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Application of Problem-Based Learning (PBL) through PBL-Coach virtual environment: a case study with an Indian middle school

Melbourne

2016

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Work presented to the Federal University of Pernambuco's Information Systems course as a partial requirement for achieving the Bachelor in Information Systems degree.

Federal University of Pernambuco

Informatics Centre

Information Systems Bachelor Degree

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Melbourne

2016

This work is dedicated to all the professors who make the most noble of all crafts: sharing knowledge.

Acknowledgements

I would like to acknowledge several people who have helped me in the last 8 years, since I started studying at the Federal University of Pernambuco. My mother, Tânia Fonseca, and my grandmother, Carmelita Alves, for making my education possible, many times abdicating their opportunities so I could have my own. Professor Maria de los Angeles, coordinator of the Chemical Engineering course and professor Fernando da Fonseca, former coordinator of the Information Systems course, for their counselling and help in the decision that I consider the most difficult and important of my life: changing degrees, in the moment I found my passion for Information Technology. Professors Simone Santos and Bruno Bessa, for their help and support throughout this project. The director of Tara International School, Ms. Bala Johnson, for the given opportunity of making such project happen. Professors Kelvin Lopes and Carla Schuenemann for their help during my graduation, giving me the possibility of doing what I love the most: teaching. Professors Bernadette Lóscio and Vinícius Garcia, for their words of wisdom throughout the course. Professor Raquel Lira, for showing me how to love the human side of Information Technology. Finally, my husband, Shane Page, whose love and partnership helped me deal with the temporary re-adaptation to my home country, and my friends: Bruna Piereck, Camila Sobreira, Filipe Sansoni, Júlia Mendes, Lorena Siqueira, Mariana Machado, Sephora Madjiheurem and Wandecleya Martins, for always being there and making this world a livable place. Without any of you, the execution of this project would not be possible.

“Man plans,
God laughs.“
(Yiddish proverb)

Abstract

The teachers that use problems as an approach for their teaching methodology motivate and incite the students' learning. Problem-Based Learning (PBL) is a learning methodology that is focused on the student, using real world problems so the pupils can interact with them and be motivated to learn, promoting the necessary abilities to solve these issues. The objective of this document is to apply a PDCA cycle (Plan-Do-Check-Adjust) using PBL within a middle school year 8 Physics class with 9 students in Tara International School, located in Raison, Himachal Pradesh, India. The use of PBL-Coach was administered to the students in order to meet the xPBL methodology requirements by using a virtual learning environment software that at the same time promotes creativity and collaboration.

Key-words: Problem-Based Learning. PBL. PBL-Coach. Education in middle school. Learning virtual environment.

Resumo

Os professores que usam problemas como metodologia de ensino motivam e estimulam o aprendizado do aluno. O Aprendizado Baseado em Problemas, do inglês Problem-Based Learning (PBL), é uma metodologia de aprendizado que é focada no estudante, utilizando problemas do mundo real para que os estudantes possam interagir com eles e serem motivados a aprender, promovendo as habilidades necessárias para resolver essas questões. O objetivo deste trabalho é aplicar um ciclo PDCA (Plan-Do-Check-Adjust) usando PBL em uma turma do oitavo ano de Física de nível médio na escola Tara International School, em Raison, Himachal Pradesh, Índia. O uso do PBL-Coach foi administrado aos alunos para se alcançar os requisitos da metodologia xPBL através deste software de ambiente de aprendizado virtual, promovendo ao mesmo tempo criatividade e colaboração.

Palavras-chaves: Problem-Based Learning. PBL. PBL-Coach. Educação no ensino médio. Ambiente virtual de aprendizagem.

List of abbreviations and acronyms

OECD	Organisation for Economic Cooperation and Development
PBL	Problem-Based Learning
PDCA	Plan-Do-Check-Adjust
PISA	Programme for International Student Assessment

Sumário

Introduction

Accordingly to Bajpai e Goyal (2004), Himachal Pradesh is one of the states in India with the lowest percentage of drop outs in primary schools, despite the fact that there is no compulsory education policies in the state. The pupil-teacher ratio was 23 at the time of the study, representing a medium to small average classrooms size. But that did not save Himachal Pradesh from scoring the lowest in Sciences between all countries in the world in the year of 2009 (WALKER, 2011) and allegedly in 2012, when India chose not to engage in the Programme for International Student Assessment (PISA) again. This could suggest that, despite the students', parents' and teachers' efforts to promote a culture of learning, there must be a problem in the state's teaching methodology.

This suspicion was particularly observed when we arrived in Raison. Ms. Bala Johnson, the director of Tara International School, in Raison, Himachal Pradesh, usually reaches for international teachers to help her with her school. Raison is a very small rural town in Himachal Pradesh, 12km away from the nearest town in the region, Kullu. Accordingly to Ms. Bala Johnson, the schools in the district of Kullu (and in Himachal Pradesh, in general), are very poorly run and many students do not complete studies. The teachers are "not experienced"and "it is very hard for them to do anything other than reading the books to the students", so the school lacks in practical activities and the way Ms. Johnson found to make the pupils more interested and learn more was by inviting international teachers to work at the school as voluntaries in exchange for experience, food and a place to sleep. When we talked about Problem-based learning, she sounded very excited and opened up for the opportunity of applying PBL for a short period trial in the Physics' year 8 class, with 9 students.

The project would last for 3 weeks, completing a PDCA cycle (Plan-Do-Check-Adjust). A team of teachers would also be available throughout the project.

In this context, the objective of this document is to apply a cycle of PDCA using PBL within a middle school Physics class through the use of PBL-Coach, a virtual learning environment software that promotes creativity and collaboration.

This project was segmented in six chapters, plus this introduction, that presents the research and objectives of this study, and the conclusion. The following chapters are described below:

- Chapter 1 - portrays the chosen methodology.
- Chapter 2 - explains what Problem-Based Learning concepts along with PBL-Coach and gives a brief overview of the education in Himachal Pradesh, India.

- Chapters 3, 4 and 5 - introduces the case study, illustrated by the four phases of the proposed PDCA cycle.
- Chapter 6 - displays the results in three main chosen goals to be achieved by the application of Problem-Based Learning, as proposed by the Academy of Sciences and Mathematics from Illinois, along with the 360 degree evaluation.
- Conclusion - makes the conclusions about what was discussed in this project.

Parte I

Methodology

1 Methodology

As explained in the introduction, this project has the objective of applying a cycle of PDCA using PBL within a middle school Physics class through the use of PBL-Coach, a virtual learning environment software that promotes creativity and collaboration. This research procedure is characterised as a single case study analysis, which Willis (2014) defines as "an empirical enquiry that investigates a contemporary phenomenon in depth and within its real-life context", which can bring "a great contribution to theory-building and, to a lesser extent, theory-testing". This fits well the project's objective, since PBL-Coach is a software with great potential for applying PBL as a different methodology in the classroom.

On the other hand, a limitation of this approach is the inherent weakness of the method, since it is qualitative by nature. This invites new researches with other methods in order to better assess the problem.

Parte II

Case Study

2 Context

2.1 Problem-Based Learning

Problem-Based Learning (PBL) is an educational process that adopts the problems of the "real world", motivating the students throughout the learning process and facilitating the development of critical thinking (DRăGHICESCU et al., 2014). This creates an environment that promotes the students' abilities towards finding the solution for the problem, interacting with it and learning with the issue (PBL-COACH-MANUAL, 2016).

The xPBL methodology proposed by Santos e Lins (2014) organise the PBL principles into manageable elements, which made it easier to assess and apply those principles into the project. Santos e Lins (2014) also gather these principles in a summarised way, with the addition of two complementary principles (marked with *), associating all of them to the key elements to be assessed during the project, as you can see below:

Santos e Lins (2014) also emphasise the need for using a real world problem in a actual environment, with the students' need to take charge of the resolution process in a multidirectional learning environment in order to successfully apply the xPBL methodology. The detailed assessment of the key elements will be further discussed on the following chapters.

PBL Principles	Key Elements
PR1. All learning activities are anchored on a task or a problem;	Problem
PR2. The learner should feel he/she owns the problem, and is responsible for his/her own learning;	
PR3. The problem should be real;	
PR6. The learning environment should stimulate and at the same time challenge the learner´s reasoning;	
PR4. The task and the learning environment should reflect the reality of the professional market;	Environment
PR5. The learner needs to own the process used so as to work out the solution to the problem;	Content
PR7. The learner should be encouraged to test his/her ideas against alternative views and contexts;	
**PR9*. The learning is collaborative and multidirectional;	Human Capital
PR8. The learner should have the opportunity and support to reflect on the content learned and the learning process;.	Process
**PR10*. PBL is supported by planning processes and continuous monitoring.	

