. 63; Foucault, 1992).

Com uma população cada vez mais multicultural, desigualdades socioculturais rapidamente ascendem, dando azo a necessidades de reestruturação educacional. Estamos a viver num mundo cada vez mais diverso, sendo que as crianças necessitam de ser educadas a serem recetivas aos diferentes tipos de pessoas à sua volta, especialmente tendo em conta aspetos sociais e culturais. É com estes objetivos que a educação inclusiva tem visto um aumento de tendência nos ambientes académicos atuais, lembrando-nos que apesar das crianças poderem ser ensinadas debaixo do mesmo teto, práticas discriminatórias ainda são passíveis de acontecer.

Há, no entanto, um número de ferramentas já desenvolvidas para avaliar às várias dimensões destas redes sociais. Estas são na sua maioria baseadas em questionários e entrevistas, cujas tendem a ser enfadonhas e não permitem medições longitudinais, e em grande escala.

Esta tese apresenta o *BlueFriends*, uma ferramenta de medição de inclusão/exclusão baseada em Bluetooth para escolas primárias. Os principais objetivos por detrás do desenvolvimento desta ferramenta são a) compreender como a exclusão manifesta-se nos comportamentos dos alunos, e b) motivar comportamento pró-sociais nas crianças através do uso de tecnologias persuasivas.

O *BlueFriends* é uma aplicação distribuída, composta de uma aplicação a correr em vários *smartphones*, uma base de dados e um computador que providencia uma representação visual da informação recolhida num ecrã panorâmico, com o objetivo de influenciar os comportamentos das crianças. A aplicação faz uso do dispositivo Bluetooth presente em cada telefone para continuamente recolher dados de IFSR (Indicação de Força de Sinal Recebida) de outros telefones, armazenando os dados localmente em cada telefone. Toda a informação armazenada é recolhida, processada e depois inserida na base de dados no final de cada dia. No princípio de cada intervalo, as crianças são lembradas de como os seus comportamentos afetam outros com a ajuda de um display visual, cujo consiste na interação entre cães. Este display ilustra os melhores amigos de cada criança, bem como os colegas com os quais a criança não interage tanto. Várias dicas que encorajam à interação social e inclusividade são exibidas, inspirando as crianças a modificar os seus comportamentos para com os seus colegas com os quais passam menos tempo.

Esta tese documenta o processo de desenho, implementação e análise dos resultados de dois estudos. No primeiro estudo, avaliamos como as ferramentas atualmente desenvolvidas são inferiores à nossa ferramenta de medição ao implementar um estudo centrado na medição, com o objetivo de constatar quanta informação pode ser obtida através da aplicação *BlueFriends* e tentando perceber como a exclusão manifesta-se no ambiente escolar. No segundo estudo, nós

seguimos o anterior e motivamos comportamentos pró-sociais nos estudantes, fazendo uso de pistas visuais e recomendações.

Ultimamente, nós confirmamos que os resultados inerentes à nossa ferramenta de medição foram satisfatórias relativamente à medição e modificação de comportamentos das crianças, e concluímos com algumas ideias para futuros melhoramentos, sugerindo algumas possíveis extensões e melhorias.

PALAVRAS-CHAVE

Exclusão Social;

Comportamento Interpessoal;

Conexão;

Análise de Redes Sociais;

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ACRONYMS

DC - Diversity Checklist

ICS - Interpersonal Competence Scale

LS - Loneliness Scale

PNI - Peer Nomination Inventory

RSSI - Receive Signal Strength Indication

I. INTRODUCTION

I.1. PROBLEM STATEMENT

Inclusive education has become one of the central focuses of the psychological community, although several challenges in inclusive schools remain. Not only there has been little work on measuring the extent and characteristics of social exclusion (Stanley, 2011), as it is difficult to directly counter-act exclusion, since social successful interactions cannot be forced upon. With this said, it becomes imperative to further analyze how social exclusion and inclusion can impact the welfare of a school social network, studying its complex features.

The development of measuring tools, like Cairns' Interpersonal Competence Scale (Cairns, 1995) and Asher's Loneliness Scale (Asher, Hymel, & Renshaw, 1984) depend heavily upon subjective opinions formed by either students or teachers, which can be misleading. Not only that, questionnaire or interview-type tools don't allow for longitudinal studies, which undermines the actual accuracy and effect of changes enforced upon the community.

Future implications of social exclusion are also very difficult to measure, as all individuals will grow in different ways, with many different experiences. However, people with socializing problems are reported to be lonelier (Horowitz & French, 1979), come from a lower socioeconomic background (Dodge, Pettit, & Bates, 1994) and have later on an increased financial cost to the society (Scott, 2001). Having only socializing problems as a predictor, and many possible outcomes, it is necessary to further increase the study on why these socializing problems prevail, learn how to predict them and attempt to counter them.

I.2. OBJECTIVES

This thesis aims to create a sociometric measuring tool that successfully depicts the structure and inner-ties of a child social network. We will attempt to design, deploy and analyze the results of two field studies.

On the first study, we assess how the current developed tools are inferior to our measuring tool by deploying a measurement only study, aimed at perceiving how much information can be obtained by the *BlueFriends* application and attempting to understand how exclusion manifests itself in the school environment.

On the second study, we pile on the previous to try and motivate pro-social behaviors on students, with the use of visual cues and recommendations. With the use of a Flash application, we will attempt to provide in-time recommendations for better interpersonal connections, while keeping the *BlueFriends* application measurement active for further understanding of the possible changes in the child social network.

It should be emphasized that in both studies there was a constant preoccupation of being as least disruptive as possible towards the normal functioning of both classes and recess.

I.3. METHODOLOGICAL APPROACH

This thesis commenced with the premise that social exclusion is a more and more regular occurrence in most educational facilities, and as such any technological and/or sociological educational approaches that aim at countering it should be regarded as highly important and rewarding. Taking this into account, it will be possible to observe throughout the specification of this thesis the methodological approach that was given, attempting to achieve a pro-social change in behaviors of students mostly, but non exclusively, regarding their least socially-preferred colleagues.

To achieve the objects that we set ourselves to, we started by reviewing a few inclusive and behavior-changing studies and applications in order to understand what has already been done, what conclusions were taken from those studies/applications, and finally designing our own application (*BlueFriends*) and deploying two field studies that would attempt to verify the validity of our measurement efforts in the real-life context, as well as the legitimacy of pro-social behavior changing.

Each study is subdivided into 4 categories:

- ➔ **Related Work** - In this category, we aim to understand what the actual state-of-art regarding each study's objectives is, and offer some background to the ulterior deployment.
- ➔ **Field Study Method** - In this category, we provide the information regarding participants, material, preparation, constraints/problems and the applied study method.
- ➔ **Findings** - In this category we provide the results obtained on each study, as well as all the possible findings arising from them.
- ➔ **Discussion** - In this category, we provide a relational discussion based on the conduction of the study, possibly interesting results and significant interpretations, as well as insight on possible improvements.

II. STUDY I – MEASUREMENT AND ANALYSIS OF SOCIAL INCLUSIVENESS

In this study we describe the development and deployment of a technology for sensing children’s social interactions.

This field study consists of the deployment of the *BlueFriends* monitoring tool, along with some other teacher-reported and child-reported ones. The deployment will aim at being as un-intrusive as possible, while gathering a large amount of data for further correlation and examination. After the monitoring is done, we will meticulously analyze the data obtained, inferring on possible relationships among existent tools and the newly created tool.

To establish the validity of the measurement tool, we correlated the data to those derived from traditional sociometric questionnaires. More specifically, each child answered two surveys: the Loneliness Scale (adapted to 6-8 year-old children), and the Peer Nomination Inventory (age-adapted as well). In addition, each teacher was asked to fill two questionnaires (Diversity Checklist and Interpersonal Competence Scale).

We expect the *BlueFriends* approach to be less time consuming, less fatiguing and more accurate than the existing technologies for sociometric measurement, due to its lack of need for subjective student or teacher opinions, while verifying how these correlated with the network’s centrality research.

On the words of Mittler, “We are far from understanding why and how children from poorer backgrounds so often underachieve in school, far less what can be done to reduce or eliminate such disparities. There is no single or simple explanation.” (Mittler, 2000)

II.1. RELATED WORK

II.1.1.Exclusion

“Social exclusion is a multidimensional process of progressive social rupture, detaching groups and individuals from social relations and institutions and preventing them from full participation in the normal, normatively prescribed activities of the society in which they live.” (Silver, 2007).

Social exclusion, or marginalization, is defined by a social shortcoming and disregardment to the peripheral side of society. It refers to the process in which individuals are constantly stripped from their rights, new opportunities and available resources that are normally accessible by all the adjacent society, being crucial for social integration (McDowell, s.d.).

Exclusion itself can be present on different forms, varying on the contributor. Many contributors include race, social status, personal habits/appearance, education, religion, etc., but fit mostly into 2 categories: Individual and Community Exclusion.

Individual exclusion, voluntary or involuntary, depicts that an individual should be deranged from society due to some kind of deviant behavior/condition he/she withstands. Involuntarily excluded people, such as single mothers who often in the past were exorcized from society based on a cultural bias towards unwed females (Garfinkel & McLanahan, 1986), are the primary targets of individual rejection by society, while voluntarily, an individual’s self-withdrawal from participation, can nonetheless be viewed as social exclusion (e.g. an individual who withdraws himself from social participation based on a previous experience of hostility and/or discrimination) (Barry, 2002),

On the other hand, Community exclusion (such as racial or economic status discriminations) illustrates social despise for a certain feature inherent to people. “Social exclusion is something that can happen to anyone. But certain groups, such as (...) those growing up in low income households or with family conflict, those who do not attend school, and people from some minority ethnic communities are disproportionately at risk of social exclusion.” (Unit & Britain, 2001)

Future implications of social exclusion are difficult to measure, as all individuals will grow in different ways, with many different experiences. However, people with socializing problems are reported to be lonelier (Horowitz & French, 1979), come from a lower socioeconomic background (Dodge, Pettit, & Bates, 1994) and have later on an increased financial cost to the society (Scott, 2001). Having only socializing problems as a predictor, and many possible outcomes, it is necessary to further increase the study on why these socializing problems prevail, learn how to predict them and attempt to counter them.

II.1.2.Inclusive Education

Generally, inclusion is a term used to advocate the right for disabled people to be accepted liberally, openly, and without pity, and to be accommodated accordingly, free of restrictions or limitations of any kind. Although this seems very straight forward and fair, only recently with the introduction of the Individuals with Disabilities Education Act (IDEA), a significant change to the whole teaching paradigm has been spotted. Before this, most of special

education needs were answered with segregation, thus retracting the disabled child from a “normal” environment and placing him/her under a need-adapted closed environment. This kind of segregation and isolation generates a permanent underclass of students, while causing them to feel as if they are not good enough, don’t fit in or belong because they couldn’t meet a certain default standard. Norman Kunc (2000) explains the hazards of “conditional acceptance” (i.e. exclusion). He points out that many of the problems recurrent in today’s children and youth are the effects of an unbending, unresponsive educational system that progressively destroys the self-esteem and self-worth of students who do not “fit the mold”.

Education-wise, inclusion is defined as a process of restructuring the school as a whole, making sure that all students have access to the whole spectrum of educational and social opportunities offered by the school. This has the objective of avoiding segregation and isolation, and is designed to bring benefits for all students, including those from ethnic or linguistic minorities, those with disabilities or special learning needs, among others. (Mittler, 2000)

As stated by (Falvey & Givner, 2005), all restructuring efforts in schools require, at the very minimum, the conviction that:

- “Each student can and will learn and succeed;
- Diversity enriches us all, and students at risk can overcome the risk for failure through involvement in a thoughtful and caring community of learners;
- Each student has unique contributions to offer to other learners;
- Each student has strengths and needs;
- Services and supports should not be relegated to one setting (e.g. special classes or schools);
- Effective learning results from the collaborative efforts of everyone working to ensure each student’s success.”

These suggestions offer a guideline towards making inclusion a reality. Belief in the inclusion results, diversity as an advantage towards learning and successful involvement, appreciation of every individual’s unique contributions, strengths and needs, no academic segregation whatsoever and collaborative effort towards effective learning are the basis for an inclusive social environment.

But even with these in mind, measuring the impact of such a restructure using observation only could be an impossible to achieve task. Henceforth, there is a need to further understand how these child social networks work, for accurate measurement and ulterior analysis.

The following section describes some of the previous approaches for measuring social inclusiveness. Some benefits and constraints will be further analyzed and discussed as well.

II.1.2.1.Approaches to Measuring Social Inclusion

Quoting Wiggins, “Social popularity (...) seems to be severely limited by the vicissitudes of the significant others involved.” (Wiggins & Winder, 1961) In fact, measuring the social status of students in relation to their peers can act as a tool to measure the social inclusion or exclusion of each child. Wiggins’s Peer Nomination Inventory is still used nowadays as one of the most widely adopted measuring tools for social cohesiveness of school communities. While taking advantage of the informed insight of children’s self-reported behaviors, the PNI determines observed physical, disruptive and retaliatory behaviors, among other relevant

metrics. It consists of several questions, covering peer characterization, likeability, aversion and deviated behaviors.

Question 1	Name which classmates you like the most (up to three names).	<i>Most Preferred</i>
Question 2	Name which classmates you like the least (up to three names).	<i>Least Preferred</i>
Question 3	Name which classmates start fights, say mean things to other kids or push them, or hit them (up to three names).	<i>Bully</i>
Question 4	Name which classmates are teased by others or called names a lot (up to three names).	<i>Victim</i>
Question 5	Name which classmates do mean things to others who are not watching and/or listening. For example, colleagues who spread rumors about other colleagues or tell them to go away when they play (up to three names).	<i>Relational Aggressor</i>
Question 6	Name which classmates play or do school tasks alone a lot (up to three names).	<i>Withdrawn</i>
Question 7	Name which classmates are often good leaders and other children like to have them in charge (up to three names).	<i>Leader</i>

Table 1 - PNI questions.

Despite its widespread adoption, PNI suffers from a number of limitations. First, PNI is designed to measure peer status and relative popularity, it does not allow the children to nominate themselves, and therefore could potentially hide relevant feelings of loneliness and/or exclusion. Second, being a self-reporting tool, PNI measures attitudes towards social behaviors but not overt behaviors. Third, PNI is cumbersome to deploy in longitudinal settings where repeated measures are required to assess the impact of educational or technological interventions on children’s behaviors. This has led to thus leading to a criticism over the lack of empirical data on how exclusion is manifested in children’s behaviors (Simpson, 2004) and at large (Fryxell & Kennedy., 1995).

Another approach to measuring children’s sociometric statuses is Cairns Interpersonal Competence Scale. The ICS consists of brief rating scales for teachers, being composed of “18 items that assess social and behavioral characteristics of children (...)” (Cairns, 1995). This teacher reported tool consists of the assessment of children’s social development by adult ratings. It is designed to be brief (2-4 minute completion time, proving the adult in question is well acquainted with the child), easy to administrate and understand, cover a wide range of sociological levels (i.e. aggressive patterns, peer social acceptance, academic/school performance, affiliation propensities, among others) and be flexible in usage (Cairns, 1995).

		7-point Likert Scale						
Q1: <i>Argue</i>	Never Argues			Sometimes			Always Argues	
Q2: <i>Trouble</i>	Always gets in trouble at school			Sometimes			Never gets in trouble at school	
Q3: <i>Smile</i>	Always smiles			Sometimes			Never smiles	
Q4: <i>Pop. w/ Boys</i>	Not popular with boys			So-So			Very popular with boys	
Q5: <i>Shy</i>	Not shy			So-So			Very shy	
Q6: <i>Sports</i>	Very good at sports			So-So			Not good at sports	
Q7: <i>Looking</i>	Very good looking			So-So			Not good looking	
Q8: <i>Spelling</i>	Very good at spelling			So-So			Not good at spelling	
Q9: <i>Fight</i>	Always gets in a fight			Sometimes			Never gets in a fight	
Q10: <i>Sad</i>	Never sad			Sometimes			Always sad	
Q11: <i>Math</i>	Not good at math			So-So			Very good at math	
Q12: <i>Pop. w/ Girls</i>	Very popular with girls			So-So			Not popular with girls	
Q13: <i>Friends</i>	Lots of Friends			Some Friends			No friends	
Q14: ---	Never gets his/her way			Sometimes			Always gets his/her way	
Q15: <i>Worry</i>	Never worries			Sometimes			Always worries	
Q16: <i>Win</i>	Wins a lot			Sometimes			Never wins	
Q17: <i>Friendly</i>	Never friendly			Sometimes			Always friendly	
Q18: ---	Cries a lot			Sometimes			Never cries	

Table 1 - ICS questions.

Teacher’s questionnaires on the other hand have shown too susceptible to biases. For instance, research has found teachers to be overestimating the social interactions of children at risk of social exclusion.

Understanding that the current measurement tools aren’t enough to have a real sense of the student’s actual feelings and behaviors, it is necessary to further analyze how child social networks work and what kind of measurements are of critical importance for the understanding and analysis of child behavioral patterns.

The following section gives a brief introduction of what social networks are, its components and key aspects for proper network analysis, while attempting to co-relate these with the study at hand.

II.1.3.Introduction to Social Networks

Networks have been one of the main subjects under study by social sciences. Investigating issues such as the strength of connections, influence and connectivity between individuals are the main objectives (Newman, 2003) to understanding its functioning.

A classroom’s main functioning works within the same concept as social networks. It is based on this notion that we proceed to identify the correlations between the two in an intent to comprehend each distinct role and its influence and/or impact in the social network.

With a similar set of items, we can interpret a network as the classroom, nodes as the children, edges as the relationships between the children, and communities as small groups formed inside the class.

In order to understand a class' functioning, hierarchy and its subject's behaviors, there are some relevant topics that have to be questioned and analyzed such as: "are the children connected to their classmates?" – Does sharing the same class prove to be enough for them to interact or not; "How far apart are the children?" – How strong are the connections between children and how many are connected through mutual friends; "do children have different levels of impact due to their position in the class?" – Is their popularity or social position in general a relevant factor towards social interaction; and "is the class composed of communities?" – Are classrooms divided into several little groups, or medium to large ones, and how much weight and influence do these groups have?

These questions will allow us to gain a better knowledge regarding the class and its students, and hopefully achieve a prediction for the development of their social behaviors.

II.1.3.1. Network Basics

Network Elements: Edges

In what comes to network elements, specifically edges, they can be classified as directed or undirected. Directed are also called arcs or links. This means that A likes B or A is B's child, meaning that their relation goes from A to B although not the other way around. Undirected is when the relationship goes both ways, in others words, when students A and B like each other, are siblings, co-authors.

Directed edges in children networks can be interpreted from peer nominations. When a child nominates another as his/her favorite colleague, the opposite doesn't necessarily happen (i.e. child A prefers child B, child B can prefer child A or not).

Undirected edges, however, can be related to proximity measurement. When a child is near another one, the latter has to be near the first (i.e. child A is near child B, Child B has to be near child A).

Substantially there are some attributes to take into account when referring to edges, such as the weight, meaning how frequently they communicate; the ranking or degree of the relationship, if they're best friends or second best friends; the type/nature of the relationship and affiliation between them, whether they are friends, relatives or co-workers; and centrality properties, depending on the structure of the rest of the graph (e.g. betweenness)

Computing Metrics

It is crucial to identify the degree of the relationships or in other words, which node has the most edges, projecting into this study as the following question: "which child has more relationships or contacts?"

For each node's network properties from immediate connections, it is possible to identify three defined subcategories: in-degree, which lets us know how many directed edges (arcs) point towards a node; out-degree, which shows how many directed edges (arcs) originate at a node; and degree (in or out), which identifies the total number of edges incident on a node.

Projecting these concepts into our study, taking peer nomination into account: the in-degree lets us know the number of children who nominated that child as per instance the leader; the out-degree shows how many nominations the child did towards his/her peers; and degree (in or out) identifies the total number of nominations a child did and received.

We can also study Node network properties for the entire graph to grasp centrality measurements (e.g. betweenness, closeness, and eigenvector centralities).

II.1.3.2. Network Centrality

When measuring based on centrality, many different characteristics have been proposed, subdividing in two types: power/influence and communication. For instance, it was proposed by Friedkin that "power/influence measures are the result of derivation from an elementary process modeling of social influence" (Friedkin, 1991). Freeman, however, presented three classic centrality measures established by his synthesis of his previous investigation on communication and group processes, concerning communication networks (Freeman, A set of measures of centrality based on betweenness, 1977).

Since our data concerns several standards of communications, Freeman's notions of measurement, such as degree, betweenness and closeness centralities are appropriate, because they allow for further exploration of different dimensions of centrality regarding communication networks (Freeman, Centrality in social networks conceptual clarification, 1979). Moreover, our study is based on the sum of minimum distances between peers, revealing the accuracy of this group of measures since the connectivity settings are assured (Freeman, A set of measures of centrality based on betweenness, 1977).

Community Structure

Social Networks are found to divide naturally into subgroups or communities, which can often refer to small social units of any size that share common values. When found and analyzed, communities can provide crucial information to better help us understand and visualize the network's structure (Leicht, 2008).

Looking at a more general definition, there's less probability of a pair of nodes being connected if they don't allocate the same community, as well as there is a higher probability that they are connected if they share the same community.

When placed in the context of networks, community structure refers to the higher internal density of connections in groups of nodes, in comparison to the rest of the network. When this is the case, it is possible to observe how nodes are joined together in tightly knit groups, which provides significant and informative community divisions.

Displaying a community structure is not a requisite needed by all networks. So, this brings us to an important question: why do we look for community structure?

When taking a given network as an object of study, it is instantly known that such group is composed of various elements, which weight differently on the whole community and are always organized as a hierarchy. It is also known that a network is composed of one or more communities. Due to the complexity of such, it is crucial to analyze its behavior, in order to get to its core. With this said, the first step towards understanding how a given network works is to seek its natural divisions and its underlying structure.

II.1.3.3. Information and Opinion Propagation

When it comes to social networks, there are some important interaction factors that have to be taken into account, essentially to understand behavioral aspects of the group in question, such as contagion, opinion formation, coordination and cooperation.

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Contagion can be characterized as simple or complex. Simple contagion happens when a node infects another one, with some probability for each unit of time. Complex contagion is identified when the contagion only spreads if a certain number of a node's neighbors are infected. In a classroom, per instance, we can observe simple contagion when a child accepts another child's opinion related to a certain matter (i.e. somehow child A influences child B). In complex contagion we can observe that a child's opinion is formed based on the group's opinion (per instance, when the group has a negative opinion towards child B, child A will also share this opinion, based on the weight of his/her group's elements).

This brings us to the question: how significant is group cohesion towards opinion diffusion? It has, in fact, a considerable weight in opinion formation and uniformity since "contagion by cohesion occurs because of socializing communications" (Burt, 1999), therefore the higher the communication's frequency and empathy is, the higher the chance of accepting a new idea or behavior will be.

When looking at group cohesion, its concept is based on elements working towards the same goal, similar interests among the elements, or sense of belonging and interpersonal attraction amongst the group. Therefore, when each node/element adopts the opinion of the majority of its neighbors, it is possible to obtain different opinions in different cohesive subgroups.

With the concept of community and cohesive groups, sharing ideas and opinions becomes common practice, although these could lead to a potential identity loss. By definition, brainstorming is good, because more minds are put together. Nevertheless, there is a danger of group thinking (i.e. minimizing conflict and reaching a consensus decision without critical evaluation of alternate ideas or view points).

Taking these aspects into account, it is necessary to gather a large amount of data from children social networks, as to have a better insight on how groups can be influencing towards overall children's sense of belongingness and loneliness, and to analyze how group-formed opinions about peers can expand to the rest of the network.

II.2. FIELD STUDY METHOD

II.2.1.Participants

This study was followed through at Escola Básica do 1º Ciclo com Pré-Escolar Eng. Luís Santos, an elementary school located in Machico, from the 11th until the 28th of June (3 weeks, 14 school days). The class levels available ranged from kindergarten to 4th year, which would position children's ages between 4 to 12 years old. According to the type of study we were trying to conduct, we decided it would be best if the children were 7 years old or older, hence we chose three 2nd year and three 3rd year classes to participate in the study.

We observed six classes, with a total of 141 children, aged between 7 to 10 years-old approximately (no specific data of age per child; male = 70). Of these 141 children, 3 children were part of Special Education, not attending normal classes, and 1 child was out of the country. These were, therefore, not part of our study.