Source: (SANTOS; LINS, 2014)

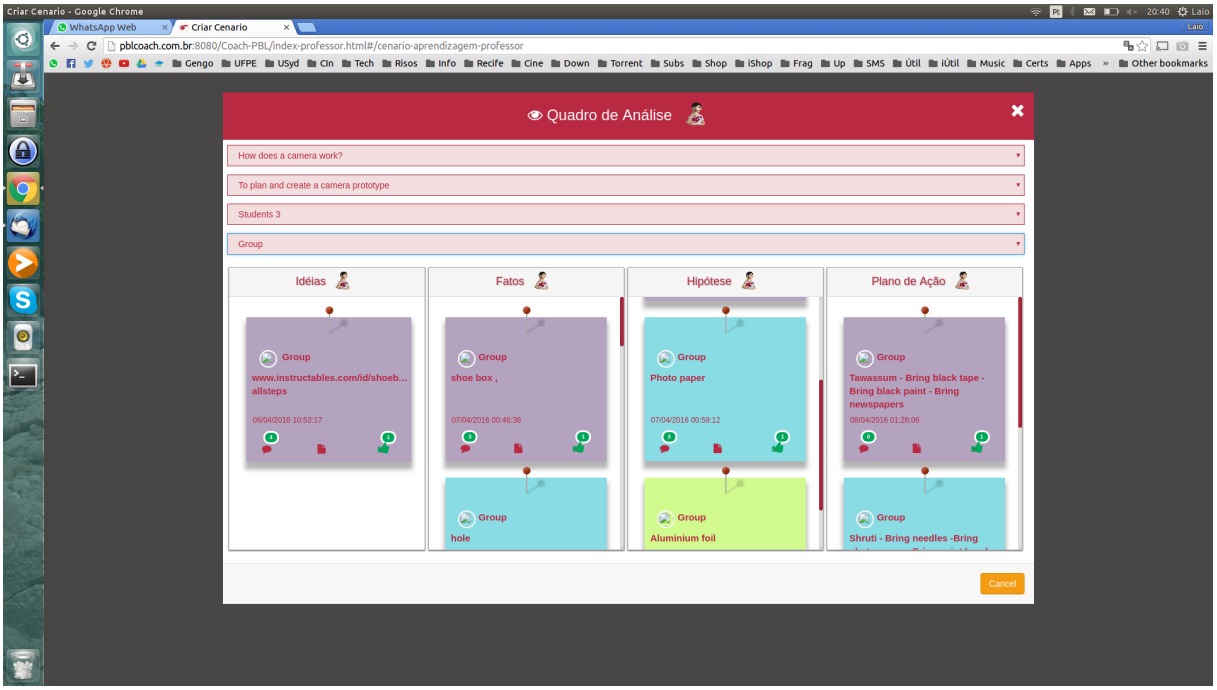
2.2 PBL-Coach

Accordingly to the PBL-Coach-Manual (2016), PBL-Coach is a "virtual learning environment to support Problem-Based Learning", bringing the 3D virtual world elements to promote a rich interaction between students and teachers. PBL-Coach provides agile tools in its environment, making it more engaging for the student to understand and use these tools to solve the problem.

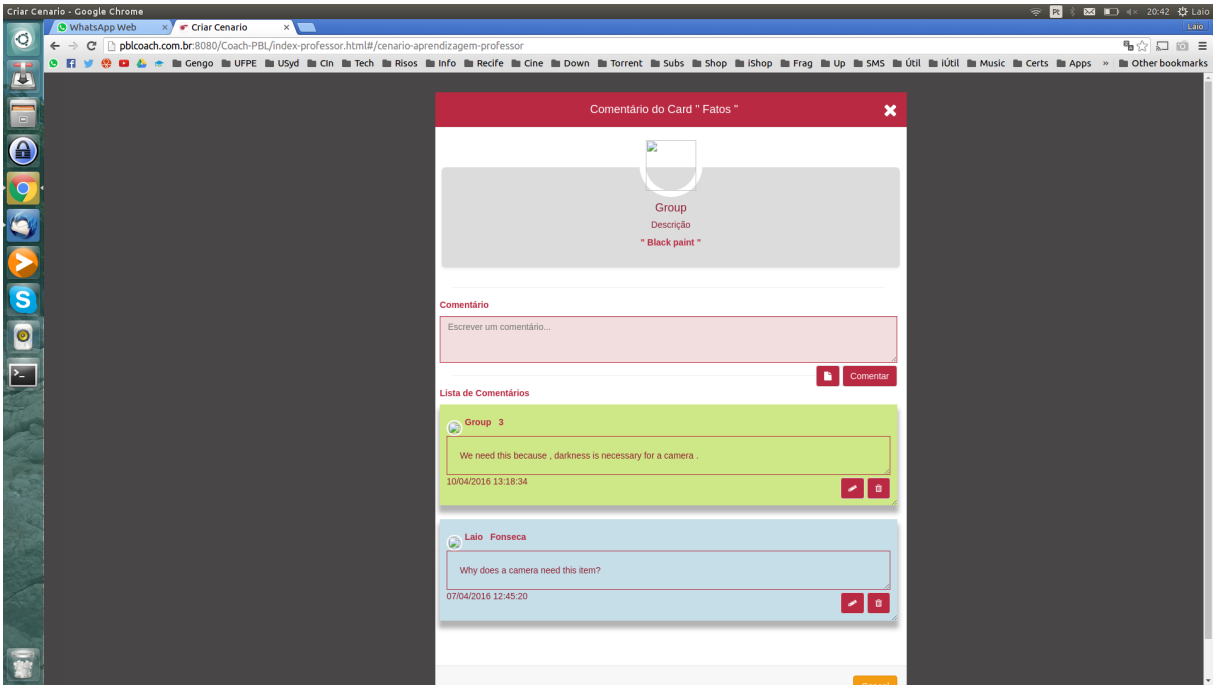
PBL-Coach-Manual (2016) describes a conceptual model of PBL-Coach, bringing features that matches the needs listed by Santos e Lins (2014). For example, PBL-Coach-Manual (2016) mentions a teaching methodology focused on the student and a virtual environment that promotes sharing information and leads the student to collaborate; a management cycle that match the PDCA cycle; an authentic evaluation, that indicates evaluation strategies within five dimensions (content, process, result, performance and stakeholder satisfaction); Deslile scale, a structure that helps students find solutions for the problems in a linear way (with facts, hypothesis and an action plan); immersion, as the environment is loaded with chairs, games, electronic devices, tablets and screens, making the virtual room look more natural and familiar to the students; Agile tools, that bring self-sufficiency to the students so they can find their own solutions; and the gamefication, with the scoreboards, that represent the point that the students collect when they use the platform and get positive feedback from their posted comment, along with social networks functionalities, that bring more familiarity to the students.

In addition to the practical tools, The software is also web-based and does not require plug-in installations, making it a powerful and flexible multi-platform tool.

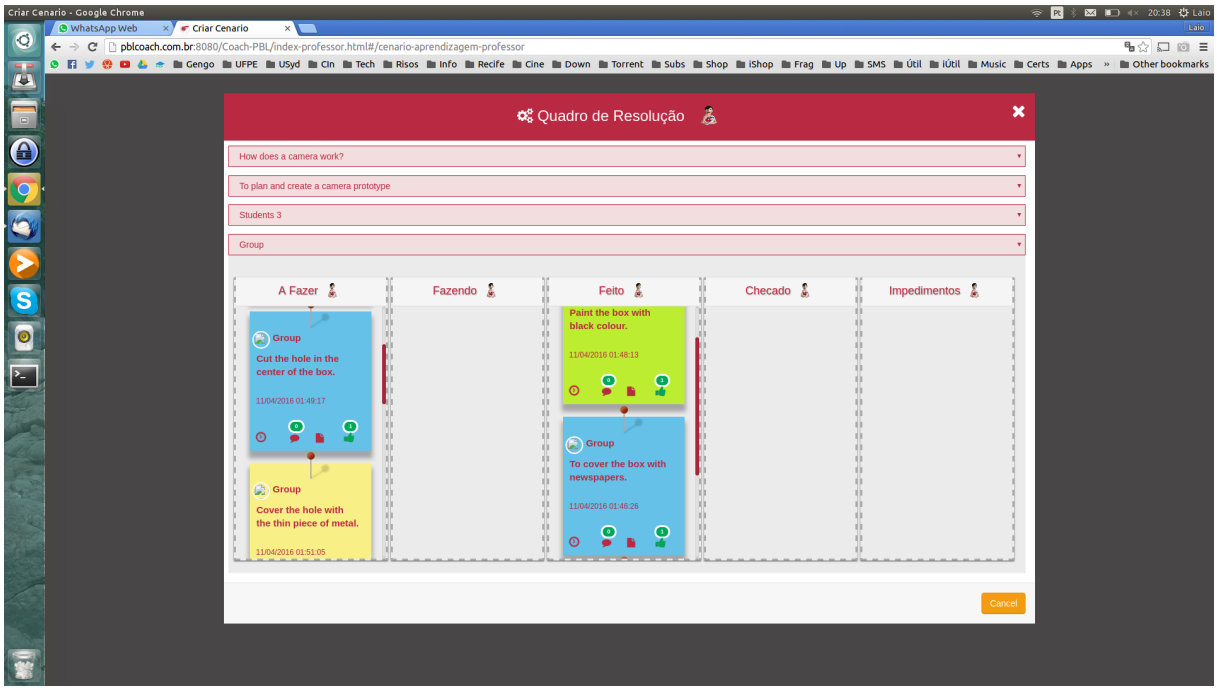
You can see below some screenshots taken from the platform, taken during the project.



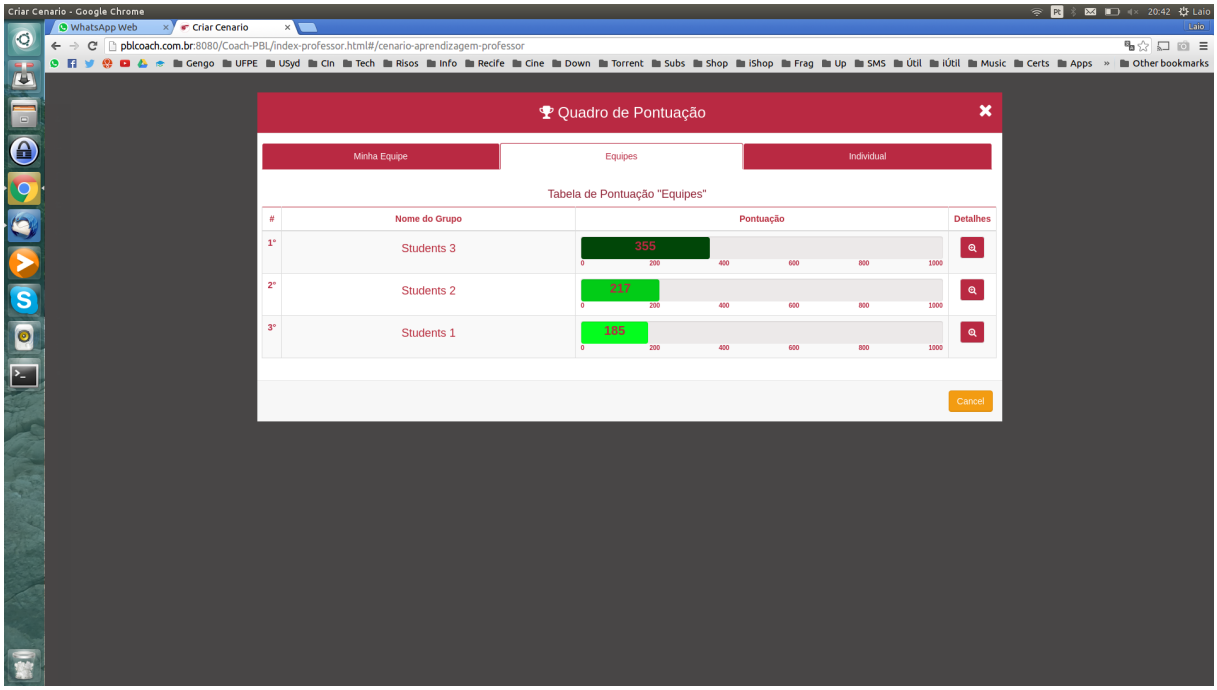
Analysis board. Source: Laio Fonseca/PBL-Coach



Card, expanded. Source: Laio Fonseca/PBL-Coach



Agile tools: resolution Board. Source: Laio Fonseca/PBL-Coach



Gamefication. Source: Laio Fonseca/PBL-Coach

2.3 Tara International School

Every three years, the Organisation for Economic Cooperation and Development (OECD) promotes the Programme for International Student Assessment (PISA), an evaluation that assesses students from all over the world in Sciences, Mathematics and Reading. The state of Himachal Pradesh, India, scored the last position in Sciences in the years of 2009 and 2012, when India decided to no longer participate in the program.

Tara International school is financed by the students' parents, who are not able to pay much. In the year 8 class, for example, all parents worked on orchards, and the school monthly fees are 800 Indian Rupees, which is roughly 12 dollars. With this kind of money and in such small classes, it is very hard to invest in the school, so the infrastructure problems were an issue. In spite of these problems, the school had computers with access to the internet, and this is a reality in many schools in India, since the government is now rolling out optical fibre across the country. The computers are not new and they run in different operating systems and have different configurations, many times being recycled and reassembled computers. For this reason, a virtual environment like PBL-Coach would be ideal for applying PBL, since it has the advantage of being a web-based platform.

For this reason, using PBL-Coach would be an easy and effective way of bringing a new teaching methodology and engaging the students at the same time in a colourful virtual environment brought by PBL-Coach.

Raison, Himachal Pradesh. Source: Laio Fonseca

3 Plan

3.1 The environment and human capital

The xPBL technique proposed by Santos e Lins (2014) was used to assess Tara International School before the project could be established. Tara International School is a private School managed by Ms. Bala Johnson, located in Raison, Kullu, Himachal Pradesh, Postal Code: 115128, India. The school is located in a rural area of the state of Himachal Pradesh, and the school teaches the primary and middle school subjects in English, since 2004, when it was founded. In a conversation with Ms. Bala Johnson prior to our arrival, we were informed that Tara International School has a library and a computer room with 12 computers, but only a few of them have access to the internet, and only 1 out of 12 teachers uses the computer room. The students have their first contact with Physics at year 8 and, in 2016, the class 8 had 9 students, which is not usually considered to be a large classroom.

They were chosen as subject to this project, given the possibility of creating smaller groups that would have access to internet-enabled computers, making it feasible for them to use the PBL-Coach environment without any costs for the school. A group of 2 teachers, Mr. Shane Page and I, engaged in preparing the computers to accommodate the platform and applying the project on site, with the help of professor Bruno Bessa, who made himself available as a PBL-Coach tutor. Shane and I communicated in person, while we both agreed to communicate with professor Bruno Bessa mainly via WhatsApp, exchanging messages daily and calling eventually to clarify the project strategy.

3.2 Timetable

Given the short available time, it was agreed that we would run a full PDCA cycle within the project, starting with the students and teachers introduction, group formation (3 groups of 3 students each) and the problem brainstorm, that raised a few questions, with a choice of "how does a camera work?"as our question-problem. With that in hands, we were able to access PBL-Coach to create the learning scenery with one associated challenge: "to plan and create a camera prototype".

The rest of the timetable was established. Since that was the first time the students had any contact with Physics, it was assessed that an introductory class about the Optics principles focusing on the problem would come in handy. After that, the students would have their first contact with the PBL-Coach tool, which would be used along the

project, for the students' research validation and the making of the cameras. At the end, the students would present their results to the other groups and perform a 360 degree evaluation.

Date	Hours	Content
30 Mar 2016	1	Introduction and problem brainstorm
04 Apr 2016	2	Optics principles
06 Apr 2016	2	PBL-Coach Introduction
07 Apr 2016	1	Research (PBL-Coach)
08 Apr 2016	1	Research (PBL-Coach)
11 Apr 2016	2	Making of the cameras (PBL-Coach)
12 Apr 2016	2	Group presentations and 360 degree evaluation

Source: Laio Fonseca

3.3 Groups

Since the students are under 18, we decided not to create a personal email address for each of them. Instead, we created a temporary email address for each of the 3 groups and allocated them to the learning environment on PBL-Coach.

Group	Login	Student
1	group1@sharklasers.com	Nikhil Thakur
1	group1@sharklasers.com	Pushkar Thakur
1	group1@sharklasers.com	Shubham Sagar
2	group2@sharklasers.com	Shruti Kashyap
2	group2@sharklasers.com	Tanvi Samwal
2	group2@sharklasers.com	Tawassum Sharma
3	group3@sharklasers.com	Shyna Verma
3	group3@sharklasers.com	Srishti Negi
3	group3@sharklasers.com	Sukriti Sharma

Source: Laio Fonseca

4 Do

4.1 Problem and content

Drăghicescu et al. (2014) propose a model of application of the PBL model within a class of Physics, with the theme "How do we manage to see the objects around us?". Inspired by this idea, along with a brainstorm with the students in the first meeting, they came up with the question: "How do cameras work?", which was the central question for this project.