II.2.2.Preparation

A series of material was necessary to deploy the study. Namely, 26 phones were used (9 x Android, 17 x Nokia N95), 13 chargers (3 x Android, 10 x Nokia), 26 phone pouches (9 x Android size, 17 x Nokia size), 17 belts (to adapt to different child sizes) built out of 14 meters of elastic and 7 meters of Velcro, 26 padlocks, ~300 printed questionnaires (2 per child, 2 per teacher) and a camera (Cannon EOS 350D).

Since the Nokia pouches were actually camera pouches, there was no way of attaching them to children. Hence, we took 14 meters of elastic and 7 meters of Velcro and sewed them all together to act as adjustably-sized belts. Also, all the pouches were numerally tagged with stickers, as to make it possible to identify who had which pouch.

The questionnaires used for both students and teachers were based on existing ones, being adapted to better fit the age of the participants, as well as crossing language barriers (i.e. all were translated from English to Portuguese). These are explained in-depth on the Questionnaires section.

The study was conducted throughout the normal course of classes, while striving to be as non-evasive as possible. The children didn't know the purpose of the study, as to not be tempted to manipulate the results, and were constantly reminded that the devices that they were wearing should not be an impediment towards their normal recess activities.

II.2.2.1.Application Development

The Android application to measure and store RSSI (Received Signal Strength Indication) values was also developed before the field study. Since the application was for measurement purposes only, there was no need to envision different personas nor scenarios.

The concept of the application relies on the communication and measuring possibilities of Bluetooth, combined with the versatility and potential of Android development.

The application consists of a module programmed to continuously discover the Bluetooth devices nearby. While using this discovery, it is possible to obtain all the info related

to each discovered Bluetooth device, including the RSSI measurement. This is done on a *BroadcastReceiver*, a listener Class which is in charge of handling Bluetooth broadcasts. The code snippet that follows demonstrates how the RSSI data is obtained (in a simplified manner).

```

static BroadcastReceiver ActionFoundReceiver = new BroadcastReceiver(){ // Assessing and handling module for Bluetooth actions
    (...) // Java specific details
    public void onReceive(Context context, final Intent intent) { // Execute procedure when Bluetooth data is received
        (...)
        try { // Attempt to:
            if(BluetoothDevice.ACTION_FOUND.equals(action)) { // If Bluetooth device has been found
                (...) // Reschedule Bluetooth forced reset
                BluetoothDevice device =
                    intent.getParcelableExtra(BluetoothDevice.EXTRA_DEVICE); // GET NEW DEVICE
                short rssi =
                    intent.getShortExtra(BluetoothDevice.EXTRA_RSSI, (short)0); // GET RSSI INFO
                if (device != null && device.getName() != null && rssi != 0) { // Check if newly found device and rssi are valid
                    (...) // Save found device with rssi and timestamp
                    (...) // Search list for device
                    (...) // Add new device or update rssi of known device
                    (...) // Update number of devices found
                }
            }
            if (mBluetoothAdapter.ACTION_DISCOVERY_STARTED.equals(action)) { // If discovery has just started
                (...) // Reset counters
            }
        } catch (Exception e) { // If error occurred while new found device was processed
            (...) // Print error stack trace
        } finally { // After everything is done, with or without error
            (...) // Update counters
        }
    }
};

```

Figure 1- Simplified code of the Broadcast Receiver module.

As observable, the code was reduced for easier comprehension, although the most important lines are still present. At the right, there is an explanation on what the code is doing/processing. The code which allows for the capture of the RSSI values has its comments written in capital letters.

Every 3 seconds, the data collected is stored into the phone’s local database as a text file, following the CSV format (Comma-Separated Values). This was done to ensure that the files would be easily exported to Microsoft’s Excel program, for later on processing and analyzing.

The application had also a simple user interface presenting the phones it was tracking in the nearby area. This user interface was exclusively used by the researchers, since children had no access to the phones, and therefore is not considered relevant to be shown here.

Although the measurement of RSSI is supported since Android version 2.0 (Bluetooth Device, s.d.), which was released on November 2009 (Android 2.0, Release 1, s.d.), there hasn’t been many studies or projects around the obtainment of correlation values between signal strength and actual distance. The following section describes how we obtained a trustable interval that would allow us to infer one from the other.

II.2.2.2.Measurement Testing

We conducted an experimental test to determine proper threshold values for data interpretation. Due to Bluetooth’s limitations, it was only possible to sample the RSSI values every 12 seconds, which resulted in about 5 measurements per minute. With this in mind, the

testing took 4 minutes for each position, which would result in 20 samples or so (enough number of samples to make a mean viable).

In order to perceive how distance (in meters) would translate to RSSI measurements, tests were made within a 10 meter range. Rotation was also taken into account, 4 specific positions for each 1-meter length, determined by the angle at which the test subject would be positioned comparatively to subject 0.

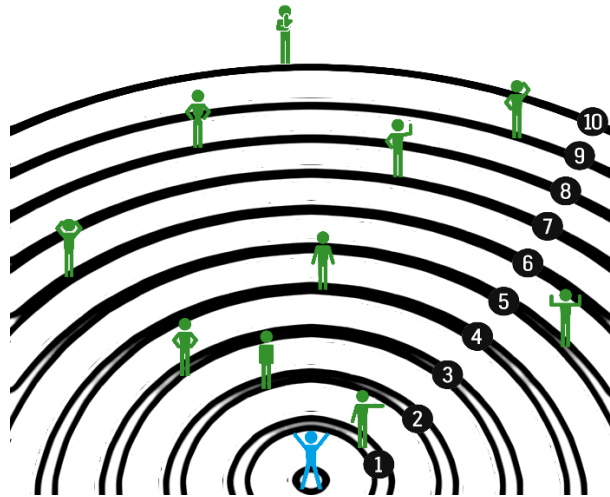


Figure 2 - Subject disposition scheme for testing.

The procedure occurred in the following way: with the purpose of recreating an environment that would be closer to a real one, it was requested for subjects to wear jeans and set their devices in their left front pocket. They were also asked to keep the screen facing them, in order to achieve a better signal strength. Subject 0's position was considered as the initial point, and was the only one measuring all others. The test subjects were then positioned 1 by 1, from 1 to 10 meters, separately.

For each 1-meter mark, 4 distinct angles were measured (0, 90, 180 and 270 degrees). The intent behind these rotations was to understand if the angles would have any influence, and if so, its impact on the receiving signals. The triangulation was made through one android Smartphone (assigned to subject 0) and Nokia phones.

The results for the previously explained test can be found further down on the "Findings" topic, as well as the data interpretation and defined threshold values.

II.2.2.3. Questionnaires

All the data collected from the questionnaires has been anonymized, respecting the school's privacy policy and protecting the identity of the children. We will henceforth denominate 2nd year classes from 2A to 2C, and 3rd year classes from 3A to 3C.

The gathered data will be presented and discussed individually for each class, but analyzed as a whole. The decision to merge all classes is based on the conjecture that an average of 26 students per class does not contain enough data to successfully analyze behavioral patterns.

Interpersonal Competence Scale

The Interpersonal Competence Scale (Cairns, 1995) is an important asset to this project because of its brief, useful and assertive measuring method for social development of children by adults, in this case the teachers, and its set of succinct rating scales, which helps us how to better understand each student and their social behavior. This is possible through the assembling of information on basic social and cognitive domains, which can then provide strong assessments of present behaviors and reliable predictions of future social adjustment.

The ICS is composed of 18 topics, consisting of three major subcategories: Aggressiveness (AGG), which measures arguing, having problems in school and getting into fights; Popularity (POP), quantifying popularity with boys, with girls, and number of friends; and Academic Achievement (ACA), which describes the level of spelling and math of the student.

Secondary factors include Social Affiliation (AFF), which measures the stability in interpersonal relationships involving frequent interaction and positive sentiment (smile, friendly), "Olympian" quantities (OLY), which measures children's capacities towards sports, victories and appearance, Internalizing Problems (INT), which rates the level of sadness, worrying and shyness, and Interpersonal Competence Scale Scores (ICSS), which sums up all the previously referred to categories (with the exception of the internalizing problems category).

These factors are measured in a Lambert's 7-point scale. In the AGG and INT categories, a low score is a positive factor and a high score a negative one. It is important to point out that these scores follow the opposite pattern of all of the remaining topics (i.e. high scores are positive factors).

Diversity Checklist

The Diversity Checklist is focused on gathering specific and detailed information, reported by the teacher, related to social surroundings, socio-economic factors and learning barriers that are crucial to children's social behavior and their social development. It also collects information on ethnicity and above average skills. This data, in conjunction with all the other questionnaires, can help to better understand different behavioral patterns adopted by children, and whether they are related to any socio-economic problems or learning disabilities.

This study consists of 8 items, subdivided into 4 categories. The first category is learning barriers, divided into 2 topics: learning disabilities, which accounts for reading/writing difficulties and diagnosed learning disorders; and special educational needs, such as autism, physical/mental disabilities and chronic diseases. The second category encompasses low socio-economic levels, determining whether the child is a part of a multi-problem household or shows signs of poverty, and poor social conditions, identifying if the child rejects or is rejected by his/her colleagues, or exhibits signs of loneliness. The third category focuses on multicultural factors, such as ethnicity, skin color or whether they are emigrants. The fourth and final category approaches above average intelligence/gifted children.

In addition to this study, a column of additional observations was included to identify any specific condition deemed relevant by the teacher. Although some teachers did not develop the topics, open ended questions were made in order to obtain detailed information, and thus a better understanding of each student's reality.

Loneliness Scale

On the Loneliness Scale (Asher, Hymel, & Renshaw, 1984), it is essential to identify and understand children's difficulties in their peer relationships. In addition to external data information such as the ICS and its rating by teachers through behavioral observations and cognitive domains, it is also substantial to support these assessment procedures with children's self-reports and their degree of satisfaction with their peer relationships. This study was developed to measure loneliness and social dissatisfaction through a 16-item self-report, which was found to be internally reliable.

The main focus of these 16-items study are children's feelings of loneliness (e.g. "I feel lonely."), feelings of social adequacy/inadequacy (e.g. "I get along with other children."), and subjective approximation of social status (e.g., "I have many friends."). The remaining 8 items focus on children's hobbies or favorite activities (e.g., "I like arts"; "I watch TV often"). These 8 items were included in the study so that children would feel more comfortable about indicating their attitudes concerning the various topics.

In total, children answered to 24 topics, which were measured on a five-point scale identifying the veracity of each statement about themselves (i.e., It is always true to me, It is often true to me, It is sometimes true to me, It is almost never true to me, It is never true to me). The possible summed score from the LS ranges from a minimum of 16 to a maximum of 80. We sub-divided these into 5 different categories: always social (< 24), social most of the time (> 24 and < 40), sometimes social (> 40 and < 56), almost never social (> 56 and < 72) and never social (> 72).

Peer Nomination Inventory

The Peer Nomination Inventory (PNI) serves an important role in understanding what kind of behaviors children observe in their classroom. We attempt with this children's self-report of aggressive behavior to better understand the relationships between children, determining observed physical, disruptive and retaliatory behaviors, among other metrics that seemed relevant.

The PNI consists of 7 questions, covering 3 themes: Peer characterization – determining different types of personalities among the children's colleagues, focusing on bullies, victims and leaders; Likeability and aversion – identification of the most and least preferred colleagues; Deviated behavior – recognition of digressed behavioral patterns, specifically relational aggression and social withdrawal.

All questions allowed the child to nominate a maximum of 3 classroom colleagues who they thought were fitting, but prohibited the child from nominating herself. This prevented self-victimization by the children, but could also hide potentially relevant feelings of loneliness (withdrawal evaluation) and/or exclusion (victim identification).

II.2.3.Constraints / Problems

Although the application was fully functional before the beginning of the deployment, different phone versions and hardware made it very unstable on the very few first days. The application was then completely remodeled half-way through the deployment, which cost us some measurements from the first and mid-second weeks.

Also, since the deployment had to be done while the children were playing outside, adverse weather conditions made it impossible to measure anything on the 17th of June. Rain prevented the children from being free to play wherever they wanted, with whoever they wanted, and therefore measuring anything on those conditions would be inaccurate.

Likewise, due to a musical parade, it was not possible to measure anything on the 21st of June. All of these lead to a delay on our predicted schedule, and made it impossible for us to measure the 8 classes we had defined at first.

Another problem we encountered was that the material at hand wasn't enough to measure everyone at the same time. The application developed targeted Android mobiles, and unfortunately, there weren't enough to measure everyone at the same time. This constraint was worked around by rotating the phones, handing out 9 androids at each rotation, while the rest would get a Nokia phone.

		Students	Assigned Phone	Class Measurement Progress
1 Full Measurement	day 1	1 - 9	Android	33%
		Rest	Nokia	
	day 2	10 - 18	Android	66%
		Rest	Nokia	
	day 3	Rest	Android	100%
		1 - 18	Nokia	

Table 2 - Schematic of the phone rotations.

The Nokia phones weren't able to collect data, but were able to transmit their Bluetooth signal, which was then captured by the Android smartphones. As illustrated in the above schematic, a total of 3 rotations per class was enough to successfully collect RSSI readings from everyone, since 9 Android devices rotated 3 times amounted to 27 children measured (maximum number of children per class was 26). It should be taken into account that this is not an ideal situation, as there could have been a lot more data retrieval if there were enough Androids for the whole class.

II.2.4.Method

The school had 2 different schedules, morning classes (1st and 2nd years) and afternoon classes (3rd and 4th years). Since there were only 2 reliable recesses, 1 for each schedule, we were able to collect measurements twice a day, 1 class in the morning and 1 class in the afternoon. A total of 3 days were necessary to complete the RSSI measurement for each class (see previous section for Android rotation explanation).

On the first day of each class, we arrived at the classroom 20 minutes prior to the recess to fully explain what we were doing, and lay out some ground rules, such as "don't try to open nor take off the pouches". After that, each child got a phone assigned and strapped-on by us, allowing us to keep track of who had which.

On the second day, we arrived at each classroom 30 minutes prior to recess, to deliver and help the children fill the LS questionnaire, as well as handing out the phones. The Android smartphones were rotated, as previously explained, so as to be able to collect RSSI data from each child.

On the third day, we arrived at each classroom 20 minutes prior to recess, delivering the PNI questionnaire and handing out the phones for the last time. We also delivered both ICS and DC questionnaires to the teacher, collecting them on the last day of school, to ensure there was no pressure on filling them, while also being non-intrusive.

We retrieved all the phones at the end of each recess, on the main hall. During the retrieval, each child and phone was confirmed, to ensure no children were swapping pouches.

The procedure was exactly the same for every class.

II.3. FINDINGS

II.3.1. Questionnaire Analysis

II.3.1.1. ICS

The following table summarizes the data collected from the ICS questionnaires regarding class 2A, identifying both highest and lowest students' ICS scores, as well as the average score for each category. Since both highest and lowest scores are shown, those that are considered to be negative have a colored background (ex: high aggressiveness).

Categories	Low ICS Scores	High ICS Scores	Average Score
Aggressiveness	• Students: 1, 10, 11, 19, 24 (1.0)	• Students: 9, 13 (7.0) • Student 25 (6.0)	3.3
Academic Achievement	• Students 4, 13 (1.8)	• Students 1, 6, 15, 19, 20, 26 (7.0)	4.9
Popularity	• Student 24 (1.0) • Student 21 (1.5)	• Student 1, 19 (7.0) • Student 17 (6.0)	3.9
Social Affiliation	• Student 13 (1.8)	• Students 6, 10, 19, 20 (7.0)	4.5
“Olympian” Quantities	• Student 13 (3.0) • Student 8 (3.5)	• Student 17 (7.0) • Student 6 (6.0)	4.7
Internalizing Problems	• Students 9, 25 (2.0)	• Student 19 (6.0)	3.8
Summed ICS Scores	• Student 13 (1.9)	• Students 1, 19 (6.6)	4.6

Table 3 - ICS Results for class 2A

*Numbers in between parenthesis are the scores obtained

** Orange cells are negative factors

We can observe through the previous table that student 13, specifically, has been quoted in most categories negatively. High aggressiveness (7.0), low academic achievement (1.8), low social affiliation (1.8) and low “Olympian” quantities (3.0) translate into the lowest summed ICS score of class (1.9).

On the other hand, Student 19, highly scored in academic achievement, popularity, social affiliation (all at 7.0) and summed ICS score (6.6), is quoted at internalizing problems (being sad, worried and shy) as the highest (6.0) of his class.

Categories	Low ICS Scores	High ICS Scores	Average Score
Aggressiveness	• Students 6, 8, 9, 12, 13, 22 (1.0)	• Students 3, 16 (7.0)	3.2
Academic Achievement	• Students 11, 15 (1.0)	• Students 1, 9, 19, 23, 24 (7.0)	4.7
Popularity	• Student 11 (2.0)	• Students 3, 7 (7.0)	5.3
Social Affiliation	• Students 3, 11 (4.0)	• Students 4, 6, 12, 13, 22, 24 (7.0)	5.7
“Olympian” Quantities	• Student 8 (3.5)	• Students 3, 7, 10, 12, 17, 20, 21 (6.5)	5.5
Internalizing Problems	• Student 3 (1.5)	• Student 11 (6.5) • Students 5, 9 (6.0)	3.5
Summed ICS Scores	• Student 16 (3.4) • Student 11 (3.5)	• Student 24 (6.5) • Student 22 (6.4) • Student 12 (6.2)	5.2

Table 4 - ICS Results for class 2B

*Numbers in between parenthesis are the scores obtained

** Orange cells are negative factors

In class 2B, student 3 is highly quoted in popularity (7.0) and Olympian quantities (6.5), but also quoted as highly aggressive (7.0). This can be interpreted that, in spite of his high aggressiveness level, the main reason towards his high popularity is his high “Olympian” quantities rating. Although this student is low rated in social affiliation (4.0), this is an intermediate value, thus not relevant. Also, he is considered to be the happiest child of his class (INT=1.5).

Student 11 is one of the lowest rated of this class. His minimally rated academic achievement (1.0), low popularity (2.0), and highest class rating for internalizing problems (6.5), translate into a low summed ICS score (3.5). Based on these values, this student could be seen as the most troubled/anxious child in his class.

On a general note, it should be emphasized that this class has high average social affiliation and “Olympian” quantities (5.7 and 5.5, respectively).

Categories	Low ICS Scores	High ICS Scores	Average Score
Aggressiveness	• Students 1, 25 (1.0) • Students 3, 8 (1.5)	• Student 4 (5.0) • Students 22, 26 (4.5)	2.6
Academic Achievement	• Student 8 (1.0)	• Students 3, 13, 24 (7.0)	5.0
Popularity	• Student 8 (4.0)	• Students 13, 24 (7.0) • Students 3, 7 (6.5)	5.3
Social Affiliation	• Students 17, 22, 23, 26 (4.8)	• Students 3, 7, 9, 16, 20, 24, 25 (7.0)	6.0
“Olympian” Quantities	• Students 1, 8, 25 (4.5)	• Student 13 (6.5) • Students 3, 19, 24 (6.0)	5.2
Internalizing Problems	• Student 2 (2.5) • Student 26 (3.0)	• Students 10, 23, 25 (5.0)	4.0
Summed ICS Scores	• Student 22 (4.1)	• Student 3 (6.6) • Students 13, 24 (6.5)	5.4

Table 5 - ICS Results for class 2C

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*Numbers in between parenthesis are the scores obtained

** Orange cells are negative factors

3 distinct situations are noticeable in the previous table. Students 3, 13 and 24 stand out positively as the highest quoted in 5 categories. These 3 students share the highest scores for academic achievement (6.6, 6.5 and 6.5, respectively), popularity (6.5, 7.0, 7.0), “Olympic” quantities (6.0, 6.5, 6.0), and summed ICS scores (6.6, 6.5, 6.5). They diverge on aggressiveness, with student 3 as the only one minimally quoted (1.5), and social affiliation, in which only students 3 and 24 stood out (7.0).

The second situation refers to student 8. Although he’s not minimally or highly quoted in summed ICS scores, he’s minimally quoted in 4 out of 7 categories: aggressiveness (1.5), academic achievement (1.0), popularity (4.0) and “Olympian” quantities (4.5).

On a general note, it should be emphasized that this is an averagely non-aggressive class (2.6), with a high average on popularity (5.3), social affiliation (6.0), “Olympian” quantities (5.2) and summed ICS scores (5.4).

Categories	Low ICS Scores	High ICS Scores	Average Score
Aggressiveness	• Students 1, 3, 4, 9, 10, 11, 12, 14, 15, 16, 19 (1.0)	• Students 2, 5, 7, 18, 21 (2.0)	1.4
Academic Achievement	• Student 7 (2.5)	• Students 3, 4, 11, 15, 19 (7.0)	5.0
Popularity	• Student 7 (1.0) • Student 14 (1.5)	• Students 3, 9 (7.0) • Students 11, 21 (6.5)	4.4
Social Affiliation	• Students 7, 14, 16 (2.5)	• Students 3, 4, 6, 9, 11, 21 (7.0)	5.3
“Olympian” Quantities	• Student 7 (4.0) • Student 20 (4.5)	• Students 3, 15 (7.0)	5.6
Internalizing Problems	• Students 1, 9, 13, 21 (3.0)	• Student 16 (6.5) • Student 14 (6.0)	4.1
Summed ICS Scores	• Student 7 (3.2)	• Student 3 (7.0) • Students 4, 11 (6.7) • Student 21 (6.5)	5.4

Table 6 - ICS Results for class 3A

*Numbers in between parenthesis are the scores obtained

** Orange cells are negative factors

Observing the beforehand table, specifically the aggressiveness levels, we concluded that aggressiveness shouldn’t be taken into account when analyzing this class. This is due to the highest score for aggressiveness being 2.0, while the lowest score is 1.0. The distance between these is so narrow that there is no real distinction between minimally or maximally rated students.

When analyzing the data from the previous table, 5 students are almost immediately identified, 3 of these positively: Student 3, who scored perfectly in all of the ICS categories; student 11, who scored the highest in academic achievement and social affiliation, and was highly quoted in popularity and summed ICS scores (6.7); and student 21, another child with the highest possible score in social affiliation, highly quoted in popularity (6.5) and summed ICS scores (6.5), and minimally quoted in internalizing problems (3.0).

The other 2 students are identified in the opposite situation of the previously mentioned. Student 7, who is minimally quoted in 5 out of 6 categories: academic achievement (2.5), popularity (1.0), social affiliation (2.5), “Olympic” quantities (4.0), and summed ICS scores (3.2); and student 14, whose low popularity (1.5) and social affiliation levels (2.5) could reflect or be a reflection itself of his high score in internalizing problems (6.0).

On a general note, class 3A has the lowest average scores regarding aggressiveness (1.4) and a high average on both “Olympian” quantities (5.6) and summed ICS scores (5.4).

Categories	Low ICS Scores	High ICS Scores	Average Score
Aggressiveness	• Students 1, 4, 8, 9, 13, 14, 15, 17, 22 (2.3)	• Students 16, 21 (6.3) • Student 7 (6.0)	3.7
Academic Achievement	• Students 2, 16, 23 (2.0)	• Students 1, 15, 22 (6.0)	4.3
Popularity	• Students 9, 21 (3.7)	• Students 1, 2, 6, 10, 11, 12, 18 (6.3)	5.2
Social Affiliation	• Student 21 (4.0)	• Students 1, 2, 6, 8, 9, 10, 12, 13, 15, 16, 17 (6.0)	5.5
“Olympian” Quantities	• Student 8 (4.7)	• Students 1, 11, 12, 18 (7.0)	6.0
Internalizing Problems	• Student 21 (1.0)	• Students 4, 8, 22 (4.3)	2.9
Summed ICS Scores	• Student 21 (3.8) • Student 16, 23 (3.9)	• Student 1 (6.2)	5.0

Table 7 - ICS Results for class 3B

*Numbers in between parenthesis are the scores obtained
** Orange cells are negative factors

As observable on the previous table, student 1 should be highlighted, with the highest summed ICS score of this class (6.2). Highly quoted in academic achievement (6.0), popularity (6.3), and social affiliation (6.0), maximally quoted in “Olympian” quantities (7.0), and quoted low in aggressiveness (2.3).

Relative to student 21, it is possible to observe two peculiar situations. Although he’s the lowest quoted child in his class for summed ICS scores (3.8), popularity (3.7) and social affiliation (4.0), these are all intermediate values (scale goes from 1 to 7), and therefore, student 21 could be considered a median student. Also, he’s quoted as one the most aggressive students of his class (6.3), and yet one of the happiest (INT score = 1.0).

In a different perspective, student 16 is also relevant due to the contrast of his values relating his high aggressiveness (6.3) and high social affiliation (6.0). In other words, despite his high aggressiveness level, he’s deemed by his teacher as often smiley and friendly. Adding his low academic achievement (2.0) to the previous categories, the overall value is reflected (or reflects) in one of the lowest summed ICS scores (3.9) of his class. It should be taken into account that, even though it is one of the lowest SICS scores for this class, it is still an intermediate value.

On a general note, students from class 3B are averagely social most of the time (5.5); have a high average rating in “Olympian” quantities (6.0), and a low rating for internalizing problems (2.9).

Categories	Low ICS Scores	High ICS Scores	Average Score
Aggressiveness	<ul style="list-style-type: none"> Students 6, 11, 19 (1.5) Student 8 (2.0) 	<ul style="list-style-type: none"> Student 10 (6.5) Students 4, 5 (5.5) 	3.7
Academic Achievement	<ul style="list-style-type: none"> Students 4, 13 (2.5) 	<ul style="list-style-type: none"> Students 6, 8, 11, 15, 20 (7.0) 	5.1
Popularity	<ul style="list-style-type: none"> Student 1 (1.5) Student 13 (2.0) 	<ul style="list-style-type: none"> Student 6 (6.5) Student 8 (5.5) 	4.1
Social Affiliation	<ul style="list-style-type: none"> Students 1, 10, 17 (3.3) 	<ul style="list-style-type: none"> Students 11, 14 (7.0) 	5.2
“Olympian” Quantities	<ul style="list-style-type: none"> Student 13 (2.5) 	<ul style="list-style-type: none"> Students 6, 8 (6.0) 	4.1
Internalizing Problems	<ul style="list-style-type: none"> Student 17 (2.0) 	<ul style="list-style-type: none"> Students 6, 8 (5.0) 	3.6
Summed ICS Scores	<ul style="list-style-type: none"> Student 1 (3.1) Students 10, 13 (3.3) 	<ul style="list-style-type: none"> Student 6 (6.3) Student 8 (6.2) Student 11 (6.0) 	4.6

Table 8 - ICS Results for class 3C

*Numbers in between parenthesis are the scores obtained

** Orange cells are negative factors

In class 3C, it is possible to observe that students 6 and 8 follow the same pattern, standing out in 6 out of 7 categories. Although they’re both identified as the most shy, worried and concerned students of their class (INT=6.0), they are non-aggressive (1.5 and 2.0, respectively), maximally rated in academic achievements (7.0), and the highest quoted students in popularity (6.5, 5.5), “Olympian” quantities (6.0) and summed ICS Scores (6.3, 6.2).

Student 11 also classifies as one of the highest rated in summed ISC scores (6.0), maximally rated academically (7.0) and minimally rated on aggressiveness (1.5), diverging from the previous 2 students in both popularity and “Olympian” quantities, but standing out as one of the most social students of his class (AFF=7.0).

Lastly, student 13 stands out negatively. He is rated as one of the lowest in summed ICS scores (3.3), academic achievement (1.5) and popularity (2.0), and the only student in his class negatively rated in “Olympian” quantities (2.5).

II.3.1.2.DC

Each diversity factor was assigned a value of 1, in which the diversity factor scores consist of the sum of all factors. It is more important for our research to understand the result of summed scores, instead of each student’s particular conditions.

On the following table, it is possible to observe each class’ students who have diversity factors, as well as the observations regarding specific conditions relevant to future analysis.

Class	Diversity Factors Scores	Observations
2A	<ul style="list-style-type: none"> • Student 13 (4) • Students 4 and 9 (3) • Students 1, 7, 15, 21, 25 (1) 	<ul style="list-style-type: none"> • Student 9 – withdrawn from family • Students 1 and 15 – gifted • Student 21 – adopted
2B	<ul style="list-style-type: none"> • Students 11 and 15 (2) • Students 1, 3, 6, 8, 13, 16 (1) 	<ul style="list-style-type: none"> • Students 1 and 3 – gifted
2C	<ul style="list-style-type: none"> • Students 1, 24, 26 (2) • Students 2, 8, 13, 17, 21, 22 (1) 	<ul style="list-style-type: none"> • Students 13 and 24 – gifted • Student 26 - hemispherectomy
3A	<ul style="list-style-type: none"> • Student 7 (3) • Students 3, 4, 14, 22 (1) 	<ul style="list-style-type: none"> • Students 3 and 4 – gifted • Student 22 – Down Syndrome • Student 8 – Special ed., not present in class
3B	<ul style="list-style-type: none"> • Students 2 and 16 (2) • Students 6, 7, 12, 23 (1) 	<ul style="list-style-type: none"> • Students 3 and 5 – Special ed., not present in class
3C	<ul style="list-style-type: none"> • Students 1, 2, 17 (3) • Student 14 (2) • Students 4, 5, 6, 10, 11, 13, 20 (1) 	<ul style="list-style-type: none"> • Student 1 – monitored by social services • Students 6, 11, 20 – gifted

Table 9 – Diversity Checklist Results

*Numbers in between parenthesis are the number of summed diversity factors

After analyzing the data from the previous table, we observed that class 3C is the most troubling class, with the highest rate of student’s summed factors (18) and highest number of diversity factored students (11). Interestingly, the student with the highest summed score (4) belongs to class 2A (student 13).

It is important to emphasize that student 8 from class 3A and students 3 and 5 from class 3B are children from special education, integrated in class but only attending special education classes. They were, therefore, excluded from our study.

On a general note, there is at least one above average student per class, in exception of class 3B.

II.3.1.3.LS

Before analyzing the data retrieved from the LS questionnaire, it was important to assert the internal consistency of it. Hence, we reversed all the questions that needed to be reversed and removed the irrelevant questions from the data, after which we ran a Reliability Analysis, resulting in a *Cronbach’s Alpha* of .83. Since a *Cronbach’s Alpha* equal or higher than .7 translates into good internal consistency, the retrieved data was accepted as relevant.

The following table summarizes the data collected from the self-reported LS questionnaire, identifying the children who have the highest and lowest self-reported loneliness. We also assessed some observations based on the analysis of the average values, class and question-specific (when relevant).

Class	Highest Loneliness	Lowest Loneliness	Observations
2A	<ul style="list-style-type: none"> Sometimes social: students 4, 16, 18, 21, 24, 26 (42 to 55) 	<ul style="list-style-type: none"> Always social: students 7, 10, 12, 17, 19 	<ul style="list-style-type: none"> Average values: highest 55, average 30.92, lowest 19
2B	<ul style="list-style-type: none"> Almost never social: Student 16 (68) Sometimes social: students 2, 5, 10, 11, 14, 18 (42 to 49) 	<ul style="list-style-type: none"> Always social: students 1, 6, 8, 21, 22, 23, 24 (17 to 23) 	<ul style="list-style-type: none"> Average values: highest 68, average 32.71, lowest 17
2C	<ul style="list-style-type: none"> Sometimes social: students 7, 8, 14, 16, 20, 22 (40 to 47) 	<ul style="list-style-type: none"> Always social: students 2, 12, 18 (18 to 20) 	<ul style="list-style-type: none"> Average values: highest 47, average 31.83, lowest 18 Average rating for question "I'm popular in my class" quoted as 3.25
3A	<ul style="list-style-type: none"> Sometimes social: students 2, 4, 7, 10, 12 (41 to 54) 	<ul style="list-style-type: none"> Always social: student 3 (20) 	<ul style="list-style-type: none"> Average values: highest 54, average 34.45, lowest 20 Average rating for the question "Hard to make other children like me" quoted as 3.0 Average rating for the question "I'm popular in my class" rated as 3.80
3B	<ul style="list-style-type: none"> Almost never social: student 7 (65) Sometimes social: students 4, 10, 12, 13, 14, 15, 16, 23 (40 to 47) 	<ul style="list-style-type: none"> Always social: students 1 (19) and 18 (17) 	<ul style="list-style-type: none"> Average values: highest 65, average 37.48, lowest 17 Average rate for the question "Watch tv often" quoted as 3.10 Average rate for the question "Hard to make friends" quoted as 3.33 Average rate for the question "hard to make other children like me" quoted as 3.14
3C	<ul style="list-style-type: none"> Almost never social: student 15 (58) Sometimes social: students 1, 2, 13 (42 to 47) 	<ul style="list-style-type: none"> Always social: students 7, 8, 12, 16, 18 (19 to 23) 	<ul style="list-style-type: none"> Average values: highest 58, average 32.20, lowest 19

Table 10 – Loneliness Scale Results

*Numbers in between parenthesis are the children’s summed scores

Based on the previously presented table, it is immediately perceivable that every class has students who consider themselves to be “always social”, while at the other end (“never social”), the same does not apply. In fact, there wasn’t a single student who qualified himself as “never social”, but there were some “almost never social” ones. These students will be analyzed later, as they have a high probability of being in fact the loneliest children of their classes.

In terms of average scores, there was some balance. Most classes scored an average value between 30 and 34 points, with only one class going up to 37, pointing out that most children are “social most of the time”.

Lastly, there were some high average scores question-wise that are worth mentioning. On both classes 2C and 3A, question “I’m popular in my class” averaged at above 3.00, which indicates that students tend to not think as themselves as popular. Also, on classes 3A and 3B, question “hard to make other children like me” averaged above 3.00, indicating that children tend to have some difficulty in being accepted for what they are, particularly on class 3B, as the question “hard to make friends” also averaged high.

II.3.1.4.PNI

The first question on the PNI is aimed at uncovering the most popular children in class, as well as the unrecognized ones. The most nominated students will clearly play an important part in the social environment of each classroom, and can potentially act as opinion changers and behavior influencers due to their high social status. On the other hand, the non-nominated ones are probably the most ignored children, having close to no real friends in their classroom, and will be deemed as unrecognized.

The following table summarizes the data collected from PNI’s first question, identifying both high popularity children (high in-degree) and unrecognized children (in-degree = 0), and assessing some observations based on the graphs generated through the data that was gathered.

Class	High Popularity	Unrecognized	Graph Observations
2A	<ul style="list-style-type: none"> • Student 1 (16) • Student 11 (10) 	<ul style="list-style-type: none"> • Students 7, 8, 18, 25 (0) 	<ul style="list-style-type: none"> • Gender-parted • Students 14 and 26 - males in the female group
2B	<ul style="list-style-type: none"> • Students 12 and 22 (8) • Student 3 (7) • Student 6 (6) 	<ul style="list-style-type: none"> • None 	<ul style="list-style-type: none"> • Gender-parted • Group-parted: male + Student 12, 3 small groups of females
2C	<ul style="list-style-type: none"> • Students 6 (9) • Student 3 (7) 	<ul style="list-style-type: none"> • Students 4, 5, 10, 11, 21, 22 (0) 	<ul style="list-style-type: none"> • Gender-parted • Student 22 - male in the female group • Student 21 - female away from female group
3A	<ul style="list-style-type: none"> • Students 9 and 18 (6) • Student 3 (5) 	<ul style="list-style-type: none"> • Students 1, 7, 19 (0) 	<ul style="list-style-type: none"> • Gender-parted • Student 15 - male away from male group
3B	<ul style="list-style-type: none"> • Students 1 (7) • Student 12 and 13 (6) 	<ul style="list-style-type: none"> • Student 4 (0) 	<ul style="list-style-type: none"> • Gender-parted
3C	<ul style="list-style-type: none"> • Students 6 (12) • Student 14 (7) 	<ul style="list-style-type: none"> • Students 17 (0) 	<ul style="list-style-type: none"> • Gender-parted • Student 17 - male in the female group • Students 1 and 2 - 2-men group, away from everyone

Table 11 - PNI Question 1 (Likeability) Results

*Numbers in between parenthesis are the number of nominations received

The first observation possible through the previous table is that every class has an accentuated gender division, which is clear proof that gender has a high impact towards likeability in this age group. It is also important to take note that only in one of the classes there were no unrecognized children, substantiating that social exclusion is a reality for most classes.

There are 2 particular situations worth mentioning. Firstly, on class 2C, students 21 and 22, and on class 3C, student 17, are part of the wrong group gender-wise, and are unrecognized (no nominations). Secondly, on class 3C, student 1 and 2 form a 2-men group, being each other’s only nominations.

On the second question of the PNI, the main focus is highlighting the most disliked children in class, and the ones who are generally liked. The following table summarizes the data collected from PNI’s second question, identifying both highly despised children (high in-degree) and generally liked children (in-degree = 0), and assessing some observations based on the graphs generated through the data that was gathered.

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Class	Highly Despised	Generally Liked	Graph Observations
2A	<ul style="list-style-type: none"> Students 9 and 13 (17) Student 21 (12) Student 7 (10) Student 4 (8) 	<ul style="list-style-type: none"> Students 1, 5, 8, 10, 11, 12, 15, 17, 19, 20, 22, 24, 26 (0) 	<ul style="list-style-type: none"> All highly despised children are males
2B	<ul style="list-style-type: none"> Student 16 (15) Student 14 (9) 	<ul style="list-style-type: none"> Students 6, 7, 10, 12, 19, 22 (0) 	<ul style="list-style-type: none"> Highest despised child is female
2C	<ul style="list-style-type: none"> Student 4 (22) Student 22 (21) Student 5 (9) 	<ul style="list-style-type: none"> Students 3, 6, 8, 9, 11, 12, 16, 17, 19, 20, 23, 24, 25 (0) 	<ul style="list-style-type: none"> All highly despised children are males
3A	<ul style="list-style-type: none"> Student 7 (14) Student 1 (12) 	<ul style="list-style-type: none"> Students 3, 4, 11, 14, 15, 16, 17, 19, 20 (0) 	<ul style="list-style-type: none"> Highest despised child is female
3B	<ul style="list-style-type: none"> Student 16 (9) Student 19 (8) Students 4 and 7 (7) 	<ul style="list-style-type: none"> Students 6, 11, 13, 14, 22 (0) 	<ul style="list-style-type: none"> Of the highest despised children, Student 4 is the only female
3C	<ul style="list-style-type: none"> Student 1 (12) Student 2 (8) 	<ul style="list-style-type: none"> Students 6, 7, 8, 11, 14, 15 (0) 	<ul style="list-style-type: none"> All highly despised children are males

Table 12 - PNI Question 2 (Aversion) Results

*Numbers in between parenthesis are the number of nominations received

When analyzing the previous results in terms of gender partition, there is no clear significance. Although most highly despised children tend to be males, on classes 2B and 3A the highest despised child was a female. Also, on class 3B, 4 different students were nominated as highly despised, one of them being a female. Hence, it isn't possible to infer that being highly despised is gender-specific.

Something to be noticed as well from the previous data is that on most classes, with the exception of class 3B, where the highest nominations scores are somewhat similar (7, 8 and 9), there seems to be 1 or 2 clear focuses of aversion.

On PNI's third question, the objective was figuring out who the bullies are, if any. The following table summarizes the data collected, identifying the students that were highly nominated as being bullies (high in-degree), while also assessing some observations.

Class	Bully	Graph Observations
2A	<ul style="list-style-type: none"> Student 9 (22) Student 13 (19) 	<ul style="list-style-type: none"> All bullies are males
2B	<ul style="list-style-type: none"> Student 3 (19) Student 21 (9) 	<ul style="list-style-type: none"> All bullies are males
2C	<ul style="list-style-type: none"> Student 22 (23) Student 4 (22) 	<ul style="list-style-type: none"> All bullies are males
3A	<ul style="list-style-type: none"> Student 21 (11) Student 6 (10) 	<ul style="list-style-type: none"> All bullies are males
3B	<ul style="list-style-type: none"> Student 16 (18) 	<ul style="list-style-type: none"> Bully is a male
3C	<ul style="list-style-type: none"> Student 10 (12) Student 17 (11) Student 1 (9) 	<ul style="list-style-type: none"> All bullies are males

Table 13 - PNI Question 3 (Bullying) Results

*Numbers in between parenthesis are the number of nominations received

It is immediately inferable that every bully identified is of the male gender. This is somewhat expected, since males tend to be more aggressive overall, even when playing.

The fourth question of the PNI had the purpose of identify the victims of each class, or in other words, who the abused, teased and pushed around children were. The following table summarizes the data collected, identifying which children were highly nominated as being victims (high in-degree), and assessing some observations based on the generated graphs.

Class	Victim	Graph Observations
2A	<ul style="list-style-type: none"> • Student 13 (16) • Student 21 (11) 	<ul style="list-style-type: none"> • All victims are males
2B	<ul style="list-style-type: none"> • Student 16 (11) 	<ul style="list-style-type: none"> • Victim is a female
2C	<ul style="list-style-type: none"> • Student 22 (19) • Students 4 and 5 (14) 	<ul style="list-style-type: none"> • All victims are males
3A	<ul style="list-style-type: none"> • Student 1 (12) • Student 7 (7) 	<ul style="list-style-type: none"> • Students 13 and 15 were each-others only nomination
3B	<ul style="list-style-type: none"> • Student 19 (8) • Student 16 (7) • Student 7 (6) 	<ul style="list-style-type: none"> • All victims are males
3C	<ul style="list-style-type: none"> • Student 2 (11) • Student 1 (10) 	<ul style="list-style-type: none"> • All victims are males

Table 14 - PNI Question 4 (Victimization) Results

*Numbers in between parenthesis are the number of nominations received

Although it isn't undoubtedly distinguishable, victimization seems to happen a bit more frequently to male students.

Something to be noticed as well from the previous data is that on most classes, with the exception of class 3B, whose highest nominations scores are somewhat similar (6, 7 and 8), 1 to 3 students are notoriously perceived as victims in comparison with the rest of the class.

PNI's fifth question aimed at identifying relational aggressors, or in other words, children who have bad behaviors towards other children while they aren't watching or listening. The following table summarizes the data collected, identifying which children were highly nominated as being relational aggressors (high in-degree), and assessing some observations based on the generated graphs.

Class	Relational Aggressor	Graph Observations
2A	<ul style="list-style-type: none"> • Student 9 (20) • Student 13 (10) 	<ul style="list-style-type: none"> • All relational aggressors are males
2B	<ul style="list-style-type: none"> • Student 1 (7) 	<ul style="list-style-type: none"> • Relational aggression more frequently identified on females
2C	<ul style="list-style-type: none"> • Student 22 (19) • Student 5 (15) • Student 4 (8) 	<ul style="list-style-type: none"> • All relational aggressors are males • Same gender nominations more frequent
3A	<ul style="list-style-type: none"> • Students 13 and 18 (8) • Student 15 (7) 	<ul style="list-style-type: none"> • None
3B	<ul style="list-style-type: none"> • Student 10 (8) • Student 16 (7) 	<ul style="list-style-type: none"> • All relational aggressors are males • Relational aggression male-centered
3C	<ul style="list-style-type: none"> • Student 10 (13) • Students 16 and 17 (7) 	<ul style="list-style-type: none"> • All relational aggressors are males • Relational aggression male-centered

Table 15 - PNI Question 5 (Relational Aggression) Results

*Numbers in between parenthesis are the number of nominations received

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Analyzing the previous table, we can infer that gender isn't a decisive factor, with all relational aggressors being males in only 4 of the classes. Even so, it is safe to determine that most relational aggressors tend to be male.

Once again, it should be highlighted that on most classes, 1 to 3 students are without hesitation perceived as relational aggressors, in comparison to the rest of the class.

The sixth question of the PNI questionnaire asked students to point out which of their colleagues were socially withdrawn. The following table summarizes the data collected, identifying which children were highly nominated as being socially withdrawn (high in-degree), and assessing some observations based on the generated graphs.

Class	Socially Withdrawn	Graph Observations
2A	<ul style="list-style-type: none"> • Student 21 (11) 	<ul style="list-style-type: none"> • Socially withdrawn student is a male
2B	<ul style="list-style-type: none"> • Student 14 (16) 	<ul style="list-style-type: none"> • Socially withdrawn student is a male
2C	<ul style="list-style-type: none"> • Students 13 and 19 (13) 	<ul style="list-style-type: none"> • All socially withdrawn students are males • Social withdrawal more frequently identified on males
3A	<ul style="list-style-type: none"> • Student 14 (14) • Student 4 (11) 	<ul style="list-style-type: none"> • All socially withdrawn students are females
3B	<ul style="list-style-type: none"> • Students 4 and 16 (8) 	<ul style="list-style-type: none"> • <i>None</i>
3C	<ul style="list-style-type: none"> • Student 13 (10) 	<ul style="list-style-type: none"> • Socially withdrawn student is a male

Table 16 - PNI Question 6 (Social Withdrawing) Results

*Numbers in between parenthesis are the number of nominations received

Gender seems to be relevant only on second grade classes, in which all socially withdrawn students are males. On third grade this correlation isn't verified, as illustrated by the previously presented table.

It is also noticeable that there was general agreement on every class towards nominating the socially withdrawn children. This can mean that children are actually sensitive towards other children's willingly (or unwillingly) isolation.

On the last question of the PNI, children were asked to nominate who they thought filled the role of class leader. The following table summarizes the data collected, identifying which children were highly nominated as being socially withdrawn (high in-degree), and assessing some observations based on the generated graphs.

Class	Leader	Graph Observations
2A	• Student 1 (22)	• Highest nominated leader is a female
2B	• Student 6 (11)	• Highest nominated leader is a male
2C	• Student 19 (16)	• Highest nominated leader is a male • Leadership male-centered
3A	• Student 3 (19) • Student 4 (15)	• Highest nominated leader is a male
3B	• Student 1 (14)	• Highest nominated leader is a female • Leadership female-centered
3C	• Student 6 (14)	• Highest nominated leader is a female

Table 17 - PNI Question 7 (Leadership) Results

*Numbers in between parenthesis are the number of nominations received

Of all of the PNI’s questions, this one collected the most unanimous voting for all classes. Excluding 2 leaders elected on class 3A, there was always one person in particular that was perceived as the class leader.

Internal Correlations

Although the previous data has been analyzed, there is no way to substantiate if a given variable is related to another one simply by observation. However, through the use of correlation tests (performed with the application SPSS), we can accurately depict if in fact variable have a significance correlation between them.

The following table presents the correlations in-between the in-degree variables of the PNI questionnaire. We used In-Degree because it corresponds to the number of times each student was nominated by others.

	Most Preferred	Least Preferred	Bully	Victim	Relational Aggressor	Withdrawn
Least Preferred	-,349**	-				
Bully	-,130	,657**	-			
Victim	-,274**	,758**	,462**	-		
Relat. Aggressor	-,064	,522**	,593**	,390**	-	
Withdrawn	-,032	,307**	,193*	,263**	,124	-
Leader	,627**	-,242**	-,157	-,202*	-,074	,193*

Table 18 - PNI Questions In-Degree Correlations

*. Correlation is significant at the 0.05 level (2-tailed)

**.. Correlation is significant at the 0.01 level (2-tailed)

As observed on the previous table, there are several correlations between the various PNI questions.

Being a most preferred peer is strongly correlated in a positive way with the peer-perceived leadership role ($r = .63, p < 0.01$), and moderately correlated in a negative way with being both least preferred peer and peer-perceived as victims ($r = -.27$ and $-.35$, respectively, both $p < 0.01$). On the other hand, being a least preferred peer is positively strongly correlated with being peer-perceived as bully, victim or relational aggressor (r 's ranged from $.52$ to $.76$, all $p < 0.01$), and positively moderately correlated with being peer-perceived as withdrawn. Lastly,

it is negatively moderately correlated with being a most preferred peer and the peer-perceived leadership role ($r = -.35$ and $-.24$, respectively, both $p < 0.01$).

Being peer-perceived as a bully is positively correlated strongly with being a least preferred peer and a relational aggressor ($r = .66$ and $.59$, respectively, both $p < 0.01$), moderately with being peer-perceived as a victim ($r = .46$, $p < 0.01$) and weakly with being peer-perceived as withdrawn ($r = .19$, $p < 0.05$). Being peer-perceived as a victim however, is positively correlated strongly with being a least preferred peer ($r = .76$, $p < 0.01$), moderately with being peer-perceived as a bully, a relational aggressor or withdrawn (r 's ranged from $.26$ to $.46$, all $p < 0.01$), and negatively correlated moderately with being a most preferred peer ($r = -.27$, $p < 0.01$) and weakly as being peer-perceived as a leader ($r = -.20$, $p < 0.05$).