We used the xPBL guidelines proposed by Santos e Lins (2014) to assess the problem, making sure the issue is relevant and at an appropriate level of complexity, also verifying its compatibility with the year 8 curriculum. The problem was then discussed with the project advisors, who agreed that the issue was innovative, relevant, viable and appropriately complex for the year 8 class.

The students had access to the internet throughout the project, and that is where they have found most of the content needed by them. The public school science books, that are the same for all schools in India, were also the base for matching the subject to the syllabus.

4.2 Analysis and Resolution Boards

Along with the development of the process, the students were advised to access the PBL-Coach interactive environment with their group to see and understand the problems and challenges. The analysis board was then filled in by the students with cards in 4 different rows:

- Ideas: links to websites with videos or steps to make a camera.
- Facts: essential tools and parts for the camera.
- Hypothesis: non-essential tools and parts that would be an increment to the group's camera and that could demonstrate other Physics concepts.
- Action plan: tasks allocated to each student within the group.

When the plan became concrete and got validated, the students were able to transfer each step from the action plan to the resolution board, an Agile board with five

rows: to do, doing, done, checked and impediments. This whole process was essential for the students' understanding of the problem.

5 Check and Adjust

5.1 Continuous validation

With the teachers and tutors constant support and supervision, along with the "like"button and comment sections in the cards at PBL-Coach, the ideas that the students posted there could be continuously validated. This way, we were able to give positive feedback, guiding the students towards the right path, from the moment they found their first ideas to the moment they actually finished their prototypes.

5.2 Prototypes presentation

At the end, the students came up with their prototypes, that were tested on spot. The students had the opportunity to make final adjustments to their prototypes before presenting them to the other group on the next class. The presentation consists in the students showing their solutions and answering a few questions that relate what they have done to the Physics contents that were learned.

5.3 360 degree evaluation

After all the groups presented their cameras, a 360 degree evaluation took place between all students. This kind of evaluation was chosen because it provides a self-evaluation, plus a pairs and teachers evaluation. We also opened up for verbal feedback and suggestions from the students on the project as a whole.

5.4 PBL-Coach group ranking

PBL-Coach also generates automatically a graph that quantifies how much the students actually entered data, commented and got positive feedback in the software. This production of visual graphs is actually one of the outputs for the process element guidelines proposed by Santos e Lins (2014).

Parte III

Results

6 Results

6.1 Students performance and understanding

The students proposed their own solutions, which inspired their curiosity, interest and generated their need to know more (DRăGHICESCU et al., 2014). This, along with the use of PBL-Coach to structure the problem using the tools and boards, helped them understand what they knew, what they needed to know and what they had to do, which was the definition of the steps to make their own camera.

During the groups presentations, each group answered questions related to their own cameras that required knowledge in Physics. For example, Group 1 presented a camera obscura, and we asked them why the image was displayed upside down in their camera, and they rightfully answered that this occurred because of the principle that light travels in a straight line.

6.2 Curriculum exploring and team work

The students had access to the internet, so they chose their sources. The information exchange was also stimulated, when at the end of the classes the students would share with the other groups what they had found, inspiring the other groups in their research. This way, every group found different solutions, that were validated with the teachers through PBL-Coach.

The minimum knowledge necessary to understand and build the cameras comprises the principles of Optics. The most basic camera prototype was presented by group 1, that presented a camera obscura. At the same time, students on groups 2 and 3 tuned up their cameras with lenses and photo paper, respectively, bringing new concepts to the classroom.

6.3 Problem solving and presentations

After creating the prototype that solves the proposed problem, students presented their work to the other groups. By following the other groups' presentations, all students obtained a complete learning (DRăGHICESCU et al., 2014). They also got a final feedback from the teachers by explaining their cameras schemes and answering questions related to Physics.

6.4 360 degrees evaluation scores and other metrics

At the very end of the project, the students made the 360 degrees evaluation (fully available on the Appendix A), assessing abilities that were developed along the process, as the understanding of the problem, ability of working in group, listening to the group, speaking to the group and being proactive. 8 out of 9 students self-scored 10 at their own understanding of the problem (with one student marking herself 9), and 8 out of 9 students were also marked by their group mates with a score equal or higher than 9 in this item (with one student being marked 8 by her group mates).

The other abilities had more variations, possibly because working in group brings out these characteristics that are not always matching between all units in a group. The teachers were also highly scored with all averages above 9, with the exception of Shane Page in the speaking to the group item. Other than that, another metric that was very positive was the group ranking graph. At the end, the most sophisticated solution was definitely represented by the highest score on the board.

Conclusion

The application of Problem-Based learning in Tara International School was a good experience, reflected by students' high level of learning, which was demonstrated by the 360 degree evaluation and the prototypes themselves. This initiative was endorsed by the director Ms. Bala Johnson, who followed the project and was clearly excited with the results. This project was also inspiring for other teachers in the institution, who started to use the laboratories and computer rooms more often. The students were also very excited about this methodology and engaged in their projects, since they did not have to deal with excessive formalisation. Instead, they could learn by investigating and solving a problem.

On the other hand, this is an incipient study, that gives a benchmark in the application of Problem-Based Learning in a middle school environment using PBL-Coach. The time limitations were the biggest impediments in making this project something bigger. This experience shows that with very little infrastructure it is possible to bring to the classroom components of project management and Agile methodologies. The natural limitation of this paper invites other teachers to do expand the scientific knowledge in PBL, which could be done by applying other in-depth and/or quantitative/mixed methodologies.

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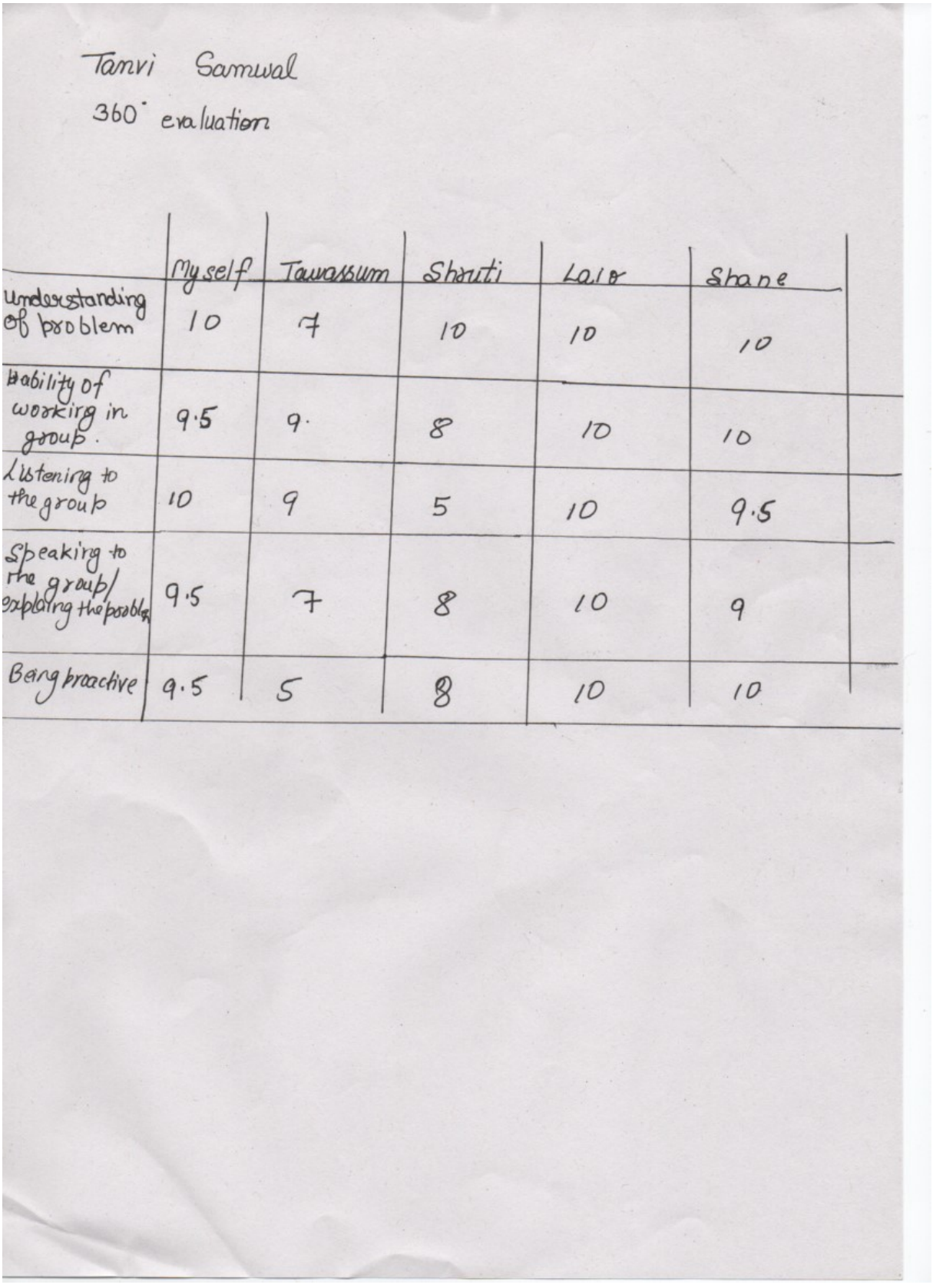
Appendix