Being peer-perceived as a relational aggressor is only positively correlated strongly with being a least preferred peer and peer-perceived as a bully ($r = .52$ and $.59$, respectively, both $p < 0.01$), and moderately with being peer-perceived as a victim ($r = .39$, $p < 0.01$).

Being peer-perceived as withdrawn is only positively correlated, moderately with being a least preferred peer and peer-perceived as a victim ($r = .31$ and $.26$, respectively, both $p < 0.01$), and weakly with being peer-perceived as a bully or a leader (both $r = .19$, both $p < 0.05$).

Finally, being peer-perceived as a leader is positively correlated strongly with being a most preferred peer ($r = .63$, $p < 0.01$), weakly with being peer-perceived as withdrawn ($r = .19$, $p < 0.05$) and negatively correlated moderately with being a least preferred peer and being peer-perceived as a victim ($r = .24$ and $.20$, respectively, $p < 0.01$ and 0.05 , respectively).

II.3.1.5. Inter-correlations between Questionnaires

Even though this study aims at understanding how RSSI is related to the different dimensions provided by current sociometric measurement tools, it is also important to see how these correlate between each other. This exercise should not only provide deeper depth to each of these, but also provide an assessment as to how RSSI correlations encompass many more metrics with fewer invasion towards the participation of children.

Although the previously analyzed data provides some insight into the network properties of the classes analyzed, there is no way to substantiate if a given variable is related to another one simply by observation. However, through the use of correlation tests (performed with the application SPSS), we can accurately depict if in fact variables have a significance correlation between them.

All of the inter-relationships in the given questionnaires have been removed, leaving only the relevant cross-questionnaire correlations properly identified. Following the table, an explanation is provided for each metric.

	Gender	Interpersonal Competence Scale							Peer Nominated Inventory							Diversity Checklist			
		AGG	ACA	POP	AFF	OLY	INT	SC	Most Liked	Least Liked	Bully	Victim	Relat. Agg.	With drawn	Leader	Learn. Diffic.	Poor Soc. Condition	Sum. D.C. Scores	
ICS	Aggressiveness	.247**																	
Peer Nominated Inventory	Most Liked	-.127	-.208*	.290**	.487**	.328**	.287**	.065	.454**										
	Least Liked	.277**	.427**	-.342**	-.397**	-.363**	-.287**	-.200*	-.531**										
	Bully	.405**	.544**	-.289**	-.165	-.303**	-.069	-.385**	-.427**										
	Victim	.273**	.333**	-.310**	-.386**	-.315**	-.316**	-.190*	-.478**										
	Relational Aggressor	.219*	.406**	-.143	-.085	-.247**	-.064	-.249**	-.291**										
	Withdrawn	.170*	.045	-.041	-.239**	-.214*	-.110	.067	-.176*										
	Leader	.001	-.225**	.436**	.431**	.321**	.269**	.172*	.488**										
Diversity Checklist	Learning Difficulties	.059	.338**	-.657**	-.356**	-.303**	-.239**	-.203*	-.571**	-.260**	.411**	.336**	.330**	.186*	.151	-.229**			
	Special Education Needs	.073	.156	-.244**	-.262**	-.312**	-.176*	-.080	-.330**	-.180*	.278**	.199*	.256**	.038	.030	-.110			
	Poor Social Condition	.102	.143	-.349**	-.419**	-.360**	-.213*	.124	-.426**	-.165	.481**	.357**	.299**	.266**	.198*	-.131			
	Emigrant	.124	.019	-.005	-.086	-.099	-.211*	.012	-.102	-.119	.199*	.007	.223**	.055	.128	-.078			
	Low Socio-Economic Level	.059	.286**	-.330**	-.234**	-.206*	-.239**	-.177*	-.381**	-.181*	.381**	.400**	.246**	.269**	.151	-.137			
	Gifted	.002	-.078	.329**	.284**	.162	.156	.028	.295**	.394**	-.132	-.004	-.067	.006	.141	.531**			
	Summed Div. Check. Scores	.126	.311**	-.465**	-.327**	-.318**	-.294**	-.160	-.503**	-.132	.484**	.445**	.383**	.270**	.227**	-.042			
	Has a Diversity Factor	.052	.264**	-.411**	-.191*	-.186*	-.185*	-.373**	-.020	.302**	.304**	.257**	.150	.225**	.075				
LS	Summed Loneliness Scores	.014	.170	-.311**	-.318**	-.148	-.164	.006	-.327**	-.267**	.318**	.106	.242**	-.013	.230**	-.183*	.325**	.196*	.194*

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Figure 3 - Inter-correlations of both student and teacher questionnaires.

Regarding the data from the previous table, it is possible to observe several correlations with a range of different levels of strengths both positively and negatively.

The teacher’s perceived measures regarding the student’s aggressiveness level positively correlates moderately to the student’s gender ($r = .25, p < 0.01$).

The number of peer nominations a student has as the most preferred peer, positively correlates moderately the teacher’s perceived measures regarding the student’s popularity, summed ICS scores, social affiliation academic achievement, and Olympian quantities (r ranges from .49 to .29, all $p < 0.01$). Negatively, it correlates weakly to the teacher’s reports regarding the student’s aggressiveness level ($r = -.21, p < 0.05$).

The number of peer nominations a student has as the least preferred peer positively correlates moderately to the teacher’s reports regarding the student’s aggressiveness and to the student’s gender ($r = .43$ and $.28$, respectively, both $p < 0.01$). Negatively, it strongly correlates to the teacher’s reports regarding the student’s summed ICS scores ($r = -.53, p < 0.01$), moderately to the teacher’s perceived measures regarding the student’s popularity, social affiliation, academic achievement and Olympian quantities (r ranges from $-.40$ to $-.29$, all $p < 0.01$), and weakly to the teachers reports regarding the student’s internalizing problems ($r = -.20, p < 0.05$).

The number of peer nominations a student has towards being a bully is positively correlated strongly to the teacher’s perceived measures regarding the student’s aggressiveness level ($r = .54, p < 0.01$), and moderately to the student’s gender ($r = .41, p < 0.01$). Negatively, it moderately correlates to the teacher’s reports regarding the student’s summed ICS scores, problem internalization, social affiliation and academic achievement (r ranges from $-.43$ to $-.29$, all $p < 0.01$).

The number of peer nominations a student has towards being a victim positively correlates moderately to the teacher’s perceived measures regarding the student’s

aggressiveness level and to the student's gender ($r = .33$ and $.27$, respectively, both $p < 0.01$). Negatively, it moderately correlates to the teacher's perceived measures regarding the student's summed ICS scores, popularity, Olympian quantities, social affiliation and academic achievement (r ranges from $-.48$ to $-.31$, all $p < 0.01$), and weakly to the teacher's perceived measures regarding the student's problem internalization ($r = -.19$, $p < 0.05$).

The number of peer nominations a student has towards being a relational aggressor is positively correlated moderately to the teacher's perceived measures regarding the student's aggressiveness level ($r = .41$, $p < 0.01$), and weakly to the student's gender ($r = .22$, $p < 0.05$). Negatively, it moderately correlates to the teacher's perceived measures regarding the student's summed ICS scores, problem internalization and social affiliation (r ranges from $-.29$ to $-.25$, all $p < 0.01$).

The number of peer nominations a student has towards being withdrawn positively correlates weakly to the student's gender ($r = .17$, $p < 0.05$). Negatively, it weakly correlates to the teacher's reports regarding the student's popularity, social affiliation and summed ICS scores (r ranges from $-.24$ to $-.18$, all $p < 0.01$ and $p < 0.05$).

The number of peer nominations a student has towards being a leader is positively correlated moderately to the teacher's perceived measures regarding the student's summed ICS scores, academic achievement, popularity, social affiliation and Olympian quantities (r ranges from $.49$ to $.27$, all $p < 0.01$), and weakly to the teacher's reports regarding the student's internalizing problems ($r = .17$, $p < 0.05$). Negatively, it correlates weakly to the teacher's reports regarding the student's aggressiveness level ($r = -.23$, $p < 0.01$).

The teacher's reports regarding the student's learning disabilities is positively correlated moderately to the number of peer nominations the student has as the least preferred peer, a bully, a victim and to the teacher's perceived measures regarding the student's aggressiveness level (r ranges from $.44$ to $.33$, all $p < 0.01$), and weakly to the number of peer nominations a student has towards being a relational aggressor ($r = .19$, $p < 0.05$). Negatively, it correlates strongly to the teacher's perceived measures regarding the student's academic achievement and summed ICS scores ($r = -.66$ and $-.57$, respectively, both $p < 0.01$), moderately to the teachers reports regarding the student's popularity, social affiliation and to the number of peer nominations a student has as the most preferred peer (r ranges from $-.36$ to $-.26$, all $p < 0.01$), and weakly to the teacher report's regarding the student's Olympian quantities, internalizing problems and to the number of peer nominations the student has towards being a leader (r ranges from $-.24$ to $-.20$, all $p < 0.01$ and $p < 0.05$).

The teacher's identified measures regarding the student's special educational needs, positively correlates moderately to the number of peer nominations the student has as the least preferred peer and a victim ($r = .28$ and $.26$, respectively, both $p < 0.01$), and weakly to the number of peer nominations the student has towards being a bully ($r = .20$, $p < 0.05$). Negatively, it correlates moderately to teacher's perceived measures regarding the student's summed ICS scores, social affiliation and popularity (r ranges from $-.33$ and $-.26$, all $p < 0.01$), and weakly to teacher's reports regarding the student's academic achievement, Olympian quantities and the number of peer nominations the student has as the most preferred peer (r ranges from $-.24$ to $-.18$, all $p < 0.01$ and $p < 0.05$).

The teacher's reports regarding the student's poor social condition is positively correlated moderately to the number of peer nominations the student has as the least preferred peer, a bully, a victim and a relational aggressor (r ranges from $.48$ to $.26$, all $p < 0.01$), and

weakly to the number of peer nominations the student has towards being withdrawn ($r = .20$, $p < 0.05$). Negatively, it correlates moderately to the teacher's perceived measures regarding the student's summed ICS Scores, popularity, social affiliation and academic achievement (r ranges from $-.43$ to $-.35$, all $p < 0.01$), and weakly to the teacher's reports regarding the student's Olympian quantities ($r = -.21$, $p < 0.05$).

The being an emigrant positively correlates weakly to the number of peer nominations the student has towards being a victim and the least preferred peer ($r = .22$ and $.20$, respectively, both $p < 0.01$ and $p < 0.05$). Negatively, it correlates weakly to the teacher's perceived measures regarding the student's Olympian quantities ($r = -.21$, $p < 0.05$).

The teacher's reports regarding the student's low socio-economic level, positively correlates moderately to the number of peer nominations the student has towards being a bully as well as a victim, the least preferred peer, a relational aggressor and to the teacher's perceived measures regarding the student's aggressiveness level (r ranges from $.40$ to $.25$, all $p < 0.01$). Negatively, it correlates moderately to the teacher's perceived measures regarding the student's summed ICS scores and academic achievement ($r = -.38$ and $-.33$, respectively, both $p < 0.01$), and weakly to teacher's reports regarding the student's Olympian quantities, popularity, social affiliation, internalization problem and to the number of peer nominations the student has as the most preferred peer (r ranges from $-.24$ to $-.18$, all $p < 0.01$ and $p < 0.05$).

The teacher's reports regarding students who are gifted or above average intelligence positively correlates strongly to the number of peer nominations the student has towards being a leader ($r = .53$, $p < 0.01$), and moderately to the number of peer nominations the student has as the most preferred peer, the teacher's perceived measures regarding the student's academic achievement, popularity and summed ICS scores (r ranges from $.39$ to $.28$, all $p < 0.01$).

The teacher's reports regarding the student's summed diversity factors positively correlate moderately to the number of peer nominations the student has as the least preferred peer, a bully, a victim, a relational aggressor and to the teacher's perceived measures regarding the student's aggressiveness level (r ranges from $.48$ to $.27$, all $p < 0.01$), and weakly to the number of peer nominations the student has towards being withdrawn ($r = .23$, $p < 0.01$). Negatively, it strongly correlates to the teacher's perceived measures regarding the student's summed ICS scores ($r = -.50$, $p < 0.01$), and moderately to the teacher's reports regarding the student's academic achievement, popularity, social affiliation and Olympian quantities (r ranges from $-.47$ to $-.29$, all $p < 0.01$).

The variable that identifies if the student has a diversity factor or not, is positively correlated moderately to the number of peer nominations the student has as the least preferred peer, a bully as well as a victim and to the teacher's perceived measures regarding the student's aggressiveness level (r ranges from $.30$ to $.26$, all $p < 0.01$), and weakly to the number of peer nominations the student has towards being withdrawn ($r = .23$, $p < 0.01$). Negatively, it correlates moderately to the teacher's reports regarding the student's academic and summed ICS scores ($r = -.41$ and $-.37$, respectively, both $p < 0.01$), and weakly to the teacher's reports regarding the student's popularity, internalization problems, social affiliation and Olympian quantities (r ranges from $-.91$ to $-.90$, all $p < 0.05$).

The sum of the scores obtained by students on the self-reported Loneliness Scale questionnaire, is positively correlated moderately to the teacher's reports regarding the student's learning disabilities and the number of peer nominations a student has as the least preferred peer ($r = .33$ and $.32$, respectively, both $p < 0.01$), and weakly to the number of peer

nominations the student has towards being a victim, withdrawn, to the teacher’s reports regarding the student’s poor social condition and summed diversity factors (r ranges from .24 to .19, all $p < 0.01$ and $p < 0.05$). Negatively, it correlates moderately to the teacher’s perceived measures regarding the student’s summed ICS scores, popularity, academic achievement, and the number of peer nominations the student has as the most preferred peer (r ranges from -.33 to -.28, all $p < 0.01$), and weakly to the number of peer nominations the student has towards being a leader ($r = -.18$, $p < 0.05$).

II.3.2. Proximity Measurement

II.3.2.1. Testing Results

As previously explained, the application went through several tests, which would provide us with enough data to be able to accurately depict relevant from irrelevant acquired data. When testing the application’s RSSI measurement, two factors were taken into account: position of test subject relative to subject 0 (from here onwards defined as rotation) and distance (in meters).

The first thing we did was analyzing the data using the IBM SPSS Statistics. Through a Paired Samples T-Test, we were able to determine that both correlations between RSSI-Distance and RSSI-Rotation are significant at the 0.01 level (2-tailed) (Pearson Correlation: -.61 and -.16, respectively).

We then proceeded into generating the following graph, which better illustrates the data obtained from the tests. The graph is represented with the use of T-Bars, which demonstrates the mean value, and associated error, of RSSI measurement for each Rotation x Distance pair.

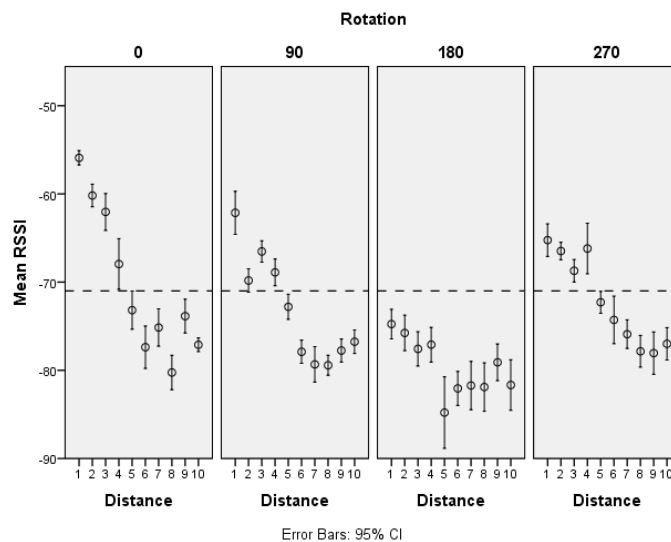


Figure 1 – Mean values of RSSI, intersected with Distance and Rotation

There are a couple of useful conclusions to be taken from the previous.

First of all, it is noticeable how rotation is significant towards measured RSSI values. Specifically, there is not much difference between 0, 90 and 270 degrees RSSI-wise, but 180 degrees completely alters this tendency. This is due to the fact that, at a 180 degree rotation, there is a human body between the two phones, and therefore the signal loses its strength. This

rotation measure, however, can be safely excluded from the test's data analysis. Based on the social interaction paradigm, two people interacting with each other are bound to either be facing one another, or sideways to each other (e.g. while walking). A 180 degrees rotation from the test subject to subject 0 means that the test subject has his back facing subject 0, which on the great majority of situations means that the subjects aren't engaging in any kind of social interaction between each other.

Also, it is very clear that there is a significant correlation between RSSI values and distance. With it in mind, we added a dotted horizontal line to the graph, signaling the -71 RSSI value, as this line separates the first 4 meters from everything else (except on 180 degrees rotation, which is irrelevant). This is an indicator that RSSI measures higher than -71 (e.g. -60, -50) are assured to be at a distance of 1 to 4 meters, and vice-versa. Hence, we can determine that the threshold for being in a social interaction with someone results in a RSSI measurement of -71 or higher.

II.3.2.2. Centrality Metrics

There are a number of RSSI metrics relevant to the study of the retrieved data. Each metric will be explained in the following paragraphs.

Degree is the number of peers a student is connected to, while weighted degree corresponds to the strength of ties between a student and its peers. It is expected for a student to be near most (if not all) his colleagues during the recess (degree measures will likely be the same), but the time spent with each of them is of valuable information towards his overall social ties (weighted degree will differentiate strong ties from weaker ones).

On centrality measurement, several metrics seem relevant and therefore will be included in the data analysis. Closeness centrality, which is the sum of a student's distances towards his peers, reversed, will identify who the best information propagators are (i.e.: it can be regarded as to how long it will take to spread information from student "s" to all other students sequentially). Betweenness centrality, which is the number of times a student acts as a bridge along the shortest path between two of his peers, will identify students in a "broker" position. Finally, Eigenvector centrality, which assigns relative scores according to the connections the student has, taking into account that connections to high-scoring students contribute more to the score of the student in question, will identify the influence of the student in his/her classroom.

The (local) clustering coefficient quantifies on how close a student's connected peers are to being a clique (closed group of inter-connected students), and will identify tight groups of friends. On the other hand. the (local) number of triangles will quantify as to how many triangles a student is inserted into, assuming that a triangle is a set of three fully connected nodes, or in other words, a group of three students connected between each other.

II.3.2.3. Student-specific Network Centrality

After gathering all the data that was collected from the RSSI measurement, it was possible to analyze some network metrics associated with each class. These metrics include Weighted Degree and Closeness, Betweenness and Eigenvector Centrality. Each network metric illustrates different aspects and conditions of each network, and so will be separated as to better understand the social phenomenon and environment of each class.

We will analyze each class separately, and determine the social demographics of each towards popularity, exclusion and other meaningful conclusions based on the previously mentioned Centrality metrics.

Class 2A

Centrality Metrics	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> Student 4 (35) 	<ul style="list-style-type: none"> Student 2 (1,620) Student 23 (1,215)
Closeness Centrality	<ul style="list-style-type: none"> Student 2 and 23 (1,167) 	<ul style="list-style-type: none"> Student 4 (2,125)
Betweenness Centrality	<ul style="list-style-type: none"> Student 4 (0) Student 24 (0,226) Student 16 (0,250) 	<ul style="list-style-type: none"> Student 23 (34,510) Student 5 (15,112) Student 2 (14,909)
Eigenvector Centrality	<ul style="list-style-type: none"> Student 4 (0,068) 	<ul style="list-style-type: none"> Student 2 (1,000) Student 23 (0,979) Student 20 (0,942)

Table 19 – RSSI measurements’ highest and lowest centrality results for class 2A

*Numbers in between parenthesis are the centrality values calculated for the student(s)

** Orange cells are negative factors

Regarding the previously presented class, there are some students worth mentioning on both the positive and negative sides of the spectrum.

On a negative note, student 4 stands out being present in all of the negative factors. With the lowest weighted degree, betweenness and eigenvector centralities, and the highest closeness centrality, we can conclude that this student spends the least time with other children and has almost zero influence and popularity in class, being the furthest away from everyone else connection-wise.

On the opposite side of the spectrum, students 2 and 23 stand out as very popular and influential, spending a lot of time with other children and being the best source for information propagation. Student 23 also stands out as the child in class who assumes the Brokerage position, being connected to almost everyone else (highest betweenness centrality), while student 2 stands out as the child who spends the most time with other children (highest weighted degree).

In terms of strong connections (i.e. RSSI measurements weight > 75), students 4, 17, 18, 21, 24 and 25 are reported as having no good/best friends, while student 2 stands out with 9 good/best friends.

Class 2B

Centrality Metrics	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> • Student 20 (313) • Student 15 (347) • Student 4 (384) 	<ul style="list-style-type: none"> • Student 16 (2,194) • Student 8 (1,771) • Student 22 (1,374)
Closeness Centrality	<ul style="list-style-type: none"> • Student 16 and 22 (1,174) 	<ul style="list-style-type: none"> • Student 20 (1,913) • Student 4 (1,826)
Betweenness Centrality	<ul style="list-style-type: none"> • Student 20 (0) • Student 3 (0,344) 	<ul style="list-style-type: none"> • Student 16 (18,498) • Student 8 (17,773) • Student 22 (16,892)
Eigenvector Centrality	<ul style="list-style-type: none"> • Student 20 (0,25) • Student 18 (0,319) 	<ul style="list-style-type: none"> • Student 22 (1,000) • Student 16 (0,971) • Student 23 (0,952)

Table 20 - RSSI measurements' highest and lowest centrality results for class 2B

*Numbers in between parenthesis are the centrality values calculated for the student(s)

** Orange cells are negative factors

Analyzing the data from the previous table, it is noticeable that some of the students are listed in several categories, reinforcing the veracity of their assumed roles, when crossing data, related to this network.

Student 20 almost instantly stands out negatively. This student is minimally quoted in weighted degree, betweenness and eigenvector centralities, and the highest quoted student in closeness centrality. Even though he does not stand alone in lowest centrality metrics, this student is the only one quoted in all of these categories.

In the opposite site of the previous example, therefore positively quoted, we find students 8, 16 and 22. These 3 students share the highest weighted degree and betweenness centrality, meanwhile students 16 and 22 also share the lowest closeness centrality and the highest eigenvector centrality.

This being said, student 20 is characterized as non-popular, lonely and has little or none influence on the network, while students 16 and 22 are popular, spend a lot of time with other children acting as a bridge between all students, and so having a great influence on the network. In what comes to information contagion, students 16 and 22 have a high impact on its spreading.

Class 2C

Centrality Metrics	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> • Student 6 (69) • Student 4 (118) 	<ul style="list-style-type: none"> • Student 16 (1,312) • Student 25 (1,270) • Student 20 (1,109)
Closeness Centrality	<ul style="list-style-type: none"> • Student 5 (1,208) • Student 21 (1,25) 	<ul style="list-style-type: none"> • Student 6 (2,125) • Student 4 (2)
Betweenness Centrality	<ul style="list-style-type: none"> • Student 4 (0) • Student 6 (0,167) • Student 22 (0,514) • Student 18 (0,688) 	<ul style="list-style-type: none"> • Student 25 (19,316) • Student 5 (14,723) • Student 21 (14,53)
Eigenvector Centrality	<ul style="list-style-type: none"> • Student 6 (0,092) • Student 4 (0,184) • Student 22 (0,349) • Student 26 (0,398) 	<ul style="list-style-type: none"> • Student 5 (1) • Student 21 (0,968)

Table 21 - RSSI measurements' highest and lowest centrality results for class 2C

*Numbers in between parenthesis are the centrality values calculated for the student(s)

** Orange cells are negative factors

When analyzing the previous table, it is possible to observe a clear separation between positive and negative values, with basically the same students standing out on either one side of the spectrum or the other, although the positive values have more oscillations or less common students in all categories.

Negatively, students 4 and 6 both share the lowest values in weighted degree, betweenness centrality and eigenvector centrality, and the highest values in closeness centrality. Being part of this group, students 18 and 22, both share with the rest of them the lowest values in their class concerning the betweenness centrality category.

Positively, students 5 and 21 share the highest betweenness centrality and eigenvector centrality, and the lowest closeness centrality. Student 25 also stands out positively, sharing with the previous students the highest betweenness centrality, and with the students 16 and 20 the highest weighted degree.

Therefore, students 4 and 6 are characterized as spending the less time with other children, having fewer friends, having no influence in their class and not diffusing information. Students 5 and 21 act as a bridge between other children, have a high influence in their class, and are information propagators. Students 25, 16 and 20 are the children who are considered to be the most popular due to the time they spend with other children.

Class 3A

Centrality Metrics	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> • Student 12 (579) • Student 9 (595) 	<ul style="list-style-type: none"> • Student 19 (1,846)
Closeness Centrality	<ul style="list-style-type: none"> • Student 18 (1,1) 	<ul style="list-style-type: none"> • Student 21 (1,65)
Betweenness Centrality	<ul style="list-style-type: none"> • Student 21 (0,291) • Student 12 (0,618) 	<ul style="list-style-type: none"> • Student 2 (6,229) • Student 5 (5,762) • Student 16 (5,754)
Eigenvector Centrality	<ul style="list-style-type: none"> • Student 21 (0,381) 	<ul style="list-style-type: none"> • Student 18 (1) • Student 22 (0,967)

Table 22 - RSSI measurements' highest and lowest centrality results for class 3A

*Numbers in between parenthesis are the centrality values calculated for the student(s)

** Orange cells are negative factors

In the previous table, it is possible to observe some students worth mentioning, who stand out individually both positively and negatively, and others listed in more than one category, especially in the negative spectrum.

Negatively, students 12 and 21 stand out, both of them classified with the lowest betweenness centrality, diverging in the lowest weighted degree and lowest eigenvector centrality, respectively. Student 21 also stands out, having the highest closeness centrality.

Positively, student 19 stands out with the highest weighted degree and student 18 with the highest eigenvector centrality and lowest closeness centrality. Students 2, 5 and 16 have the highest betweenness centrality.

This being said, students 12 and 21 are the children who the least are in brokerage position, student 12 is considered one of the loneliest children, and student 21 has low information propagation, therefore, no influence in the network. On the other side of the spectrum, student 19 stand out as the most popular child and student 18 as the student who the fastest propagates information, having a high influence on the network. The students 2, 5 and 16 are only present in the highest betweenness centrality assuming, in their network, the brokerage position, meaning that act as a bridge between other children.

Class 3B

Centrality Metrics	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> • Student 10 (366) • Student 19 (412) 	<ul style="list-style-type: none"> • Student 14 (1,339) • Student 17 (1,259) • Student 6 (1,255)
Closeness Centrality	<ul style="list-style-type: none"> • Students 1, 8, 11, 12 and 22 (1.1) 	<ul style="list-style-type: none"> • Students 10 and 19 (1,6) • Students 15 and 18 (1,5)
Betweenness Centrality	<ul style="list-style-type: none"> • Student 18 (0,205) 	<ul style="list-style-type: none"> • Student 11 (5,914)
Eigenvector Centrality	<ul style="list-style-type: none"> • Student 19 (0,417) • Student 10 (0,434) 	<ul style="list-style-type: none"> • Student 22 (1) • Students 8 and 11 (0,992)

Table 23- RSSI measurements' highest and lowest centrality results for class 3B

*Numbers in between parenthesis are the centrality values calculated for the student(s)
 ** Orange cells are negative factors

The previous table presents us a diversified range of students and values, diverging from the previous classes, in which the same student is listed in several categories. In this class, the positively quoted students are more widely positioned, playing a more versatile role in what comes to influencing the network, popularity and brokerage position.

Negatively, students 10 and 19 both share the lowest weighted degree, eigenvector centrality and the highest closeness centrality. Student 18 stands out with the lowest betweenness centrality and highest closeness centrality.

Positively, student 11 is the student that instantly stands out in this class, listed in 3 categories as the student with the highest betweenness centrality, and one of the students with the highest eigenvector centrality and lowest closeness centrality.

In overview, students 10 and 19 are the least popular, less communicative, therefore having no influence on the class. Student 18 is characterized through these values as lonely, not communicative, not susceptible to propagate information. Student 11 is in brokerage position, acting as a bridge amongst other children, easily spreading information and influencing the network. Although student 22 is also a child with a high information propagation and influence, the most popular children in this class are students 14, 17 and 6, being these who spend more time with other children.

Class 3C

Centrality Metrics	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> Student 13 (183) Student 12 (245) 	<ul style="list-style-type: none"> Student 6 (901)
Closeness Centrality	<ul style="list-style-type: none"> Student 15 (1,158) Students 6 and 8 (1,211) 	<ul style="list-style-type: none"> Students 12 and 13 (1,737)
Betweenness Centrality	<ul style="list-style-type: none"> Student 13 (0,125) 	<ul style="list-style-type: none"> Student 15 (10,972) Student 6 (10,485)
Eigenvector Centrality	<ul style="list-style-type: none"> Student 12 (0,323) Student 13 (0,353) 	<ul style="list-style-type: none"> Student 15 (1) Student 18 (0,96) Student 6 (0,93)

Table 24 - RSSI measurements' highest and lowest centrality results for class 3C

*Numbers in between parenthesis are the centrality values calculated for the student(s)
 ** Orange cells are negative factors

When analyzing the previous table, it is possible to observe that only two students compose the negative outcome, listed in all categories, therefore, standing with more than one negative category. Positively, there are also some common students listed severally, except for two who are listed one time in one category.

Negatively, students 13 and 12 are the only students standing out, sharing the lowest weighted degree, eigenvector centrality and highest closeness centrality, diverging in the lowest betweenness centrality in which student 13 is the only student minimally quoted.

Positively, students 15 and 6 share the highest eigenvector centrality with student 18, the lowest closeness centrality with student 8, both standing out with the highest betweenness centrality, and student 6 standing out with the highest weighted degree.

Students 13 is considered to be the loneliest child in this class, sharing with student 12 the lowest popularity and lowest information spreading, therefore, they are the students that have the least or none existing influence on the network. Students 15 and 16 are the ones who have more influence over the class along with student 18, are both responsible for spreading information along with student 8, and are in brokerage position. Also student 6 stands out as the most popular child, spending most time with other children.

II.3.2.4.Data Analysis

When trying to define a proper threshold value for the minimally accepted time spent together between any pair of students that would translate into a successful social interaction, we came across an impasse. With not enough literature to support any kind of time-defined minimum threshold towards an acceptable social interaction, we decided not to simply define a filtering threshold based on common sense, but to define 3 that could then be examined as to determine which best suited our intents and the real world context. The thresholds would consist of 0 minutes (no filtering added on the RSSI measurement), 5 minutes (any pair of students with a weight less than 25 excluded from the sample) and 10 minutes (any pair of students with a weight less than 50 excluded from the sample). These numbers were calculated by the average number of samples the Bluetooth can capture (~5 samples) per minute.

These filtering thresholds seemed appropriate, taking into account that we measured the equivalent to 1 hour for each student (2 recesses). Hence, a 5 minute filter would consider any interaction less than 8.3% of the total recess time as ephemeral. Accordingly, a 10 minute filter would consider any interaction less than 16.7% to also be discarded.

RSSI-related Correlations

As previously mentioned, the RSSI measurement data is going to be partitioned into 3 sets of data before being analyzed: 0 minutes filtered, 5 minutes filtered and 10 minutes filtered. The following table illustrates all the correlations found between the “0 minutes filtered” RSSI metrics and all other variables.

Study I – Measurement and Analysis of Social Inclusiveness

	Gender	Degree	Weighted Degree	Closeness Centrality	Betweenness Centrality	Clustering Coefficient	Number Of Triangles	Eigenvector Centrality
Weighted Degree	-,360**	,042	–					
Closeness Centrality	-,097	-,055	-,188*	–				
Betweenness Centrality	-,027	,612**	,024	-,180*	–			
Clustering Coefficient	-,005	-,675**	,005	,192*	-,858**	–		
Number Of Triangles	-,017	,991**	,036	-,023	,540**	-,578**	–	
Eigenvector Centrality	,040	,364**	,065	-,584**	,207*	-,167	,357**	–
AGG	,247**	,041	-,213*	-,019	-,055	,040	,053	,183*
POP	-,103	,015	,123	-,136	,190*	-,177*	-,018	,061
OLY	-,014	,006	,177*	-,035	,039	-,015	-,015	,028
INT	-,088	,135	,087	-,060	,184*	-,181*	,125	-,046
Sum. ICS Scores	-,164	-,037	,194*	-,071	,136	-,121	-,065	-,066
Least Preferred	,277**	-,043	-,205*	,043	-,114	,093	-,030	-,039
Bully	,405**	-,024	-,306**	,058	-,092	,079	-,012	-,027
Relational Aggressor	,219*	-,047	-,172*	,035	-,087	,092	-,031	-,032
Special Educational Needs	,073	,023	-,196*	-,026	,043	-,167	-,015	,013
Low Socio-Economic Level	,059	,071	-,205*	,080	-,056	,071	,090	,060
Sum. Diversity Checklist Scores	,126	-,036	-,187*	-,012	-,013	-,001	-,037	,037

Table 25 – RSSI Measurement Correlations (0 minutes filtered)

*. Correlation is significant at the 0.05 level (2-tailed)

** . Correlation is significant at the 0.01 level (2-tailed)

The degree, or the number of peers a student is connected to, is strongly and positively correlated to the number of times that a student acts as a bridge along the shortest path between two of his peers, and the number of triangles in which a student is inserted into ($r = .61$ and $.99$, respectively, both $p < 0.01$). It also correlates positively, yet moderately, with the influence of a student in his/her classroom ($r = .36$, $p < 0.01$). Lastly, it strongly correlated negatively with how close a student’s connected peers are to being a closed group of friends ($r = -.68$, $p < 0.01$).

The weighted degree, or strength of ties between a student and its peers is correlated positively, although weakly, with the teacher’s perceived measures on Olympian Quantities and Summed ICS Score of the student ($r = .18$ and $.19$, respectively, both $p < 0.05$). It moderately correlates negatively with the student’s gender, and with the number of peer nominations a student has towards being a bully ($r = -.36$ and $.31$, respectively, both $p < 0.01$). At last, and also negatively, but weakly, it correlates with the teacher’s perceived measure of the student’s aggressiveness level, the number of peer nominations a student has as the least preferred peer, the teacher identification of the student’s low socio-economic level and special educational needs, a measure as to how long it will take to spread information from student “s” to all other students sequentially, the sum of the student’s teacher-identified diversity factors, and the number of peer nominations a student has towards being a relational aggressor (r ranges from $-.21$ to $-.17$, all $p < 0.05$).

The closeness centrality or the sum of a student’s distances towards his peers, reversed, correlates positively and moderately to how close a student’s connected peers are to being a

closed group of friends ($r = .19, p < 0.05$). Negatively, it correlates strongly to the influence of a student in his/her classroom ($r = -.58, p < 0.01$), and weakly to the strength of ties between a student and its peers and the number of times a student acts as a bridge along the shortest path between two of his peers ($r = -.19$ and $-.18$, respectively, both $p < 0.05$).

The betweenness centrality or the number of times a student acts as a bridge along the shortest path between two of his peers has a strong positive correlation with the number of peers a student is connected to, and the number of triangles in which he/she is inserted into ($r = .61$ and $.54$, respectively, both $p < 0.01$). It correlates weakly and positively to the influence of a student in his/her classroom, and to teacher's perceived measures of the student's popularity and problem Internalization (r ranges from $.21$ to $.18$, all $p < 0.05$). Negatively, there's a strong correlation to how close a student's connected peers are to being a closed group of friends ($r = -.86, p < 0.01$), and weakly to how long it will take to spread information from student "s" to all other students sequentially ($r = -.18, p < 0.05$).

The clustering coefficient or how close a student's connected peers are to being a closed group of friends is weakly and positively correlated to how long it will take to spread information from student "s" to all other students sequentially ($r = .19, p < 0.05$). It strongly correlates negatively to the number of times a student acts as a bridge along the shortest path between two of his peers, to the strength of ties between a student and its peers, and to the number of triangles in which he/she is inserted into (r ranges from $-.86$ to $-.58$, all $p < 0.01$). Also negatively, yet weakly, it correlates to the teacher's perceived measures on problem Internalization and student's popularity (both $r = -.18, p < 0.05$).

The number of triangles in which a student is inserted into is strongly correlated positively to the strength of ties between a student and its peers and to the number of times a student acts as a bridge along the shortest path between two of his peers ($r = .99$ and $.54$, respectively, both $p < 0.01$), and moderately to the influence of a student in his/her classroom ($r = .36, p < 0.01$). It also strongly correlates negatively to how close a student's connected peers are to being a closed group of friends ($r = -.58, p < 0.01$).

Finally, the eigenvector centrality or the influence of a student in the classroom is moderately correlated positively to the number of peers a student is connected to and to the number of triangles in which he/she is inserted into (both $r = .36, p < 0.01$), and weakly to the number of times a student acts as a bridge along the shortest path between two of his peers and to the teacher's perceived measures towards the student's aggressiveness level ($r = .21$ and $.18$, respectively, both $p < 0.05$). Negatively, it correlates strongly to the sum of a student's distances towards his peers, reversed ($r = -.58, p < 0.01$).

The following table illustrates all the correlations found between the "5 minutes filtered" RSSI metrics and all other variables.

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	Gender	Degree	Weighted Degree	Closeness Centrality	Betweenness Centrality	Clustering Coefficient	Number Of Triangles	Eigenvector Centrality
Degree	-,185*	-						
Weighted Degree	-,347**	,788**	-					
Closeness Centrality	,156	-,682**	-,550**	-				
Betweenness Centrality	-,103	,586**	,490**	-,406**	-			
Clustering Coefficient	,049	-,263**	-,185*	,221*	-,579**	-		
Number Of Triangles	-,106	,717**	,582**	-,454**	,331**	,129	-	
Eigenvector Centrality	-,186*	,967**	,762**	-,720**	,490**	-,169	,691**	-
AGG	,247**	-,159	-,215*	,127	-,013	,050	-,074	-,161
OLY	-,014	,170*	,185*	-,080	-,110	,121	,152	,136
INT	-,088	,119	,086	-,185*	,130	-,222**	,095	,108
Sum. ICS Scores	-,164	,174*	,201*	-,149	,039	-,088	,022	,177*
Least Preferred	,277**	-,244**	-,205*	,170*	-,126	,172*	-,101	-,260**
Bully	,405**	-,344**	-,310**	,280**	-,207*	,218*	-,184*	-,350**
Victim	,273**	-,148	-,153	,164	,043	,050	-,122	-,171*
Relational Aggressor	,219*	-,197*	-,172*	,106	-,103	,014	-,193*	-,207*
Special Educational Needs	,073	-,114	-,195*	,193*	-,062	-,146	-,139	-,133
Poor Social Condition	,102	-,148	-,173*	,118	-,050	,008	,078	-,187*
Low Socio Economic Level	,059	-,202*	-,219*	,190*	-,144	,139	,031	-,214*
Sum. Diversity Checklist Scores	,126	-,190*	-,195*	,199*	-,113	,010	-,021	-,177*
Sum. Loneliness Scale Scores	,014	-,055	,026	-,032	-,077	,190*	,131	-,054

Table 26 - RSSI Measurement Correlations (5 minutes filtered)

*. Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed)

* Rows colored in light green are new correlations, not present on the “0 minutes filtered” correlations

** Although not illustrated, ICS’s POP is no longer present as correlated to any RSSI metrics

The Degree, or number of peers a student is connected to, is strongly correlated positively to the student’s influence in his/her classroom, to the strength of ties between a student and its peers, to the number of triangles in which a student is inserted into, and to the number of times a student acts as a bridge along the shortest path between two of his peers (r ranges from .97 to .59, all $p < 0.01$). It is also positively correlated, yet weakly, to the teacher’s perceived measures of the student’s summed ICS scores and Olympian quantities (both $r = .17$, $p < 0.05$). Negatively, it strongly correlates to the student’s sum distances towards his peers, reversed ($r = -.68$, $p < 0.01$), moderately to the number of peer nominations a student has towards being a bully and, to how close a student’s connected peers are to being a closed group of friends ($r = -.34$ and $-.26$, respectively, both $p < 0.01$), and weakly correlated to the number of peer nominations a student has as the least preferred peer, to the low socio-economic level identified by the teacher, to the number of peer nominations a student has towards being a relational aggressor, to the variable that identifies if student has a diversity factor or not, and to the student’s gender (r ranges from $-.24$ to $-.19$, all $p < 0.05$ or $p < 0.01$).

The weighted degree, or the strength of ties between a student and its peers strongly correlates positively with number of peers a student is connected to, with a student's influence in his/her classroom, and with the number of triangles in which he/she is inserted into (r ranges from .79 to .58, all $p < 0.01$). Also positively, yet moderately, it correlates with the number of times a student acts as a bridge along the shortest path between two of his peers ($r = .49$, $p < 0.01$), and weakly with the teacher's perceived measures towards student's summed ICS Scores and Olympian quantities ($r = .20$ and $.19$, respectively, both $p < 0.05$). Negatively, it strongly correlates to the sum of a student's distances towards his peers, reversed ($r = .55$, $p < 0.01$), moderately to student's gender and to the number of peer nominations a student has towards being a bully ($r = -.35$ and $-.31$, respectively, both $p < 0.01$), and weakly to the teacher's reports towards student's summed diversity factors, special educational needs, aggressiveness level, low socio-economic level and poor social condition, to the number of peer nominations a student has as the least preferred peer, to how close a student's connected peers are to being a closed group of friends, and the number of peer nominations a student has towards being a relational aggressor (r ranges from $-.22$ to $-.17$, all $p < 0.05$).

The closeness centrality or the sum of a student's distances towards his peers, reversed is positively correlated moderately to the number of peer nominations a student has towards being a bully ($r = .28$, $p < 0.01$), weakly to how close a student's connected peers are to being a closed group of friends, to teacher's reports regarding students sum diversity factors, special educational needs, low socio-economic level, and to the number of peer nominations a student has as the least preferred peer (r range from $.22$ to $.17$, all $p < 0.05$). Negatively, it strongly correlates to the student's influence in his/her classroom, to the number of peers a student is connected to, and to the ties between a student and its peers (r ranges from $-.72$ to $-.55$, all $p < 0.01$). Still negatively, it moderately correlates to of triangles in which a student is inserted into and, to the number of times he/she acts as a bridge along the shortest path between two of his peers ($r = -.45$ and $-.41$, respectively, both $p < 0.01$), and weakly with the teacher's perceived measures regarding student's problems Internalization ($r = -.19$, $p < 0.05$).

The betweenness centrality or the number of times a student acts as a bridge along the shortest path between two of his peers is positively correlated strongly with the number of peers a student is connected to ($r = .59$, $p < 0.01$), and moderately with the strength of ties between a student and its peers, the number of triangles in which a student is inserted into, and the student's influence in his/her classroom (r range from $.49$ to $.33$, all $p < 0.01$). Negatively, it is strongly correlated to how close a student's connected peers are to being a closed group of friends ($r = -.58$, $p < 0.01$), moderately to student's sum distances towards his peers, reversed ($r = -.41$, $p < 0.01$), and weakly correlated to the number of peer nominations a student has towards being a bully ($r = -.21$, $p < 0.05$).

The clustering coefficient or how close a student's connected peers are to being a closed group of friends is weakly correlated positively with student's sum distances towards his/her peers, reversed, with the number of peer nominations a student has towards being a bully, with the sum of the scores obtained by students on the self-reported Loneliness Scale questionnaire, and with the number of peer nominations he/she has as the least preferred peer (r range from $.22$ to $.17$, all $p < 0.05$). It is negatively correlated strongly to the number of times a student acts as a bridge along the shortest path between two of his peers ($r = -.58$, $p < 0.01$), moderately to the number of peers a student is connected to ($r = -.26$, $p < 0.01$), and weakly correlated to the teacher's report regarding student's problems Internalization, and to the strength of ties between a student and its peers ($r = -.22$ and $-.19$, respectively, all $p < 0.01$ or $p < 0.05$).

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The number of triangles in which a student is inserted into is strongly correlated positively with the number of peers a student is connected to, with the influence of a student in his/her classroom and, with the strength of ties between a student and its peers (r ranges from .72 to .58, all $p < 0.01$). It is also positively correlated, yet moderately, to the number of times a student acts as a bridge along the shortest path between two of his peers ($r = .33$, $p < 0.01$). Negatively, it moderately correlates to the student's summed distances towards his peers, reversed ($r = -.45$, $p < 0.01$), and weakly to the number of peer nominations a student has towards being a relational aggressor, and towards being a bully ($r = -.19$ and $-.18$, respectively, both $p < 0.05$).

The eigenvector centrality or the influence of a student in his/her classroom is strongly correlated positively to the number of peers a student is connected to, to the strength of ties between a student and its peers, and to the number of triangles in which a student is inserted into (r ranges from .98 to .69, all $p < 0.01$), moderately with the number of times a student acts as a bridge along the shortest path between two of his peers ($r = .49$, $p < 0.01$), and weakly with the teacher's perceived summed ICS score relating the student ($r = .18$, $p < 0.05$). Negatively, it strongly correlates to the sum of a student's distances towards his peers, reversed ($r = -.72$, $p < 0.01$), moderately to the number of peer nominations a student has towards being a bully, and the number of peer nominations a student has as the least preferred peer ($r = -.35$ and $-.26$, respectively, all $p < 0.01$), and weakly to teacher's reports regarding student's the student's diversity factors, low socio-economic level and poor social condition, to the number of peer nominations a student has towards being a victim and towards being a relational aggressor, and lastly to the student's gender (r ranges from $-.21$ to $-.17$, all $p < 0.05$).

The following table illustrates all the correlations found between the “10 minutes filtered” RSSI metrics and all other variables.

	Gender	Degree	Weighted Degree	Closeness Centrality	Betweenness Centrality	Clustering Coefficient	Number Of Triangles	Eigenvector Centrality
Degree	-,234**	-						
Weighted Degree	-,345**	,938**	-					
Closeness Centrality	,104	-,442**	-,431**	-				
Betweenness Centrality	-,129	,590**	,551**	-,233**	-			
Clustering Coefficient	,105	-,363**	-,347**	,213*	-,539**	-		
Number Of Triangles	-,019	,209*	,228**	-,497**	,097	,123	-	
Eigenvector Centrality	-,200*	,836**	,742**	-,354**	,509**	-,192*	,143	-
AGG	,247**	-,137	-,208*	,133	,010	-,025	,046	-,172*
ACA	-,043	-,006	,019	,065	,019	,041	-,194*	,087
POP	-,103	,079	,102	,036	-,012	-,106	-,213*	,054
OLY	-,014	,134	,149	-,230**	-,137	-,052	-,079	,058
Sum. ICS Scores	-,164	,116	,170	-,062	-,018	-,036	-,197*	,136
Most Preferred	-,127	,116	,113	-,111	,038	-,033	-,048	,193*
Least Preferred	,277**	-,139	-,152	-,005	-,071	,069	,121	-,210*
Bully	,405**	-,249**	-,252**	,046	-,137	,065	,075	-,284**
Victim	,273**	-,117	-,132	,057	-,067	,119	,040	-,200*
Learning Difficulties	,059	,012	,006	,080	,030	-,096	,196*	-,100
Special Educational Needs	,073	-,157	-,193*	,066	-,063	-,037	-,096	-,195*
Poor Social Condition	,102	-,167	-,162	-,239**	-,112	,005	,329**	-,178*
Low Socio-Economic Level	,059	-,236**	-,210*	-,012	-,047	-,104	,195*	-,288**
Sum. Diversity Checklist Scores	,126	-,161	-,169*	-,007	,000	-,141	,186*	-,209*

Table 27 - RSSI Measurement Correlations (10 minutes filtered)

*. Correlation is significant at the 0.05 level (2-tailed)

** . Correlation is significant at the 0.01 level (2-tailed)

* Rows colored in light green are new correlations, not present on the “5 minutes filtered” correlations

** Although not illustrated, ICS’s INT, PNI’s Q5 and LS’s SLSS are no longer present as correlated to any RSSI metrics

The degree or number of peers a student is connected to strongly correlates, positively with the strength of ties between a student and its peers, the influence of a student in the classroom, and the number of times a student acts as a bridge along the shortest path between two of his peers (r ranges from .94 to .59, all $p < 0.01$). It also correlates positively, yet moderately, with the number of triangles in which a student is inserted into ($r = .21$, $p < 0.05$). Negatively, it moderately correlates to the student’s distances towards his peers, reversed, to how close a student’s connected peers are to being closed group of friends, and to the number of peer nominations a student has towards being a bully (r ranges from -.44 to -.25, all $p < 0.01$), and weakly to the teacher’s reports towards student’s low socio-economic level as well as his/her gender ($r = -.24$ and $-.23$, respectively, both $p < 0.01$).