APPENDIX A – 360 degree evaluation

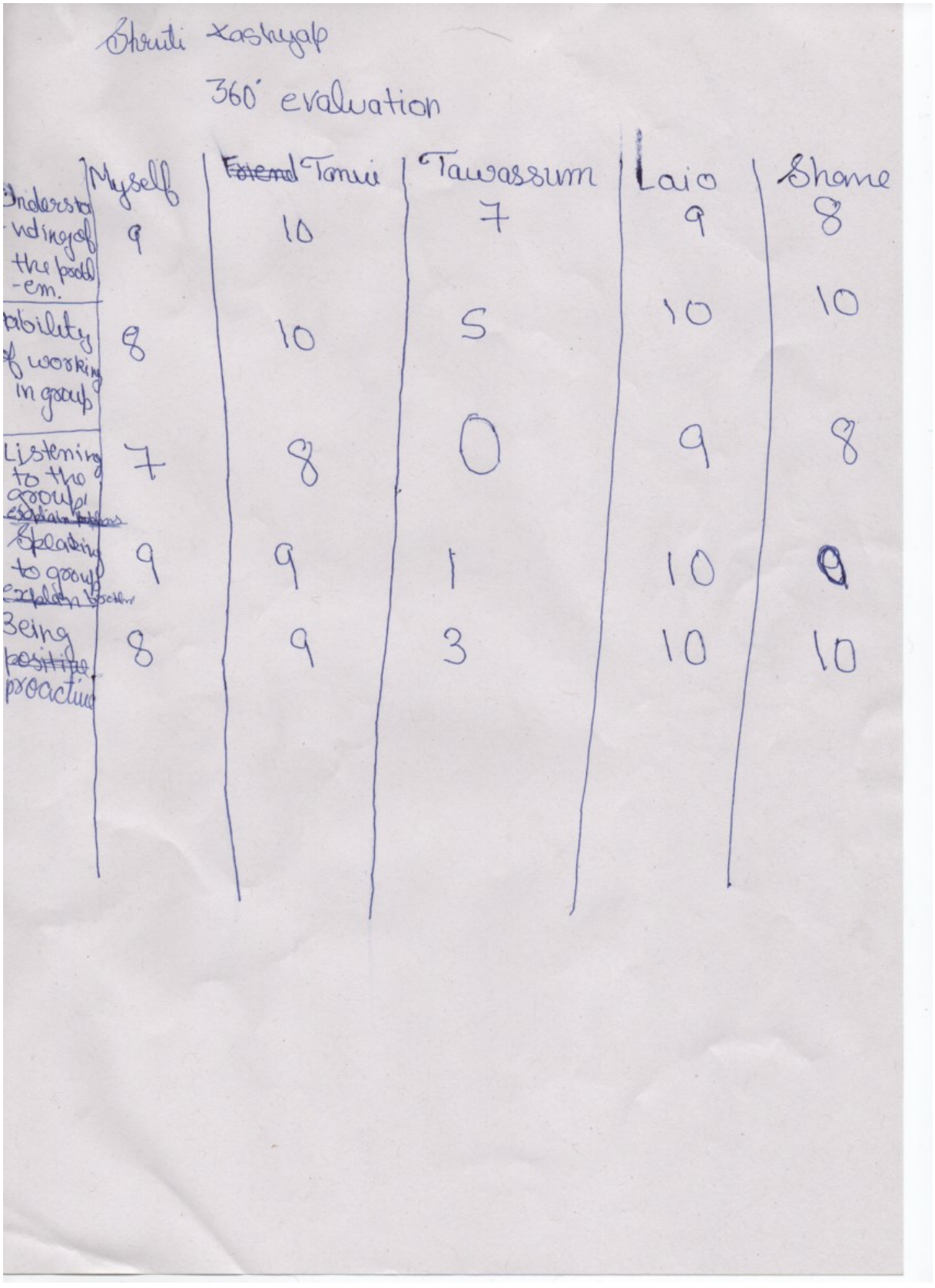


Tanvi Samwal

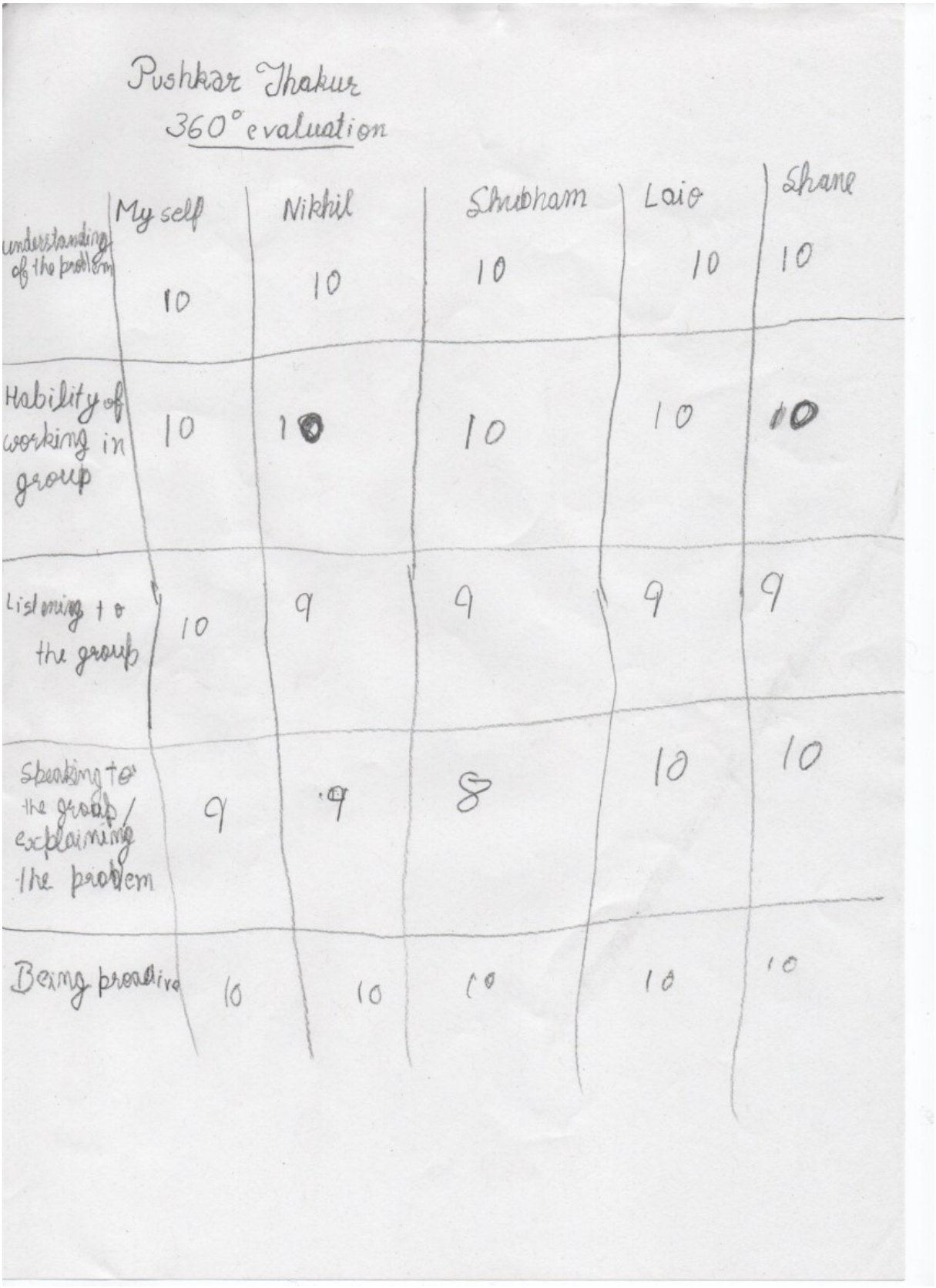
360° evaluation

	Myself	Tawassum	Shruti	Laio	Shane
Understanding of problem	10	7	10	10	10
Ability of working in group.	9.5	9.	8	10	10
Listening to the group	10	9	5	10	9.5
Speaking to the group/ exploring the proble	9.5	7	8	10	9
Being proactive	9.5	5	8	10	10