The weighted degree or the strength of ties between a student and its peers positively correlates, strongly to the number of peers a student is connected to, to the student’s influence

in his/her classroom, and the number of times a student acts as a bridge along the shortest path between two of his peers (r ranges from .94 to .55, all $p < 0.01$), and weakly to the number of triangles in which a student is inserted into ($r = .23$, $p < 0.01$). Negatively, it moderately correlates with the student's sum distances towards his peers, reversed, with how close a student's connected peers are to being a closed group of friends, with student's gender, and to the number of peer nominations a student has towards being a bully (r ranges from -.43 to -.25, all $p < 0.01$), and weakly to teacher's reports regarding student's low socio-economic level, special educational needs, aggressiveness level and summed diversity factors (r ranges from -.21 to -.17, all $p < 0.05$).

The closeness centrality or the sum of a student's distances towards his peers is weakly correlated, positively to how close a student's connected peers are to being a closed group of friends ($r = .21$, $p < 0.05$). Negatively, it strongly correlates to the number of triangles in which a student is inserted into ($r = -.50$, $p < 0.01$), moderately to the strength of ties between a student and its peers, the number of peers a student is connected to, and his/her influence in the classroom (r ranges from -.44 to -.35, all $p < 0.01$), and weakly to the number of times a student acts as a bridge along the shortest path between two of his peers, and to teacher's reports regarding the student's Olympian quantities and poor social condition (r ranges from -.24 to -.23, all $p < 0.01$).

The betweenness centrality or the number of times a student acts as a bridge along the shortest path between two of his peers positively correlates, strongly with the number of peers a student is connected to, with the strength of ties between a student and its peers, and with the influence of a student in his/her classroom (r ranges from .59 to .51, all $p < 0.01$). Negatively, it correlates strongly how close a student's connected peers are to being a closed group of friends ($r = -.54$, $p < 0.01$), and weakly to sum of a student's distances towards his peers, reversed ($r = -.23$, $p < 0.01$).

The clustering coefficient or how close a student's connected peers are to being a closed group of friends is positively, yet weakly, correlated to the sum of a student's distances towards his peers, reversed ($r = .21$, $p < 0.05$). Negatively, it strongly correlates to the number of times a student acts as a bridge along the shortest path between two of his peers ($r = -.54$, $p < 0.01$), moderately to the number of peers a student is connected to and to the strength of ties between a student and its peers ($r = -.36$ and $-.35$, respectively, both $p < 0.01$), and weakly correlated to the student's influence in his/her classroom ($r = -.19$, $p < 0.05$).

The number of triangles in which a student is inserted into is positively correlated, moderately to the teacher's identification on the student's poor social condition ($r = .33$, $p < 0.01$), and weakly to the strength of ties between a student and its peers, to the number of peers a student is connected to, with teacher's reports regarding student's learning disabilities and/or diagnosed learning disorders, low socio-economic level, summed diversity factors, and to the sum of the scores obtained by students on the self-reported Loneliness Scale questionnaire (r ranges from .23 to .19, all $p < 0.01$ or $p < 0.05$). Negatively, it strongly correlates to the sum of a student's distances towards his peers, reversed ($r = -.50$, $p < 0.01$), and weakly to the teacher's perceived popularity and academic achievement of the student, as well as the student's summed ICS score (r ranges from -.21 to -.19, all $p < 0.05$).

The eigenvector centrality or the influence of a student in his/her classroom is strongly correlated positively with the number of peers a student is connected to, with the strength of ties between a student and its peers, and with the number of times a student acts as a bridge along the shortest path between two of his peers (r ranges from .84 to .51, all $p < 0.01$). Also

positively, yet weakly, it correlates with the number of peer nominations a student has as the most preferred peer ($r = .19$, $p < 0.05$). Negatively, it moderately correlates to the sum of the student's distances towards his peers, reversed, to the teacher's reports on student's low socio-economic level, and to the number of peer nominations a student has towards being a bully (r ranges from $-.35$ to $-.28$, all $p < 0.01$). Lastly, it negatively correlates weakly to the student's gender, to teacher's reports regarding the student's summed diversity factors, special educational needs, poor social condition and his/her aggressiveness level, to the number of peer nominations a student has as the least preferred peer and towards being a victim, and to how close a student's connected peers are to being a closed group of friends (r ranges from $-.21$ to $-.17$, all $p < 0.05$).

CORRELATION ANALYSIS

The previous section proposed a question: "which filtering best reflects the real world context, accounting for random and meaningless encounters?" Indeed, the answer to this question was satisfyingly obtained, as there is no margin for questioning, correlation-wise.

When opposing 0 minute, 5 minute and 10 minute filtering, we come across 32, 66 and 51 correlations, respectively. We can then infer with this information, that out of the 3 dimensions we analyzed, the 5 minute filtering proves to be the best. Also, not only with the highest number of correlations, it was the only filtering option that successfully correlated Loneliness scores with RSSI. This is immensely important, as the Loneliness scores were children self-reported, more reliable than teacher-reported values and one of the main scopes of this study (discovering who the lonely children are, for future action).

II.4. DISCUSSION

In this study, we presented an analysis on our previously developed tool *BlueFriends*. *BlueFriends* which is aimed at successfully measuring actual children behaviors, hence eliminating the need for unreliable self-reports or adult-reported data. This has been a major issue pointed out several times by the IDC (Interaction Design and Children) community, as Druin so eloquently explained: “young people are (...) an entirely different user population with their own culture (...) Yet, it is common for developers of new technologies to ask parents and teachers what they think their children or students may need (...) In addition, as we know, young children have a more difficult time verbalizing their thoughts, especially when it concerns abstract concepts and actions (...)” (Druin, 2002).

Also, adding to the previously mentioned improvements towards the known sociometric measurement technologies, *BlueFriends* can potentially monitor children indefinitely, especially if embedded into a wearable object, or even clothes (possible future work). The amount of resources used for this study was not substantial, with the exception of a researcher having to be consistently present, mostly to aid the children setting their pouches correctly. The pouches were always placed frontally to the children, which enhanced the Bluetooth detection due to its antenna design. This also could potentially constitute a problem because children fall a lot while running around and playing, which could damage the phones. Hard cases, like the ones we used, are an absolute necessity.

This study revealed that there is a significant number of metrics closely related to the RSSI measurements obtained. Although some correlations were to be expected (such as popularity being inversely correlated with being a bully or relational aggressor), some were quite unexpected. The fact that the clustering coefficient, i.e. the measure of the degree to which children tend to cluster together and form a clique (complete graph), correlated positively with PNI’s bully assessment, which intrigued us. Are children in fact clustering around bullies, or bullies around each other, or other children? Could this mean there is a gang mentality in 7 year-old bullies? Or do victims gather together when being bullied, and therefore create a cluster around bullies? More investigation and analysis would be necessary to answer these and other related questions.

One interesting metric to be taken into account is the gender, correlating with 8 other categories. RSSI-wise, we learned that girls have more connections, are more popular and more influent than boys, while boys proved to be more aggressive on the ICS teacher-perceived questionnaire. In what relates to the PNI questionnaire, boys were found to be least preferred, while assuming the part of bullies and relational aggressors, and interestingly victims as well. This tells us a lot, in the sense that we can infer that bullying and overall aggression is directed towards the male gender, which could be due to several reasons, from male’s frequent aggressive nature, to the fact that females are perceived as popular, or to have more friends around them.

Out of all the metrics analyzed, weighted degree played the most reliable correlational metric, with 16 correlations to others. In fact, the strength of the ties between the children is the best predictor of behavior patterns, mostly due to its simplicity. Even observation-wise, it’s easier to perceive which children hang together, and which don’t. However, observational logging never allows for a complete, accurate depiction of reality, as such task would require a

lot of observers to be perfectly complete. This is another aspect at which *BlueFriends* excels, for there is no need for researcher-driven logging.

It is also important to highlight that there is a certain sense of exclusiveness from the children who carried the phones. Not only did children from other classes constantly come to us asking if we would go to their classroom, as they would often gather around children wearing the devices, asking questions and engaging in social interactions with them, which denotes the social appeal adjacent to the carrying of sensing tools. On the other hand, children did not demonstrate any kind of ownership of a given phone, on the contrary it was very common for children to not appreciate the fact that they had the same phone for 2 days in a row (the phone pouches were numbered, letting the students know the phone they had assigned to them).

In terms of required resources, *BlueFriends* proved to be less evasive than existing measurement tools. There was a lot more disruption created by the filling of the questionnaires, than with the maintenance of the *BlueFriends*' system. Even when accounting for the time it took to place the phones on the children before the recess (5-10 minutes) and to remove them afterwards (5 minutes), there was no possible comparison when overviewing the time it took to complete the questionnaires. PNI took around 20 minutes of class time, LS took 30 minutes, and the teacher questionnaires have an estimated time completion of around 1 hour for each teacher. Summing it all together, it is obvious that, although we're physically attaching pouches to the students, they feel much less harassed by *BlueFriends*' approach than by current methods.

None-the-less, the deployment of *BlueFriends* still requires a researcher to be present for phone distributing, as well as retrieving. Tracking if children don't swap pouches is imperative, as a simple switch will change the whole data collected, rendering the measurements misleading and ultimately worthless.

Ultimately, as a possible future design it would be interesting to make use of a specially developed object, accessory or piece of clothing with a Bluetooth sensor attached running an Android operating system. The children could be monitored without being aware of such for weeks, while the data collected could be used to better understand behavioral pattern changes, pin-point friendship paradigm shifts and accurately depict potentially excluded or under-socializing children.

The biggest setback with *BlueFriends* are activities that involve distance between the children. Football, playing catch, hide & seek are a few examples of activities that will most likely not report the actual social engagement the student is undergoing. This could be countered with a set of Bluetooth devices scattered around the school for pin-pointing only, offering information to where the child was and inferring data from there as well (i.e. for 5 minutes, students 1 and 3 were at the football field, but their measurements did not show them together. We can infer that they were not engaging in social affiliation, but they were certainly sharing a similar space and are more likely to eventually play together and get along).

III. STUDY II – INFLUENCING BEHAVIORAL CHANGES THROUGH VISUAL CUES

In this study, we continue the deployment of the *BlueFriend's* sociometric sensing technology, while developing and deploying *BlueFriend's* Flash animated display, with the intent of influencing children behavioral changes through the use of visual cues. We present this study with the aim of exploring how sociometric sensing technologies can positively affect children networks, when aided by an engaging and pedagogical visual display. Our primary concern was held at the documenting of present and post-feedback social behaviors, while being minimally impacting towards children's class and playground time.

To successfully establish the validation of the visual representation tool, we correlated the data chronologically, from pre to post-feedback. More specifically, each class was measured pre-feedback, ensuring the present social connections were taken into account, and then re-measured after the use of *BlueFriend's* Flash component, as to fully understand to which extent a pro-social behavioral change was successfully implemented. The Flash application was child-adapted, being comprised of an animated playful look, while also providing visual cues towards the understanding and consequent improvement of behavioral patterns.

III.1. RELATED WORK

III.1.1. Sociometric and Behavioral Measurement

One of the main interests of Child-Computer Interaction is to measure children's behaviors and experiences. Although it represents one of the biggest challenges, it is crucial for researchers to try and find new interesting ways to stimulate the children's active participation.

A method to achieve this is through interviews. However, these require highly developed communication skills (Markopoulos, 2008) that may or may not be present in the studied population. The Piagetian stages of development (Piaget, 1971) state that a 7 year-old child is undergoing the process of leaving intuitive thought to beginning to understand concrete operations. This means that children are beginning to take into account the view point of others, while starting to classify things and understand the notion of reversibility and conservation.

Interviews also require the children to have the ability of self-emotional awareness in order to establish more substantial self-reports (Pasch, 2010) (Read, MacFarlane, & Casey, 2002). Yet, taking into account that children may have difficulties understanding the concept concerning the interviews, it is decisive to the viability of it to describe those using words and phrases they know (Read, MacFarlane, & Casey, 2002). Besides the difficulties previously mentioned, children also tend to become unresponsive to interviews due to their usually long duration (Markopoulos, 2008).

Consequently, researchers conceived new means to assist children with their speech, throughout specific activities such as drawing, which allows children to narrate their experiences, ideas and feeling by manipulating images, shapes and colors (Wright, 2007) (Desjardins & Wakkary, 2011) (Xu, 2009), or interaction with tangible objects as an incentive for emotional expression (Pasch, 2010).

Another method of measuring children's interactions is through questionnaires, yet with equivalent difficulties since children often have difficulties writing what they want to say, whether by not being able to spell or find the words that translates their thoughts, it is possible to provide them help, such as symbols (Read, MacFarlane, & Casey, 2002) (Read, MacFarlane, & Stuart, 2006) (Druin, 2002). Questionnaires also reveal to be long and dreary to children.

These barriers often force the children to complete the questionnaires, or answer the interviews in wrongful ways without full knowledge or comprehension of the questions being asked. These result in multiple concerns over the extracted data, validity and reliability-wise (Markopoulos, 2008) (Druin, 2002).

Behavioral measurements, when performed over a long period, have also encountered a few difficulties. A significant percentage of the studies depend on the researcher's pre-defined observation schemes of the activity. Taking into account that several children are playing together, while others observe or try to join, creates the possibility of a distorted result or slightest incomplete description of the behavior that the game in question provides, thus becoming uncomfortable and inconvenient to perform long-term. This inconvenience opens up the possibility to the use technology to complement the observations (Bakker, Saskia, Markopoulos, & Kort, 2008).

On one hand, technologies would be useful on overcoming these barriers, yet raising new ones such as becoming intrusive and requiring the use of substantial resources. Despite the privacy and health concerns of parents regarding the technologies which have a direct influence on the children's social interactions during playtime (Lyra, Karapanos, Kostakos, & Vassilis, 2011), these were found to be minor or none.

III.1.2. Influencing Behavioral Changes

From early stages, human beings often learn from imitating actions by observing others surrounding them. These imitations can either be intentional aiming to a specific goal or unconscious mimicry such as the chameleon effect (Chartrand & Bargh., 1999). This phenomenon has been documented and proven to have a passive, yet direct effect of social perception on social behavior, although it is an unintentional effect with no intended purpose (Dijksterhuis & Knippenberg, 1998). It is possible to observe its manifestation through idiosyncratic verbal expressions or speech inflections of a friend, or in simple actions such as crossing one's arms while in a conversation with someone who has his/her arms crossed, yet one is not aware of his/her actions.

Along the course of history, it has been argued that the act of perceiving another person's behavior creates a tendency to behave similarly oneself, along with the principle of William James (James, 1890) regarding ideomotor action which states that merely thinking about a behavior increases the tendency to engage in that behavior (Chartrand & Bargh., 1999).

It is based on this concept that we see a breach in how to influence children's social behaviors. Once we can successfully influence pro-social behavioral changes in some of the students, we expect the rest of the class to follow up on these based on the previously explained principle.

III.2. FIELD STUDY METHOD

III.2.1. Participants

This second study complements the first study previously developed, also followed through at Escola Básica do 1º Ciclo com Pré-Escolar Eng. Luís Santos, an elementary school located in Machico, from the 25th of November until the 17th of December. This school's class levels range from kindergarten to 4th year, in which the children's ages variety is between 4 and 12 years old. In order to follow the study earlier conducted, 7 year-old children or older were our main target, therefore choosing one 2nd year and one 3rd year classes to be a part of the study.

These two chosen classes, with a total of 50 children, aged between 7 and 8 year-old (male = 25) were observed and measured. Of these 70 children, 1 child had special learning needs and was not attending all classes. Due to his special needs, he was absent during recess, thus he didn't participate in the study.

III.2.2. Preparation

A series of material was necessary to deploy the study. Namely, 26 phones (9 x Android, 17 x Nokia N95), 13 chargers (3 x Android, 10 x Nokia), 26 phone pouches (9 x Android size, 17 x Nokia size), 17 belts (to adapt to different child sizes), 26 padlocks, 1 TV (LG wide screen) and 1 computer (Apple Mac mini).

Before the beginning of the study, a Flash application was developed with the aim of offering visual cues for students about their behaviors. This application consisted of the interconnection of both Flash and a remotely allocated MySQL database, which denotes the need for internet access at all times.

It was continuously projected throughout the course of the recesses on an LG wide-screen television, which was connected to a Mac Mini. There was no input equipment, such as a mouse or a keyboard, to avoid the children's manipulation of the computer. The TV color settings were highlighted with the goal of drawing more attention from the students. Also, the TV was strategically positioned next to the stairs, right before the canteen, which allowed the children's attention to be drawn as soon as they came out of their classrooms to both recess and lunch.

The application projection was always set up before the recess, ensuring that children did not understand that there was a computer associated with the TV. Also, since there was no reliability in leaving the TV as well as the Mac Mini in the hallway, the equipment would always be stored at the end of the day in a locked room, and re-setup in the following morning.

Although sometimes the phones were distributed before the recess, the measurements were limited using a punch-in/punch-out system, assuring that measurements obtained while the children were not at the playground were disregarded. An additional phone located next to the TV with Bluetooth permanently enabled was visible to all other phones. Its range maxed out at the door which separated the corridor from both the playground and the canteen. This means that all measurements obtained while children were eating, or next to the TV, were excluded from the study.

The study was conducted throughout the normal course of classes, while striving to be as non-evasive as possible. The children were constantly reminded of the purpose of the study, giving them a chance to improve their overall attitudes and behaviors towards their peers. Also, we continuously reiterated that the devices that they were wearing should not be an impediment towards their normal recess activities.

III.2.2.1.Application Development

The Flash application consists of a playground with several dogs, which symbolize the children taking part in the study. All dogs, except the center one, are white with brown spots, having girl-associated dogs an additional pink bow on the top of their head. The center dog is yellow, to be easily distinguishable from the rest.

The dogs are anthropomorphic, exhibiting expressions such as happiness, apathy and sadness. These emotions are defined by the amount of time the student has spent with the other students, inter-changing as necessary throughout the course of the application. There is also a name tag floating above each dog, providing identification.

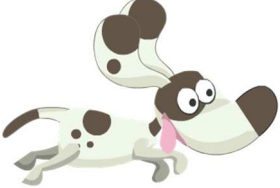





Happy	Smiley	Sad
		
		

Table 28 - Dogs emotions portrayed in the visual display.

When the application starts, a given student is selected to be viewed, and therefore is played by the yellow dog. It starts on the utmost left side of the screen, where it is possible to see his house and his closest friends next to him. The friends demonstrate a very happy expression, while being constantly on the move. These movements alternate from running to stopping arbitrarily, but remaining more or less around the same space.



Figure 6 - Flash's application in motion - third screen.

After a final time frame that allows the student to absorb the given information, the application restarts with another student portraying the yellow dog, and so forth.

There was a major concern with the fact that excluded children would have substantially less best friends and more peers with whom they did not spend enough time. To avoid this kind of discrimination, since the display was public and every kid was able to see other children's screens, we reduced the amount of possible friends for each screen to a maximum of 5. This way, there were no major differences in the different outputs of the children, with number of screen-related nearby colleagues varying mostly between 3 and 5.

The application was input enabled, for easier testing. When it was deployed however, input accessories (mouse and keyboard) were not made available for the students, as these would distract them from the actual purpose of the application. Also, some features that were developed for the application were not used, such as seasons, fireworks and up to 5 different levels. This was due to the restricted time table available for the fulfillment of the study.

III.2.2.2. New Friendship Choices

In order to further spark on the students the spirit of companionship and achievement, they were proposed to pick 2 of their peers with whom they had spent less time with to try and spend more time with them after the first 2 full-measurements. These choices were personal preference, as no input other than each child's was allowed for the duration of the picking exercise.

Children were called, one by one, to the front of the screen to allow for better engagement with the displayed application. They were explained how every screen and aspect of the application worked, while being constantly reminded of the importance of friendship, cooperation and pro-social behaviors. On the last screen, after analyzing who and why these peers were perceived to have weak ties with the student at hand, each student was prompted to pick 2 of them for, during the duration of the rest of the study, try to spend more time with.

III.2.3.Constraints / Problems

Although the Flash application was functional before the deployment of this study, some bugs were encountered and had to be dealt with. This meant that there was an interruption to the course of the study, namely during days 25 to 29 of November.

Also, winter got significantly worse at the beginning of December, which eventually led us to have to abandon the idea of continuing the study after the 5th of December. As explained in the previous study, the deployment had to be done while the children were playing outside, and so adverse weather conditions made it impossible to measure anything accurately. Rain prevented the children from being free to play wherever they wanted, with whoever they wanted, and therefore measuring anything on those conditions would be erroneous.

A persistent problem from the first to the second study was that the material at hand wasn't enough to measure everyone at the same time. The application developed targeted Android mobiles, and unfortunately, there weren't enough to measure everyone at the same time. This constraint was worked around by rotating the phones, handing out 9 androids at each rotation, while the rest would get a Nokia phone.

		Students	Assigned Phone	Class Measurement Progress
1 Full Measurement	day 1	1 - 9	Android	33%
		Rest	Nokia	
	day 2	10 - 18	Android	66%
		Rest	Nokia	
	day 3	Rest	Android	100%
		1 - 18	Nokia	

Table 29 - Schematic of the phone rotations.

The Nokia phones weren't able to collect data, but were able to transmit their Bluetooth signal, which was then captured by the Android smartphones. As illustrated in the above schematic, a total of 3 rotations per class was enough to successfully collect RSSI readings from everyone, since 9 Android devices rotated 3 times amounted to 27 children measured (maximum number of children per class was 26). It should be taken into account that this is not an ideal situation, as there could have been a lot more data retrieval if there were enough Androids for the whole class.

Based on the experience obtained on the first study, there was no constraining of the children's physical activity, since the phones were placed in small adaptable pouches at the student's waist. This adaptability enabled the weight to be disregarded. Also, the phones were previously locked avoiding the interaction between the student and the device. Since the phones were measuring the proximity through the strength of the signal provided by the Bluetooth, it was crucial that the students could not manipulate them.

The resources also did not reveal to be substantial. This was due to the durability of the Nokia batteries that had sustenance of a week or more, while the androids only remained turned on for the duration of the measurements (30 minutes, twice a day) and data extraction, also being charged once a week.

A photographic camera was also in question to complement the study with visual information. Yet, our presence in the playground proved to be too disruptive, interfering with

the student’s normal behaviors due to their attempt to interact with the researcher. This factor disabled the researcher from documenting the student’s on their normal daily activities.

III.2.4.Method

The school had 2 different schedules, morning classes (1st and 2nd years) and afternoon classes (3rd and 4th years). Since there were only 2 reliable recesses, 1 for each schedule, we were able to collect measurements twice a day, 1 class in the morning and 1 class in the afternoon. One 2nd and one 3rd year classes were selected to be a part of the deployment due to the age group that fill our main target of 7 and 8 year-old children. A total of 3 days were necessary to complete the RSSI measurement for each class (see previous section for Android rotation explanation). The following table explains how the study was conducted.

	Pre-Feedback						Post-Feedback			
	1 st Full Measurement			2 nd Full Measurement			3 rd Full Measurement			
Days	1	2	3	4	5	6	7	8	9	10
Measuring Students	X	X	X	X	X	X		X	X	X
Providing Feedback							X	X	X	X

Table 30 - 2nd study schedule.

The second study subdivides in two parts. The first part is similar to the first deployment, based on measuring the children’s social metrics using the phones. Therefore, we arrived earlier to the classroom on the first day in order to explain that they would be using the devices during the following days.

The pouches were always handed out prior to children leaving the class, thus demanding our presence 5 minutes before the class was finished, and collected at the end of each recess. The measurements had a duration of 6 days, allowing us to gather 2 full measurements per child.

After collecting, analyzing and processing the data that we believed to be consistent to gather a sample of the children’s behavior and connections, this information was placed in a MySQL server.

On the 7th day we strategically prepared the location of the TV and ran the application as soon as children came down for recess. Right away they were able to associate their names with dog ones projected on the TV and raised a number of questions. We proceeded into explaining to them what the study was all about and how the application worked, while pointing out some pro-social behaviors they could adopt towards a better social experience for both them and their peers.

Since that day was only selected to explain the Flash application and present them with a challenge, measurements were not made. We explained all 3 screens of the Flash application, while highlighting that in order to have access to their peers on the other side of the river, they would have to build a bridge themselves. This was possible by choosing two of the peers with whom they had weak connections with, and spending the following week trying to know more about them.

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The process of new friendship choosing was done by having them watch their screens one by one, outside of the classroom. Each stage was once again explained individually, invigorating the importance of friendship and acceptance, yet focusing on the peers on the opposite side of the river and on the importance of fellowship and spirit of friendship. Although some children seemed to be reluctant, due to their idea that there was no common interests or simply no connection between them and the peer with which they had the weakest connections, the vast majority was happy to do so.

During the following, and last, 3 days, the students were continuously measured and the visual display was kept on during recesses for remembrance and motivational purposes. Our initial goal was to update the data every day so that children could see their changes and evolution, but due to the lack of resources (only 9 smartphones available), this was an impossibility. Updating the data after the first or second days would generate a significantly larger amount of data for the children who had been in possession of the androids only, and would potentially cause misunderstandings towards the data.

III.3.FINDINGS

III.3.1.Proximity Measurement

III.3.1.1.Student-specific Network Centrality

After gathering all the data that was collected from the RSSI measurement, it was possible to analyze some network metrics associated with each class. These metrics include Weighted Degree and Closeness, Betweenness and Eigenvector Centrality. Each network metric illustrates different aspects and conditions of each network, and so will be separated as to better understand the social phenomenon and environment of each class.

We will analyze each class separately, and determine the social demographics of each towards popularity, exclusion and other meaningful conclusions based on the previously mentioned Centrality metrics.

Class 2A

	Pre - feedback		Post - feedback	
Centrality Metrics	Lowest	Highest	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> Student 9 (655) Student 21(709) Student 11 (748) 	<ul style="list-style-type: none"> Student 5 (1690) Student 13 (1585) Student 1 (1493) Student 24 (1426) 	<ul style="list-style-type: none"> Student 4 (693) Student 1(768) Student 16 (783) Student 6 (789) 	<ul style="list-style-type: none"> Student 21 (1323)
Closeness Centrality	<ul style="list-style-type: none"> Students 5, 10 and 20 (1,045) 	<ul style="list-style-type: none"> Students 9, 15 and 21 (1.455) 	<ul style="list-style-type: none"> Student 5 (1) Student 2 (1,046) Students 9 and 14 (1,091) 	<ul style="list-style-type: none"> Student 18(1,455) Students 11 (1,409)
Betweenness Centrality	<ul style="list-style-type: none"> Student 9 (0,256) Student 21 (0,325) Student 15 (0,332) 	<ul style="list-style-type: none"> Student 19 (3,840) Student 5 (3,426) Students 10 and 20 (3,416) 	<ul style="list-style-type: none"> Student 16 (0,767) Student 17 (0,882) Student 18 (0,918) 	<ul style="list-style-type: none"> Student 5 (5,929) Student 2 (5,608) Student 9 (4,230)
Eigenvector Centrality	<ul style="list-style-type: none"> Student 15 (0.599) Student 21 (0.601) Student 9 (0.610) 	<ul style="list-style-type: none"> Students 5, 10 and 20 (1) 	<ul style="list-style-type: none"> Student 18 (0,561) Student 11 (0,604) 	<ul style="list-style-type: none"> Student 5 (1) Student 2 (0,954) Student 14 (0,933) Student 9 (0,928)

Table 31 - Student-specific network centrality for class 2A.

*Numbers in between parenthesis are the centrality values calculated for the student(s)

** Orange cells are negative factors

In the previous table, regarding student’s centrality metrics, there were major changes in students 9 and 21. Pre-feedback these students held the negative extremity, both quoting low on weighted degree, betweenness and eigenvector centralities and highly on closeness centrality. Post-feedback, student 9 quoted highly on betweenness and eigenvector centralities and low on closeness centrality, while student 21 held the highest weighted degree, therefore leaving the negative extremity to be held in the positive one, having both a positive evolution.

The following students went through minor changes, although, with different paths. Students 16 and 18 were not held either positively or negatively pre-feedback, evolving post-

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feedback to the negative spectrum where both students quoted a low betweenness centrality, while student 16 quoted a low weighted degree, and student 18 quoted a low eigenvector centrality and the highest closeness centrality.

On the other hand, students 10 and 20 were held pre-feedback on the positive extremity, quoting highly in betweenness and eigenvector centralities and low on closeness centrality. Post-feedback it is possible to observe that these students also had a minor, yet a negative evolution, from good students to average students.

With a positive evolution, student 15 quoted low pre-feedback on both betweenness and eigenvector centralities and one of the highest closeness centralities to no longer being held post-feedback, thus going from to average.

Also positively, yet from average to good, students 2 and 14 who were not held on any of the extremities pre-feedback, found themselves post-feedback quoting highly on eigenvector centrality and low on closeness centrality, diverging on the betweenness centrality, which was held by student 2.

Students 5 and 11 were coherent on their scores since they had no significant evolution. While student 11 remained bad diverging from his low weighted degree pre-feedback to a low eigenvector centrality and a high closeness centrality post-feedback, student 5 remained a good student, diverging on his high weighted degree previously held, although progressing to the highest betweenness and eigenvector centralities and the lowest closeness centrality of his class on the post-feedback data.

On a general note, students 9 and 21 were the ones with the major evolution. Both students evolved from low popularity, spending less time with other children, little influence and not diffusing information, in the case of student 9 to brokerage position, influencing and propagating information, while student 21 became the most popular child.

Students 16 and 18 were considered to be average students by not being held pre-feedback. Post-feedback both held the negative spectrum, as the least friendly, while student 16 was considered to be one of the least popular and student 18 one of the loneliest children, thus a low source of information propagation.

Students 10 and 20 also had a negative, although minor, evolution from pre to post-feedback. Acting as a bridge between other children, in brokerage position and influencing the class, these two students had no impact post-feedback.

Negatively standing out, pre-feedback, as lonely, having no influence on his classroom and a low source of information, student 15 had a minor yet positive evolution by no longer being held on any extremity post-feedback.

On a different perspective, students 2 and 14 were considered to be averagely quoted by not being held on any spectrum pre-feedback, standing out positively post-feedback as having influence on their classroom and acting as a bridge between other children, while student 2 was also broker.

With no evolution, student 11 remains low quoted diverging on his low popularity to a low influence and information propagation, and student 5 standing out by remaining a highly quoted student although diverging in his popularity which he did not held, yet improving his brokerage position, influence and information propagation, quoting the highest from pre-to post-feedback.

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Class 3A

Centrality Metrics	Pre - feedback		Post - feedback	
	Lowest	Highest	Lowest	Highest
Weighted Degree	<ul style="list-style-type: none"> • Student 1 (315) • Student 19 (359) 	<ul style="list-style-type: none"> • Student 2 (2099) 	<ul style="list-style-type: none"> • Student 10 (702) • Student 16 (768) 	<ul style="list-style-type: none"> • Student 4 (1500) • Student 5 (1496) • Student 21 (1486)
Closeness Centrality	<ul style="list-style-type: none"> • Students 2 (1,040) • Students 14 and 26(1,080) 	<ul style="list-style-type: none"> • Students 1 and 15 (1,720) • Student 19 (1,600) 	<ul style="list-style-type: none"> • Students 2 and 5 (1) • Students 8 and 21 (1,040) 	<ul style="list-style-type: none"> • Student 10 (1,520) • Student 16 (1,400)
Betweenness Centrality	<ul style="list-style-type: none"> • Students 15 and 19 (0,118) • Student 1 (0,125) 	<ul style="list-style-type: none"> • Student 2 (11,730) • Student 26 (10,807) • Student 21 (10,227) 	<ul style="list-style-type: none"> • Student 10 (0,577) 	<ul style="list-style-type: none"> • Students 2 and 5 (4,365) • Student 8 (4,167) • Student 4 (4,072)
Eigenvector Centrality	<ul style="list-style-type: none"> • Student 1 (0,334) • Student 15 (0,340) 	<ul style="list-style-type: none"> • Student 2 (1) • Student 14 (0,998) • Student 26 (0,960) • Student 18 (0,958) 	<ul style="list-style-type: none"> • Student 10 (0,499) • Student 16 (0,622) 	<ul style="list-style-type: none"> • Students 2 and 5 (1) • Student 21 (0,977) • Student 8 (0,962)

Table 32 - Student-specific network centrality for class 3A.

*Numbers in between parenthesis are the centrality values calculated for the student(s)

** Orange cells are negative factors

It is possible to observe in the previous table that although there was no major evolution, several minor changes weighted out on the general outcome of this class.

On the pre-feedback data, students 10 and 16 revealed to be averagely quoted, by not being held in any of the data extremities. Post-feedback, both revealed a negative evolution, with the lowest betweenness centrality being held by student 10, while sharing with student 16 a low weighted degree, low eigenvector and the two highest closeness centralities.

On a similar situation, yet shifting from good to average, we find that students 14 and 26 both shared a low closeness and high eigenvector centralities, while student 26 also quoted highly in betweenness centrality pre-feedback, to no longer be part of neither positive nor negative data post-feedback.

Still a minor change, yet from bad to average, this evolution revealed to be significant to the social status of the students 1, 15 and 19, who were the main subjects of the negative spectrum pre-feedback. With all sharing low betweenness and high closeness centralities, students 1 and 19 a low weighted degree and students 1 and 15 a low eigenvector centrality. The post-feedback data did not include any of the previous in any of the extremities.

On the other hand, students 4, 5 and 8, who did not hold any highly positive or negative scores pre-feedback, went through a positive evolution. Post-feedback, all the previously mentioned quoted highly in betweenness centrality, with students 4 and 5 also quoting highly on weighted degree, students 5 and 8 low in closeness centrality, and student 8 quoting a high eigenvector centrality.

There was no evolution on students 2 and 21 that remained positive reinforcing their status on the class. Student 2 maintained post-feedback his highest betweenness, eigenvector and lowest closeness centrality, diverging on the highest weighted degree that was only achieved pre-feedback. Student 21 stood out pre-feedback with a high betweenness centrality and post-feedback with a high weighted degree, eigenvector and low closeness centralities.

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On a general note, pre-feedback, students 10 and 16 were neither quoted positively nor negatively. Post-feedback, student 10 is more isolated, and along with student 16 the least popular students, with low influence and a low source of information propagation.

Students 14 and 26 quoted positively pre-feedback, being both information propagators and influent students, while student 26 was also in brokerage position, to have a slight negative evolution from good to average, not standing out positively or negatively post-feedback.

It is possible to observe a positive evolution in students 1, 15 and 19 quoting the lowest brokerage position, students 1 and 19 as the least popular, and students 1 and 15 as the least influent children in their class, that were no longer held post-feedback as bad but as average students.

Also positively, students 4, 5 and 8 were pre-feedback average students, standing out post-feedback as brokers, acting as a bridge between other children. Students 4 and 5 also became popular, and students 5 and 8 became information propagators, strongly influencing their class.

Student 2 continued to be a good student, quoting positively in all categories pre-feedback acting as a bridge between other children, diffusing information and being an influence on the class, with a minor change in his popularity which he did not quoted post-feedback. Student 21, previously identified as broker, is now a popular and influent child, being the source of information contagion.

III.3.1.2. Class Average Network Centrality

After gathering all the data that was collected from the RSSI measurement, it was possible to analyze some network metrics associated with each class. These metrics include Weighted Degree and Closeness, Betweenness and Eigenvector Centrality. Each network metric illustrates different aspects and conditions of each network, and so will be separated as to better understand the social phenomenon and environment of each class.

We will analyze each class separately, and determine the social demographics of each towards popularity, exclusion and other meaningful conclusions based on the previously mentioned Centrality metrics.

Class 2A

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	wDegree	1138,3478	23	263,61329	54,96717
	postWDegree	1013,4783	23	181,71678	37,89057
Pair 2	closeness	1,1976	23	,13067	,02725
	postCloseness	1,2371	23	,12556	,02618
Pair 3	between	2,1739	23	1,11480	,23245
	postBetween	2,6087	23	1,39692	,29128
Pair 4	eigenvector	,8545	23	,12548	,02616
	postEigenvector	,7905	23	,12236	,02551

Table 33 - Paired Samples Statistics for class 2A.

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The previous table presents a general average and standard deviation concerning the centrality metrics of class 2A. Although the average weighted degree was lower post-feedback, the standard deviation was also lower, meaning that there was less disparity between students concerning their popularity.

The average betweenness centrality increased from pre to post-feedback. This can be seen as students acting more as a bridge between other children. The standard deviation also increased, although not significantly.

The average maintained similar from pre to post-feedback on closeness and eigenvector centralities, as well as its standard deviation. Therefore, the student’s influence and brokerage position maintained coherent, as well as its disparity.

On a general note, we can infer that children spend more or less the same time with other children as before, took about the same measure of time to spread information, also standing the same regarding the amount of time that children act as a bridge between other children and still there was no variation on the children’s influence on their class.

	Paired Differences					t	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			
				Lower	Upper		
wDegree - postWDegree	124,86957	344,65731	71,86602	-24,17143	273,91056	1,738	,096
closeness - postCloseness	-,03958	,19122	,03987	-,12227	,04311	-,993	,332
between - postBetween	-,43483	1,91977	,40030	-1,26500	,39534	-1,086	,289
eigenvector - postEigenvector	,06393	,18115	,03777	-,01441	,14227	1,693	,105

Table 34 - Paired Samples Test for class 2A.

Running a paired-sample T-test, we calculated, with a 95% Confidence Interval, the differences between pre and post-feedback, while measuring its significance (2-tailed). Regarding class 2M, none of the centrality metrics revealed a significant difference at the 2-tail level from pre to post-feedback. The closest value to have an impact, concerns the weighted degree and eigenvector centrality, although still higher than 0.05 ($p = 0.096$ and $p = 0.105$, respectively).

Class 3A

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	wDegree	969,0769	26	416,92656	81,76602
	postWDegree	1127,6154	26	244,74135	47,99773
Pair 2	closeness	1,3169	26	,18345	,03598
	postCloseness	1,1846	26	,12189	,02391
Pair 3	between	3,9615	26	3,24113	,63564
	postBetween	2,3077	26	1,24685	,24453
Pair 4	eigenvector	,7595	26	,17909	,03512
	postEigenvector	,8377	26	,11512	,02258

Table 35 - Paired Samples Statistics for class 3A.

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Regarding the previous table it is possible to observe some oscillations concerning the student’s average centrality metrics from pre to post-feedback, in class 3A.

The average weighted degree increased while its standard deviation decreased. On a general perspective we can infer that averagely students became more popular with less disparity between them.

Although the average closeness centrality underwent a minor oscillation as well as its standard deviation, it was a positive one. This could be seen as a minor amount of time being need to propagate information between students from pre to post-feedback.

The average betweenness centrality as well as its standard deviation decreased. Fewer children are now in brokerage position.

The average eigenvector centrality and its standard deviation also underwent some positive oscillations from pre to post-feedback. Generally speaking, the student’s influence increased slightly with a lower disparity between them.

On a general note, the student’s average popularity became higher, spending more time with each other, also taking less time to spread information. There were fewer students in brokerage position while the influence maintained more or less the same.

	Paired Differences					t	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference			
				Lower	Upper		
wDegree - postWDegree	-158,53846	437,08555	85,71953	-335,08114	18,00421	-1,850	,076
closeness - postCloseness	,13231	,21129	,04144	,04697	,21765	3,193	,004
between - postBetween	1,65385	3,34659	,65632	,30213	3,00556	2,520	,018
eigenvector - postEigenvector	-,07812	,20745	,04068	-,16191	,00567	-1,920	,066

Table 36 - Paired Samples Test for class 3A.

Running a paired-sample T-test, we calculated, with a 95% Confidence Interval, the differences between pre and post-feedback, while measuring its significance (2-tailed). Both closeness and betweenness centralities are proven to have significant changes from pre to post-feedback. As we can see the correlations are significant at the 2-tail level, being both lower than 0.05 ($p = 0.004$ and $p = 0.018$, respectively). Although the weighted degree and the eigenvector centrality did not reveal a significant evolution at the 2-tail level, its values were not much higher than 0.05 ($p = 0.076$ and $p = 0.066$, respectively).

III.3.1.3. Standard Deviation Interval Correlations

Because of the fact that this study had multi-temporal measurements, there is a need to supply an appropriate comparative method. But, since the maximum dimensions were different for most factors (with the exception of degree, which was the number of students for each class), we had to first calculate how relevant scores were towards each student percentage-wise, for both pre and post-feedback, and then compare the appropriate differences. With this in mind, we proceeded to calculate the Standard Deviation Intervals, which consist on the following equation:

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$$\%Deviation_{StudX} = \frac{\sigma_{postFactorStudX} - \frac{\sum_1^n \sigma_n}{n}}{\frac{\sum_1^n \sigma_n}{n}} - \frac{\sigma_{preFactorStudX} - \frac{\sum_1^n \sigma_n}{n}}{\frac{\sum_1^n \sigma_n}{n}}$$

As the equation illustrates, by subtracting the initial percentage deviation associated with a given student from its final percentage deviation, we attain his Standard Deviation Interval.

In the following section, we will correlate and analyze the different standard deviation intervals with each other, as well as with the new friend choices and the student’s gender. The implications of these correlations will be further discussed in the discussion section.

Class 2A

		Interval of Standard Deviation							
		New Friend Choice	Gender	Degree	Weighted Degree	Closeness	Betweenness	Clustering Coefficient	Number of Triangles
Interval of Standard Deviation	Degree	,552**	-,186						
	Weighted Degree	,641**	-,310	,749**					
	Closeness	-,560**	,183	-1,000**	-,754**				
	Betweenness	,546**	-,103	,947**	,705**	-,948**			
	Clustering Coefficient	-,540**	,130	-,838**	-,668**	,841**	-,936**		
	N° of Triangles	,515*	-,188	,994**	,733**	-,993**	,924**	-,782**	
	Eigenvector	,521*	-,199	,994**	,722**	-,993**	,910**	-,778**	,995**

Table 37 - Inter-correlations between questionnaires for class 2A.

** Correlation is significant at the 0.01 level (2-tailed)
 * Correlation is significant at the 0.05 level (2-tailed)

The new friend choice is positively correlated strongly to Strength of ties between the student and its peers, the number of peers the student is connected to, the number of times the student acts as a bridge along the shortest path between two of his peers, the influence of the student in the classroom, and the number of triangles in which the student is inserted into (r ranges from .64 to .52, all p < 0.01 and p < 0.05). Negatively, it strongly correlates to the sum of the student’s distances towards his peers, reversed, and to how close the student’s connected peers are to being a clique (r = -.56 and -.54, respectively, both p < 0.01).

The Degree, or the number of peers a student is connected to is positively correlated strongly to the influence of the student in the classroom, the number of triangles in which the student is inserted into, the number of times the student acts as a bridge along the shortest path between two of his peers, the strength of ties between the student and its peers, and to the new friend choice (r ranges from .99 to .55, all p < 0.01). Negatively, it strongly correlates to the sum of the student’s distances towards his peers, reversed, and to how close the student’s connected peers are to being a clique (r = -.1 and -.84, respectively, both p < 0.01).

The Weighted Degree, or the strength of ties between a student and its peers positively correlates strongly to the number of peers and triangles in which the student is connected to and inserted into, respectively, the influence of the student in the classroom, the number of times the student acts as a bridge along the shortest path between two of his peers, and to the

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new friend choice (r ranges from .75 to .64, all $p < 0.01$). Negatively, it strongly correlates to the sum of the student's distances towards his peers, reversed, and to how close the student's connected peers are to being a clique ($r = -.75$ and $-.67$, respectively, both $p < 0.01$).

The Closeness Centrality, or the sum of a student's distances towards his peers, reversed, is strongly correlated positively to how close the student's connected peers are to being a clique ($r = .84$, $p < 0.01$), and negatively to the number of peers and triangles in which the student is connected to and inserted into, respectively, the influence of the student in the classroom, the number of times the student acts as a bridge along the shortest path between two of his peers, the strength of ties between the student and its peers, and to the new friend choice (r ranges from -1 to $-.56$, all $p < 0.01$).

The Betweenness Centrality or the number of times a student acts as a bridge along the shortest path between two of his peers, positively correlates strongly to the number of peers and triangles in which the students is connected to and inserted into, respectively, the influence of the student in the classroom, the strength of ties between the student and its peers, and to the new friend choice (r ranges from .95 to .55, all $p < 0.01$). Negatively, it strongly correlates to the sum of the student's distances towards his peers, reversed, and to how close the student's connected peers are to being a clique ($r = -.95$ and $-.94$, respectively, both $p < 0.01$).

The Clustering Coefficient or how close a student's connected peers are to being a clique is strongly correlated positively to the sum of the student's distances towards his peers, reversed ($r = .84$, $p < 0.01$), and negatively to the number of times the student acts as a bridge along the shortest path between two of his peers, the number of peers and triangles in which the student is connected to and inserted into, respectively, the influence of the student in the classroom, the strength of ties between the student and its peers, and to the new friend choice (r ranges from $-.94$ to $-.54$, all $p < 0.01$).

The number of triangles in which a student is inserted into, positively correlates strongly to the influence of the student in his/her classroom, the number of peers the student is connected to, the number of times the student acts as a bridge along the shortest path between two of his peers, the strength of ties between the student and its peers, and to the new friend choice (r ranges from 1 to $.52$, all $p < 0.01$). Negatively, it strongly correlates to the sum of the student's distances towards his peers, reversed, and to how close the student's connected peers are to being a clique ($r = -.99$ and $-.78$, respectively, both $p < 0.01$).

The Eigenvector Centrality or the influence of a student in the classroom, is positively correlated strongly to the number of triangles and peers in which the student is inserted into and connected to, respectively, the number of times the student acts as a bridge along the shortest path between two of his peers, the strength of ties between the student and its peers, and to the new friend choice (r ranges from 1 to $.52$, all $p < 0.01$ and $p < 0.05$). Negatively, it strongly correlates to the sum of the student's distances towards his peers, reversed, and to how close the student's connected peers are to being a clique ($r = -.99$ and $-.78$, respectively, both $p < 0.01$).

Class 3A

		Interval of Standard Deviation							
		New Friend Choice	Gender	Degree	Weighted Degree	Closeness	Betweenness	Clustering Coefficient	Number of Triangles
Interval of Standard Deviation	Degree	,576**	-,189						
	Weighted Degree	,496**	-,391*	,856**					
	Closeness	-,567**	,181	-,999**	-,841**				
	Betweenness	,346	,025	,783**	,708**	-,777**			
	Clustering Coefficient	-,382	,060	-,772**	-,690**	,759**	-,903**		
	N° of Triangles	,583**	-,207	,984**	,875**	-,980**	,731**	-,696**	
	Eigenvector	,600**	-,232	,992**	,861**	-,988**	,714**	-,721**	,988**

Table 38 - Inter-correlations between questionnaires for class 3A.

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

The student’s new friend choice is positively correlated strongly to the influence of the student in his/her classroom, the number of triangles in which the student is inserted into, the number of peers a student is connected to (r ranges from .60 to .58, all $p < 0.01$), and moderately to the strength of ties between a student and its peers ($r = .58$, $p < 0.01$). Negatively, it strongly correlates to the sum of a student’s distances towards his peers, reversed ($r = -.57$, $p < 0.01$).

The student’s gender negatively correlates moderately to strength of ties between a student and its peers ($r = -.93$, $p < 0.05$).

The degree, or the number of peers a student is connected to is positively correlated strongly to the influence of a student in his/her classroom, the number of triangles in which the student is inserted into, the strength of ties between the student and its peers, the number of times the student acts as a bridge along the shortest path between two of his peers, and to the student’s new friend choice (r ranges from .99 to .58, all $p < 0.01$). Negatively, it strongly correlates to the sum of the student’s distances towards his peers, reversed, and to how close a student’s connected peers are to being a clique (closed group of friends)($r = -1$ and $-.77$, respectively, both $p < 0.01$).