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca



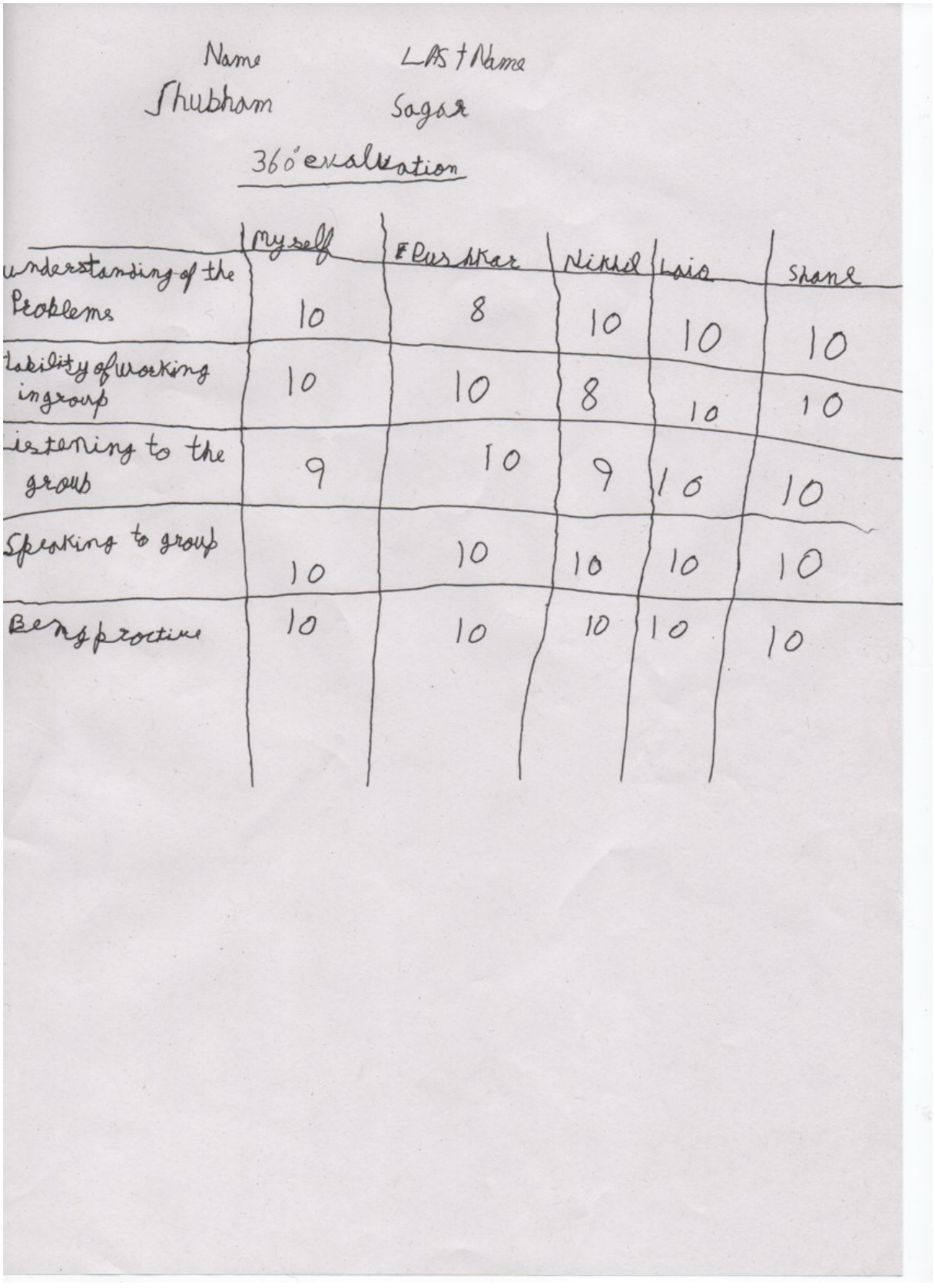
360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca



Pushkar Thakur
360° evaluation

	My self	Nikhil	Shubham	Laio	Shane
understanding of the problem	10	10	10	10	10
Hability of working in group	10	10	10	10	10
Listening to the group	10	9	9	9	9
Speaking to the group / explaining the problem	9	9	8	10	10
Being proactive	10	10	10	10	10

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca



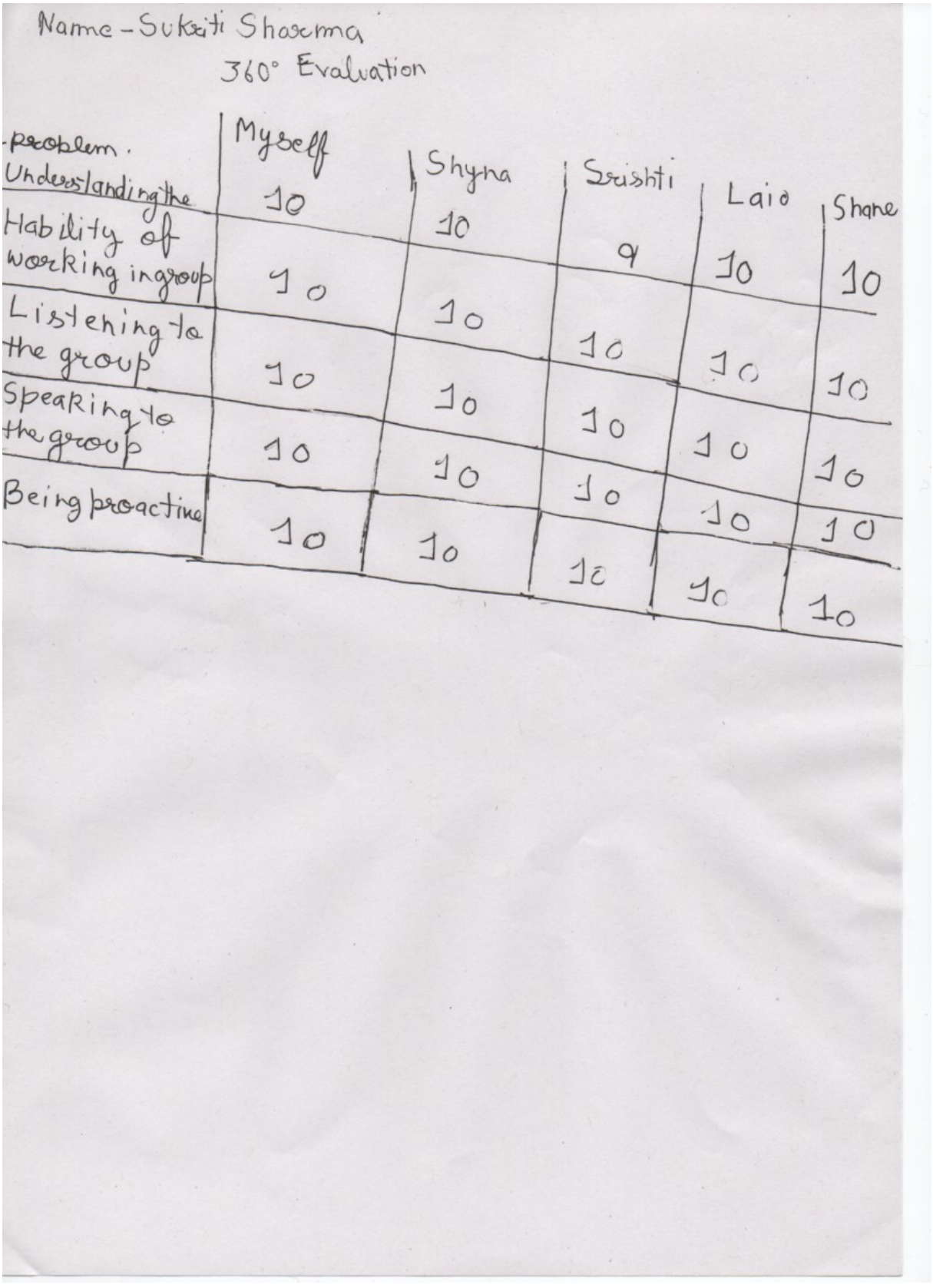
Name Last Name

Shubham Sagar

360° evaluation

	myself	Parshar	Nikhil	Laio	Shane
understanding of the Problems	10	8	10	10	10
ability of working in group	10	10	8	10	10
listening to the group	9	10	9	10	10
Speaking to group	10	10	10	10	10
Being proctive	10	10	10	10	10