The weighted degree, or the strength of ties between a student and its peers is positively correlated strongly to the number of triangles in which the student is inserted into, the influence of the student in his/her classroom, the number of peers the student is connected to, and to the number of times the student acts as a bridge along the shortest path between two of his peers (r ranges from .88 to .71, all $p < 0.01$). Also positively, yet moderately, it correlates to the student’s new friend choice ($r = .47$, $p < 0.01$). Negatively, it strongly correlates to the sum of the student’s distances towards his peers, reversed and to how close the student’s connected peers are to being a clique ($r = -.84$ and $-.69$, respectively, both $p < 0.01$), and moderately to the student’s gender ($r = -.39$, $p < 0.05$).

The closeness centrality, or the sum of the student’s distances towards his peers, reversed, positively correlates strongly to how close the student’s connected peers are to being a clique ($r = .76$, $p < 0.01$). Negatively, it strongly correlates to the number of peers the student is connected to, the influence of the student in the classroom, the number of triangles in which the

student is inserted into, the strength of ties between the student and its peers, the number of times the student acts as a bridge along the shortest path between two of his peers, and to the student’s new friend choice (r ranges from -1 to $-.57$, all $p < 0.01$).

The betweenness centrality, or the number of times a student acts as a bridge along the shortest path between two of his peers is positively correlated strongly to the number of peers the student is connected to, the number of triangles in which the student is inserted into, his/her influence in the classroom and the strength of ties between the student and its peers (r ranges from $.78$ to $.71$, all $p < 0.01$). Negatively, it correlates strongly to how close the student’s connected peers are to being a clique, and the sum of a student’s distances towards his peers, reversed ($r = -.90$ and $-.78$, respectively, both $p < 0.01$).

The Clustering Coefficient, or how close a student’s connected peers are to being a clique positively correlates strongly to the sum of the student’s distances towards his peers, reversed ($r = .76$, $p < 0.01$), and negatively, also strongly, to the number of times the student acts as a bridge along the shortest path between two of his peers, the number of peers and triangles in which the student is connected to and inserted into, his/her influence in the classroom, and the strength of ties between the student and its peers (r ranges from $-.90$ to $-.69$, all $p < 0.01$).

The number of triangles in which a student is inserted into positively correlates strongly to influence of the student in his/her classroom, the number of peers the student is connected to, the strength of ties between a student and its peers, the number of times a student acts as a bridge along the shortest path between two of his peers, and to the student’s new friend choice (r ranges from $.99$ to $.58$, all $p < 0.01$). Negatively, it strongly correlates to how close the student’s connected peers are to being a clique ($r = -.70$, $p < 0.01$).

The Eigenvector Centrality or the influence of a student in the classroom, is positively correlated strongly to the number of peers and triangles the student is connected and inserted into, the strength of ties between a student and its peers, the number of times the student acts as a bridge along the shortest path between two of his peers, and to the student’s new friend choice (r ranges from $.99$ to $.60$, all $p < 0.01$). Negatively, it strongly correlates to the sum of the student’s distances towards his peers, reversed, and to how close a student’s connected peers are to being a clique ($r = -.99$ and $-.72$, respectively, both $p < 0.01$).

III.3.1.4.Measuring the Influence of New Friendship Choice

Class 2A

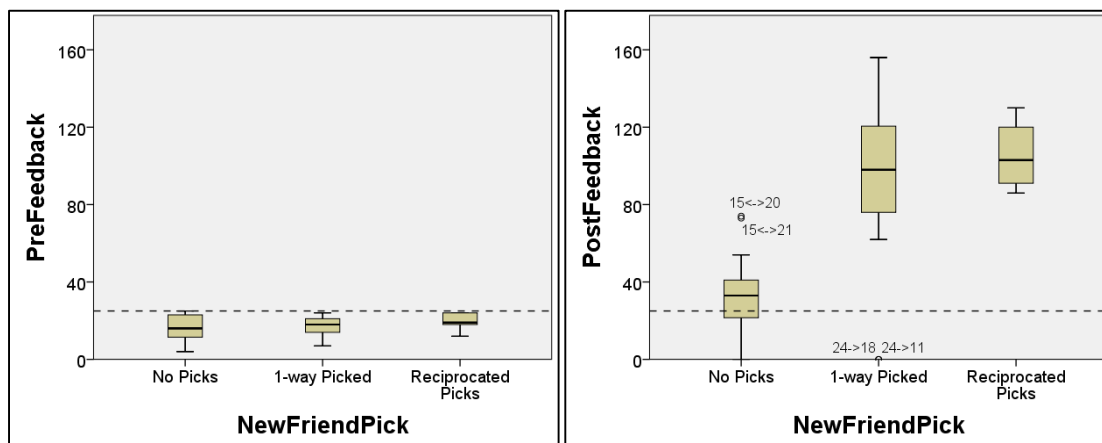


Figure 7 - Evolution of weak connections from pre to post-feedback for class 2A.

This clustered boxplot illustrates the evolution regarding the students with the lowest peer connections pre-feedback, separating these based of the new friend choice nominations: no picks, 1-way picks and reciprocated picks. The connections that were taken into account were the ones with a weight of 25 or less (as illustrated by the dashed line), which corresponds to the best RSSI threshold found in the first study for the disregard of non-relevant interactions.

As the above pictures illustrate, there is a clear difference between those who were nominated for new friendships, and those who weren't, but not between 1-way nominations to reciprocated ones. There are only 2 students that correspond to outlier measurements (an observation point that is distant from other observations): students 15 and 24.

On student's 15 case, we can see that he measured a high number of interactions with students 20 and 21, while not nominating and not being nominated by any of these. This means that student 15 went the extra mile towards spending time with other students with whom he had the least connections with, even when not nominating them. On the other hand, student 24 proves to be the exact opposite. With both interaction measurements between him and students (he picked) 18 and 11 being at 0, we can infer that this student did not follow the pro-social behavioral changes advised, by not attempting to spend time with neither of them.

New Friend Choices		Pre Feedback	Post Feedback
No Picks	Mean	16,50	32,71
	Std. Deviation	7,09	19,02
	N	24	24
1-way Picked	Mean	17,30	94,78
	Std. Deviation	4,54	37,11
	N	27	27
Reciprocated Picks	Mean	19,33	105,50
	Std. Deviation	4,46	17,00
	N	6	6

Table 39 – Evolution of weak connections from pre to post-feedback: mean and standard deviation for class 2A.

As the previous table illustrates, there are significant changes towards the means and standard deviations between the several dimensions of the new friend choices.

For students who did not nominate each-other in any way, we can see a very low mean of 32.71, with a 19.02 standard deviation. Although it still provides an increase on the pre-feedback measurements, this improvement is minor.

For students with 1-way nominations and reciprocated ones, we account for a major evolution in the mean of number of connections (mean = 94.78, Std. Dev = 37.11; and mean = 105.50, Std. Dev = 17.00, respectively). We can also argue that there is a clear different between the standard deviations of the previously mentioned, accounting for much sparser statistics for 1-way nominations. This is to be expected, since it is more likely for disparity to be present among the 1-way connections, as opposite to reciprocated ones, due to the fact that in these last ones there is a higher probability that both students will attempt to increase their connections with each other.

Based on the analyzed data, we can conclude that the nominations of new friend choices were a detrimental factor for the improvement of pro-social behaviors, and that (although with

some exceptions) all students of class 2A were sensitized and pro-active about their social behaviors.

Class 3A

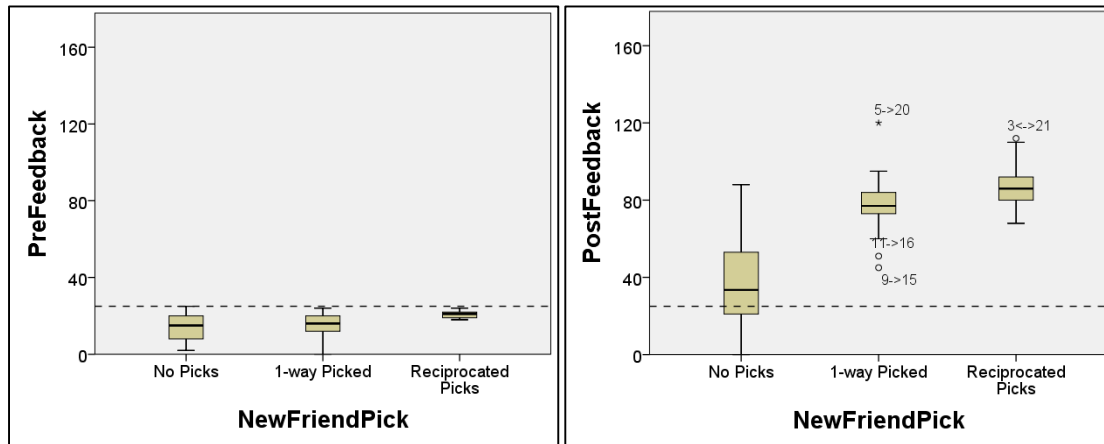


Figure 8 - Evolution of weak connections from pre to post-feedback for class 3A.

The above clustered boxplot shares the same set of properties of the previously analyzed one.

Following the trend of class 2A, there is still a big, although not as major, difference between the social connection evolution of students who were not nominated and those who were, while the difference between 1-way and reciprocated picks don't account for a significant extent difference.

A set of students didn't however, follow the trends associated with the rest of the class, being therefore referred to as outliers (properly highlighted in the previous figures). On the 1-way nominations, students 11 and 9 picked students 16 and 15, respectively, as new friend choices, but their overall interaction resulted in significantly lower than average results for the rest of the 1-way nominated results of the rest of the class. On the opposite end of the scope, the connection between students 5 and 20, and 3 and 21, were above average, respectively towards 1-way and reciprocated nominations. These could be due to several factors, such as different common interests, or even previously defined likeability/aversion between them.

New Friend Choices		Pre Feedback	Post Feedback
No Picks	Mean	14,34	36,94
	Std. Deviation	6,78	20,94
	N	62	62
1-way Picked	Mean	15,12	78,18
	Std. Deviation	6,55	13,04
	N	33	33
Reciprocated Picks	Mean	21,00	88,89
	Std. Deviation	2,00	14,42
	N	9	9

Table 40 - Evolution of weak connections from pre to post-feedback: mean and standard deviation for class 3A.

As the previous table illustrates, changes between the mean and standard deviation of the different dimensions inherent in the new friendship choices are significant.

In what refers to students who did not nominate each-other in any way, we can observe a low mean of 36.94, with a high standard deviation of 20.94. These, although averagely improved from pre to post-feedback (pre-feedback: mean = 14.34, std. Dev = 6.78), qualify as minor changes in the overall social spectrum of social interactions.

1-way nominations present both lower mean and standard deviation than reciprocated nominations, although the difference between them, post-feedback-wise, is not very considerable (mean = 78.18, std. Dev = 13.04; and mean = 88.89, std. Dev = 14.42; respectively). However, the evolution from both is very evident (pre-feedback: mean = 15.12, std. Dev = 6.55; mean = 21.00, std. Dev = 2.00; 1-way and reciprocated nominations, respectively), and it should be emphasized that disparity between the calculated statistics is much lower than the one found in class 2A.

Based on the previously analyzed data, we can interpret that the use of visual cues for behavior changing was valid, but had much more impact on the chosen new friendships. Finally, we can determine that most students followed the pro-social tips and guidance offered by both the visual display and the researchers.

III.3.2. Qualitative Data

Overall, children reacted surprised with the public display, asking several questions regarding the pre-disposition and emotions of the dogs (e.g. *“Why are the dogs on the other side of the river crying?”*), or regarding the fact that there was a different colored dog (e.g. *“Why am I a yellow dog?”*). Other children supported the visual data curious to how it was possible that the information was accurate to their social interactions (e.g. *“How do you know that we are best friends?”*; *“How do you know that we have been playing together in recess?”*). Also, some students were confused as to why they were not present in a given peer’s display (e.g. *“Why am I not there?”*; *“Isn’t everybody present?”*).

We proceeded to gather the whole class in front of the display to explain how the flash application worked, as well as to explain what the phones they had been wearing were for. While some children maintained reluctant to how we were able to connect their phones to the dogs (e.g. *“Is that really him walking?”*), others offered visual suggestions (e.g. *“what if you made an apple fall from the tree?”*). By explaining that peer visualization consisted in the closest, intermediate and furthest away connections with their peers, we noticed some astonishment in their reactions (e.g. *“why is she placed in the group of students that I don’t play with? I play with her”*; *“He is also one of my best friends, why isn’t he near me playing?”*).

However, while explaining the existence of the different groups, and announcing that they would choose two of their peers with whom they shared the least connections with to spend more time during the following week, children had quite different reactions. Some debates were taking place amongst girls, being clear to us that their choice of playing with their most distant peers was going to be influenced by their closest peers’ opinions regarding other children’s appearances and behaviors (e.g. *“We won’t play with him... don’t think anybody will because he’s repulsive”*; *“He smells, kicks and pushes all the time”*).

When choosing their most distant peers, the children’s justifications and emotions towards their choice ranged from being happy with the fact that a specific student was one of the common lowest peers for two good/best friends (e.g. *“Cool, I will also play with him”*; *“Great, we can all play together”*), to only choosing to play with one of their lowest peers, due to not

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feeling any affinity with all other peers (e.g. *“I only want to play with him. I don’t like the other one”*). In a particular case, one of the students was held in the same year for the second time, relating more to his previous class therefore spending his recess time with his old classmates instead of the new ones. Some choices were simply based on gender (e.g. *“I prefer playing with girls rather than boys. Boys are rude”*).

Finally, the students had a few questions regarding their connections during the following days after the introduction of the public display (e.g. *“If we are playing together during recess, why aren’t we playing together on the TV?”*; *“I have been playing with A., so why doesn’t the image on the TV change?”*). As previously explained in the constraints/problems section, the measurements are only viable for upload after a minimum amount of three intervals, translating into 3 days, which did not allow for real-time data tracking.

III.4. DISCUSSION

In this study, we continued our analysis on our previously developed tool *BlueFriends*, while analyzing the impact that adding a visual element could potentially have towards behavioral changes in children. In the last few years, patterns have been developed with the purpose of explaining and changing social behaviors (Rosenstock, Strecher, & Becker, 1988), and an accepted hypothesis by Skinner states that the frequency of a behavior is determined by its consequences (i.e. reinforcements) (Skinner, 1938). We piled on this premise by positively reinforcing students to change their behaviors, using visual cues to demonstrate how and why exclusionary behaviors are negative towards the overall society, including them.

There are a number of contributions that stem from this study. Not only is it a contribution to the currently almost unexplored field of sociometric measurement and behavioral changing, its non-intrusive deployment and general documentation enable further development and deployment(s), searching for a better grasp on social behavioral aspects of child networks and its ulterior pro-social manipulation.

This study revealed children to be, generally, open-minded towards accepting new social challenges. The results obtained from the post-feedback data pointed to the conclusion that almost all children attempted to change their behaviors towards their least connected-to peers, presenting a considerably significant reduction on socially excluded children.

The visual cues for behavioral changes have also played an important part through the course of this study. Students were able to identify the dogs' feelings represented on the Flash application, understanding how those related to them and their social reality peer-wise. They were emotionally connected, and their efforts towards changing such reality were proof that the visual cues were a success. Also, it is necessary to infer that students not present in the deployment approached us several times, asking if they could see their interactions on the TV, and why not.

As mentioned previously, a few students were reluctant in choosing their pairs. Specifically, one of the students (e.g. A) had only 2 colleagues with whom he held the weakest connections (e.g. B and C). When prompted to choose, he left out one of the students (student C), to which he answered that this particular student was someone he disliked. When we analyzed the data, it was noticeable that the student he left out was one of the loneliest children, and the least popular child in class. However, it was also possible to observe during the recess that this student (student C) had more friends from other classes than from his own, based on the fact that he was held back that same year.

Overall, for the duration of the study, the student's positions within the network became more clustered, forming a much tighter group. The average scores increased from the pre to post-feedback data, as well as the standard deviation decreased, which therefore denotes the lowering of the disparity between students centrality metrics.

Our main goal with this study was to provide opportunity for the least accepted children to let themselves be known, hopefully inducing a social network paradigm shift within the tested classes. In fact, it was shown that when given the opportunity, the least popular students can become central elements of the classes' network.

IV. CONCLUSION

There are a number of conclusions to be drawn from both studies that were deployed, and which validate the hypothesis that excluded or socially withdrawn children can in fact be pin-pointed accurately using non-evasive technology, and also that it is possible to influence pro-social behaviours through persuasive visual cues.

One of the first things that we noticed is that classes' network structure became more and more clustered as the study went by. This translates into a much tighter group of peers, and therefore the possibility for new friendships to erupt and existing ones to solidify are ever growing. On an opposite note, we also denoted that some students were reluctant (or even refused) choosing their pairs for new social attachment. This shows that although most weak relationships are possible to strengthen, some might be irreversibly damaged due to possible personality clash, previously bad experiences, etc.

Secondly, we can safely affirm that shifting the social popularity paradigm affects all, and while some are affected positively, some struggle negatively with the implemented changes. This was understandable as some kids were deemed as very popular on an initial assessment of the classes' social environment, to be later on "dismissed" as regularly popular kids due to other's ascension of the social ladder. This is an aspect that needs to be carefully examined in future studies, as it is possible that the intervention of researchers could potentially hamper the social interactions that popular children have while attempting to improve socially neglected children's popularity.

Something that seemed to be a substantial improvement in the future was the addition of real-time data processing and visualizing, as well as possible area/activity tracking. This is due to some children finding themselves confused as to why their new social interactions were not being displayed promptly on the screen. In fact, the kind of motivation that such improvement would provide would be massive, as there would be a real-time incentive towards pro-social behavioural changes. Non-the-less, children proved themselves open-minded towards accepting new social challenges, while visual cues allowed them to be emotionally attached, teaching and instilling in them the social responsibility associated with each of their actions and behaviours.

V. FUTURE WORK

Building on the reactions obtained by both the participants of these studies, as well as other children who came in contact with our deployments, we believe that a future deployment would be feasible to execute. Increasing certain aspects, such as the duration of the study and number of classes involved, would prove very beneficial towards the overall outcome of our research, as it would come closer to reality while also possibly offering a standard for student proximal evaluation.

We believe that using the Flash application for a longer period along while updating the data on a daily basis would be a larger incentive for students to get to know better all of their classmates. A longer term study, with access to more resources, would probably encourage them to also be connected to other students from different classes.

Although some technical problems are at hand and have to be dealt with before undergoing a large scale deployment of this measuring tool, the evolution of technology will eventually provide more and better resources to capture these assessed behaviors, as well as new and exciting ways to improve them. This could mean that *BlueFriends* could be even further improved in the future, especially if considering the possible platform change from phones to wearable technological devices.

This thesis explored and investigated how children social networks work, how deviant behaviors can affect the perception of students about each other and how visual cues can aid in the propagation of pro-social behaviors. Future work in this field could and should amount on the information gathered on this thesis, extending the measurement and action-taking for extended periods of time for further validation on accomplished behavioral changes.

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APPENDIX

There were four questionnaires distributed, two for students (appendixes A and B) and two for teachers (appendixes C and D). These were written in Portuguese, but will be documented here in English for general understanding.

Also, during the course of this thesis, the main researcher successfully completed a course on Social Network Analysis, with distinction. The course was offered by the University of Michigan through the *Coursera* on-line platform. The Certificate can be found on Appendix E.

APPENDIX A – LONELINESS SCALE

Instructions: To each statement, insert a check mark on the box that you feel it makes more sense to you. There is no right or wrong answer, just what you think is more accurate to you. Remember, answer each statement by placing a check mark in one of the five boxes. Insert only one check mark for each statement.

EXAMPLE:

I don't like to ride a bicycle.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me
	✓			

ANSWER ACCORDING TO THE FOLLOWING STATEMENTS:

1. It is easy for me to make new friends at school.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

2. I like to read.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

3. I do not have anyone to talk to.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

4. I work well with other children.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

5. I watch TV often.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

6. It is hard for me to make new friends.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

7. I like going to school.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

8. I have many friends.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

9. I feel lonely.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

10. I can find a friend when I need one.

Appendix

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

11. I practice sports often.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

12. I have some difficulty in getting other kids to like me.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

13. I like science.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

14. I do not have anyone to play with.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

15. I like music.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

16. I get along with other children.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

17. I feel pushed aside.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

18. When I need help I have no one who I can call for help.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

19. I like to paint and draw.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

20. I do not get along with other children.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

21. I am alone.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

22. I am popular in my class.

Appendix

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

23. I love to play board games.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

24. I do not have friends.

1. It is always true to me	2. It is often true to me	3. It is sometimes true to me	4. It is almost never true to me	5. It is never true to me

APPENDIX B – PEER NOMINATION INVENTORY

Instructions: Look around and observe your classmates. You are surrounded by several children and all of them are different. If someone is not in the classroom, his/her name will be written on the board. Answer the questions about your classmates, by pointing out three colleagues who you think fit to each question. There is no right or wrong answers, answer according to what makes more sense to you. Answer all questions with three colleagues, try your best to not leave blank answers. Once you finish answering, do not talk to your colleagues about your answers.

1. Name which classmates you like the most (up to three names).

1. _____ 2. _____ 3. _____

2. Name which classmates you like the least (up to three names).

1. _____ 2. _____ 3. _____

3. Name which classmates start fights, say mean things to other kids or push them, or hit them (up to three names).

1. _____ 2. _____ 3. _____

4. Name which classmates are teased by others or called names a lot (up to three names).

1. _____ 2. _____ 3. _____

5. Name which classmates do mean things to others who are not watching and/or listening. For example, colleagues who spread rumors about other colleagues or tell them to go away when they play (up to three names).

1. _____ 2. _____ 3. _____

6. Name which classmates play or do school tasks alone a lot (up to three names).

1. _____ 2. _____ 3. _____

7. Name which classmates are often good leaders and other children like to have them in charge (up to three names).

1. _____ 2. _____ 3. _____

APPENDIX C – DIVERSITY CHECKLIST

DIVERSITY FACTORS

Nº	Student Name	Learning Barriers		Poor Social Condition	Non-Portuguese Ethnicity	Different Skin Color	Emigrant	Low Socio-Economic level	Gifted or Above Average intelligence	Other
		Learning Disabilities	Special Educational Needs	(rejected by colleagues or signs of loneliness)	(please describe)		(please describe)	(signs of poverty, multi-problem household)	(exceptional performance on tasks, talented)	(please describe)
		(for example: reading, writing, diagnosed learning disorders) *	(for example: autism, disability, chronic disease) **							
1										
2										
3										
4										
...										
...										
26										

Comments:

Observations:

*: Please indicate the type and degree of difficulty or learning disability

**: Please indicate type of difficulty

APPENDIX D – INTERPERSONAL COMPETENCE SCALE

Instructions: Make an evaluation of each parameter, according to the student at issue. Use your knowledge of the child as your guide to respond swiftly, without excessive hesitation.

NEVER ARGUES — — — — ALWAYS ARGUES
Sometimes

ALWAYS GETS IN TROUBLE AT SCHOOL — — — — NEVER GETS IN TROUBLE AT SCHOOL
Sometimes

ALWAYS SMILES — — — — NEVER SMILES
Sometimes

NOT POPULAR WITH BOYS — — — — VERY POPULAR WITH BOYS
So-So

NOT SHY — — — — VERY SHY
So-So

VERY GOOD AT SPORTS — — — — NOT GOOD AT SPORTS
So-So

VERY GOOD LOOKING — — — — NOT GOOD LOOKING
So-So

VERY GOOD AT SPELLING — — — — NOT GOOD AT SPELLING
So-So

ALWAYS GETS IN A FIGHT — — — — NEVER GETS IN A FIGHT
Sometimes

Appendix

NEVER SAD — — — — ALWAYS SAD
Sometimes

NOT GOOD AT MATH — — — — VERY GOOD AT MATH
So-So

VERY POPULAR WITH GIRLS — — — — NOT POPULAR WITH GIRLS
So-So

LOTS OF FRIENDS — — — — NO FRIENDS
Some Friends

NEVER GETS HIS/HER WAY — — — — ALWAYS GETS HIS/HER WAY
Sometimes

NEVER WORRIES — — — — ALWAYS WORRIES
Sometimes

WINS A LOT — — — — NEVER WINS
Sometimes

NEVER FRIENDLY — — — — ALWAYS FRIENDLY
Sometimes

CRIES A LOT — — — — NEVER CRIES
Sometimes

APPENDIX E – SOCIAL NETWORKS ANALYSIS COURSE CERTIFICATE