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca

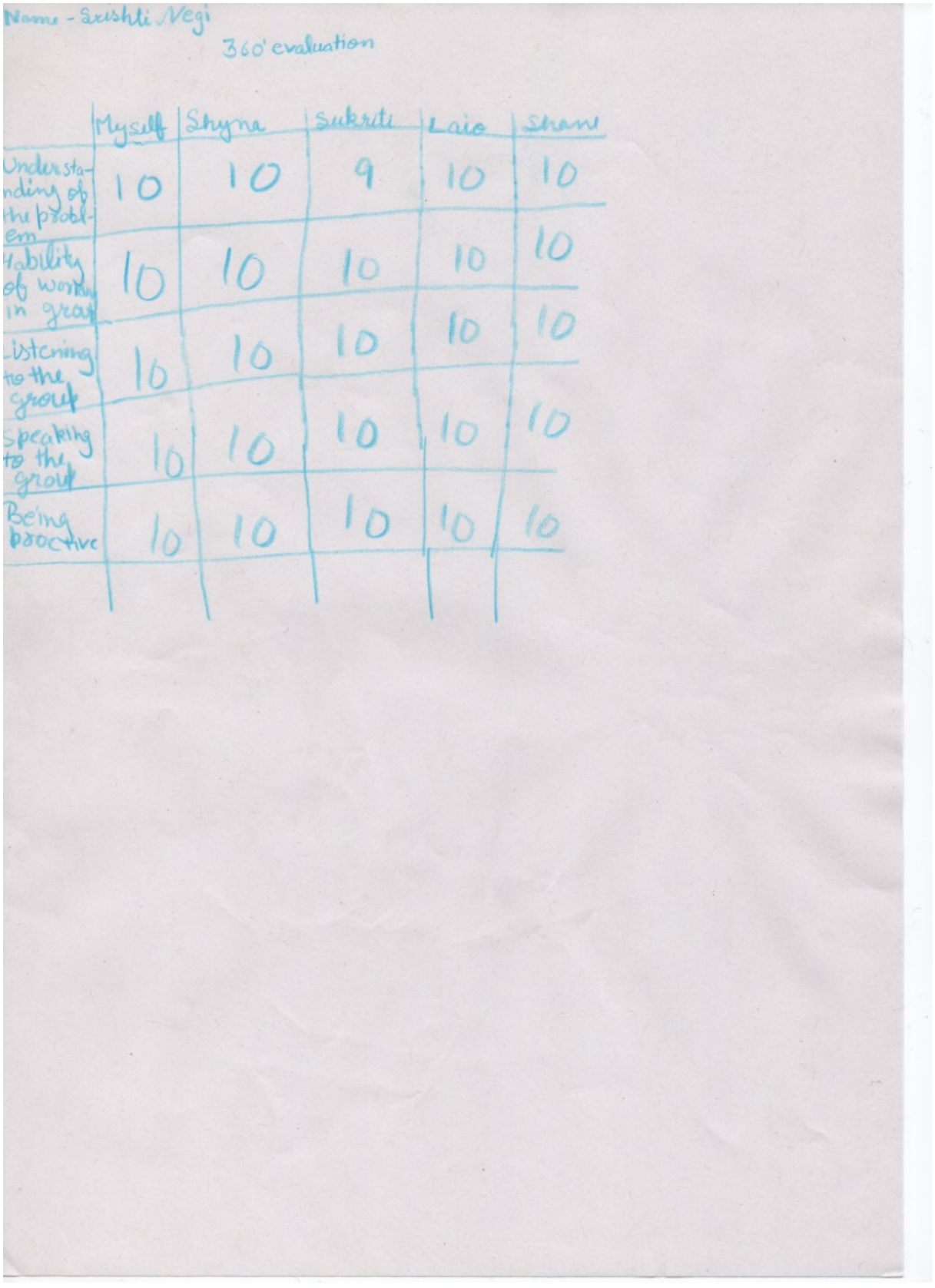


Name - Sukriti Sharma

360° Evaluation

problem.	Myself	Shyna	Srishti	Laio	Shane
Understanding the	10	10	9	10	10
Hability of working in group	10	10	10	10	10
Listening to the group	10	10	10	10	10
Speaking to the group	10	10	10	10	10
Being proactive	10	10	10	10	10

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca

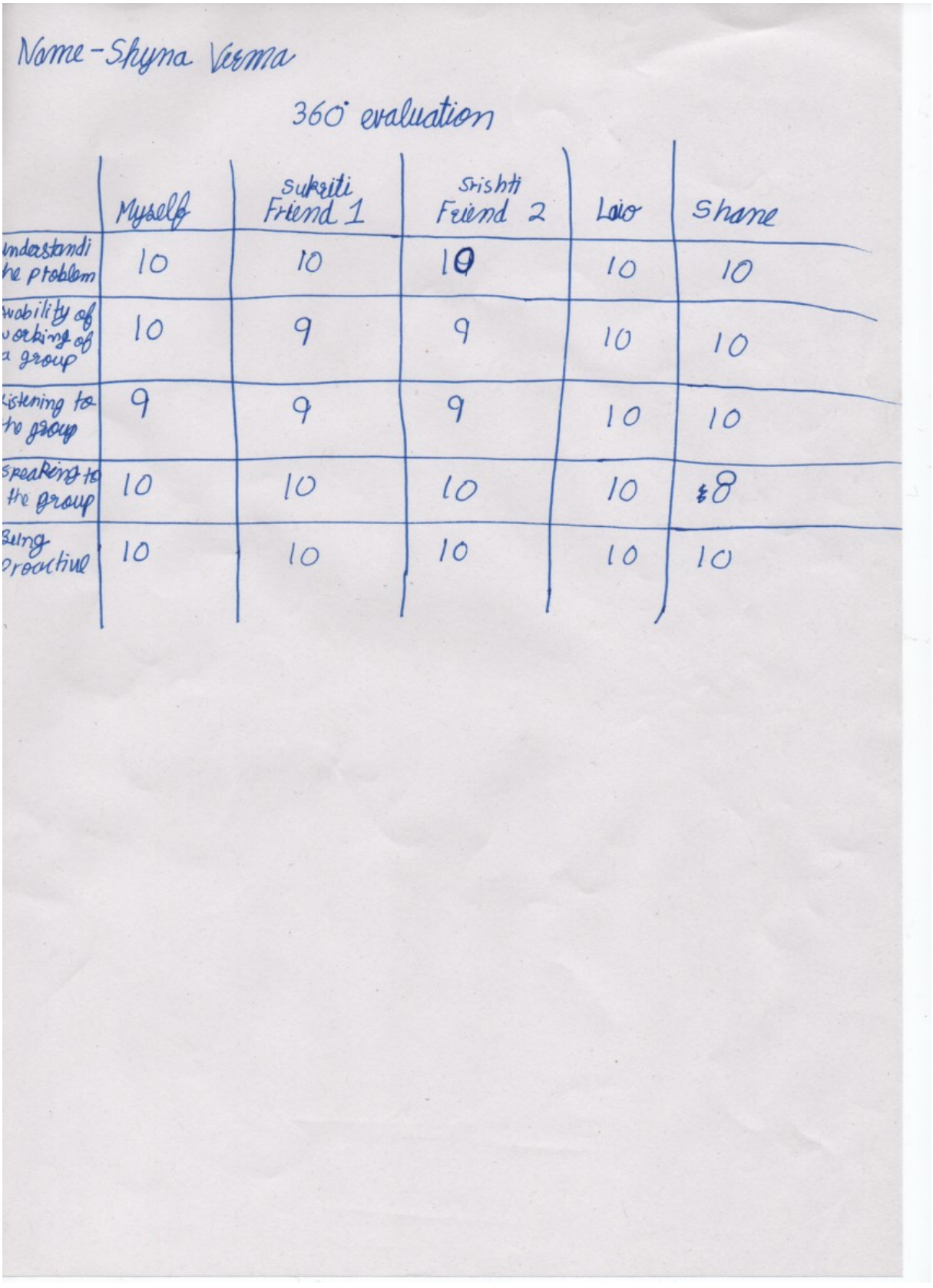


Name - Srishti Negi

360' evaluation

	Myself	Shyna	Sukriti	Laio	Shanu
Understanding of the problem	10	10	9	10	10
Ability of working in group	10	10	10	10	10
Listening to the group	10	10	10	10	10
Speaking to the group	10	10	10	10	10
Being proactive	10	10	10	10	10

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca

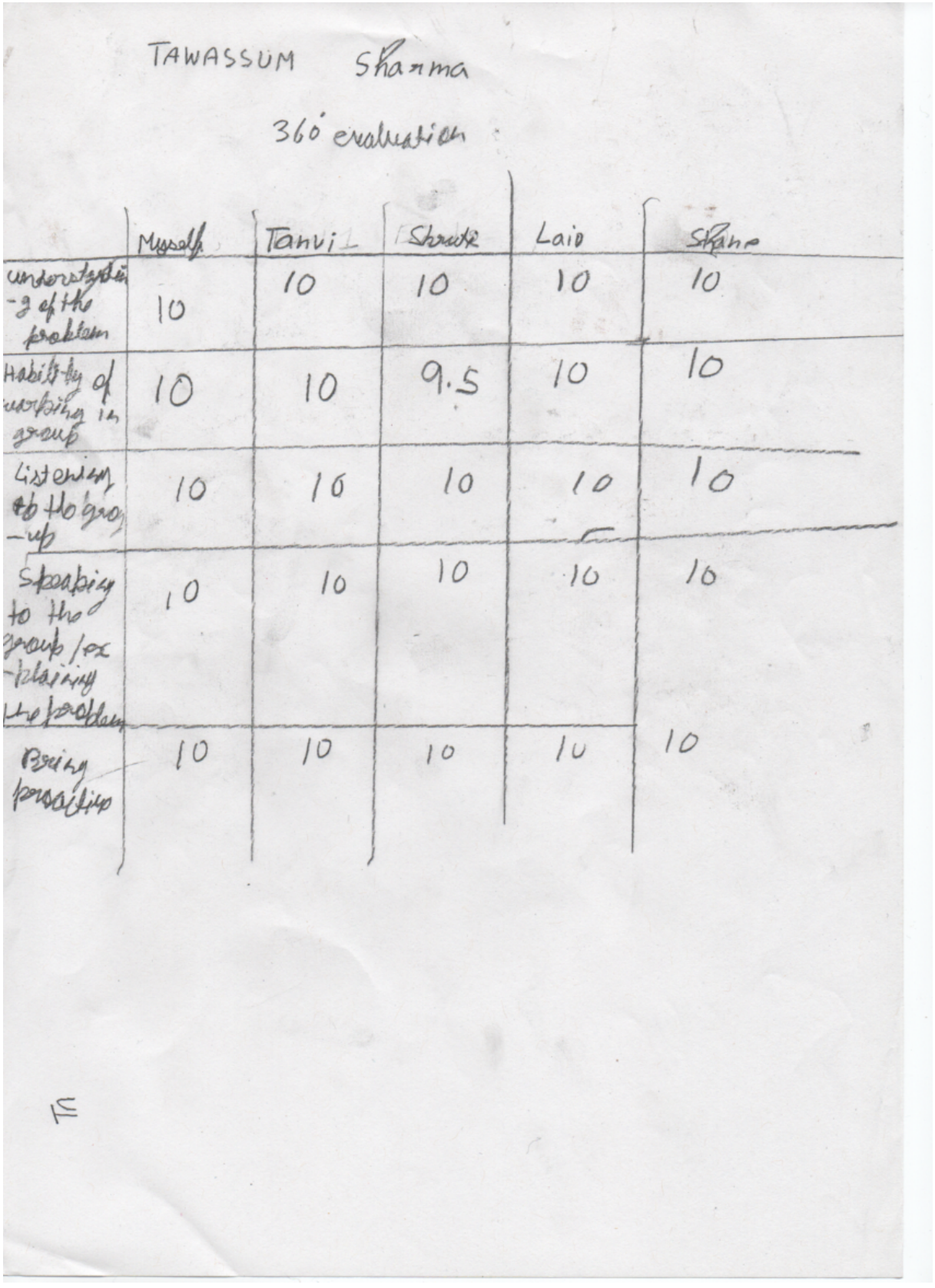


Name - Shyna Verma

360° evaluation

	Myself	Sukriti Friend 1	Srishti Friend 2	Laio	Shane
Understanding the problem	10	10	10	10	10
Availability of working of a group	10	9	9	10	10
Listening to the group	9	9	9	10	10
Speaking to the group	10	10	10	10	8
Being proactive	10	10	10	10	10

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca

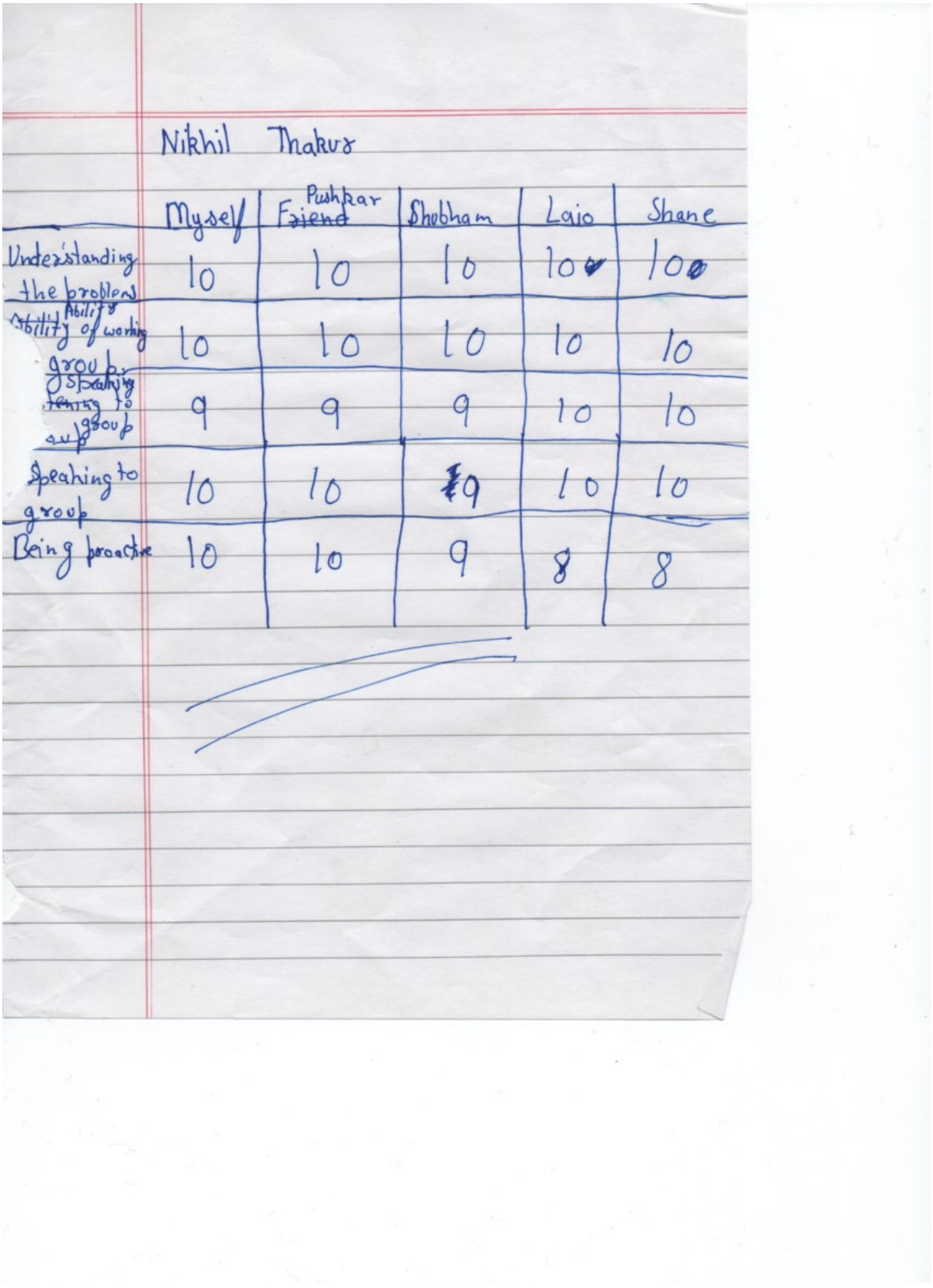


TAWASSUM Sharma

360° evaluation

	Myself	Tanvi	Shruti	Laio	Shane
understanding of the problem	10	10	10	10	10
Ability of working in group	10	10	9.5	10	10
Listening to the group	10	10	10	10	10
Speaking to the group for explaining the problem	10	10	10	10	10
Being positive	10	10	10	10	10

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca



Nikhil Thakur

	Myself	Pushkar Friend	Shobham	Laio	Shane
Understanding the problem	10	10	10	10	10
Ability of working group	10	10	10	10	10
Speaking time to group	9	9	9	10	10
Speaking to group	10	10	9	10	10
Being proactive	10	10	9	8	8

360 degree evaluation, Himachal Pradesh. Source: Laio Fonseca

APPENDIX B – Pictures

Manali, Himachal Pradesh. Source: Laio Fonseca

Raison, Himachal Pradesh. Source: Laio Fonseca

Kasol, Himachal Pradesh. Source: Laio Fonseca

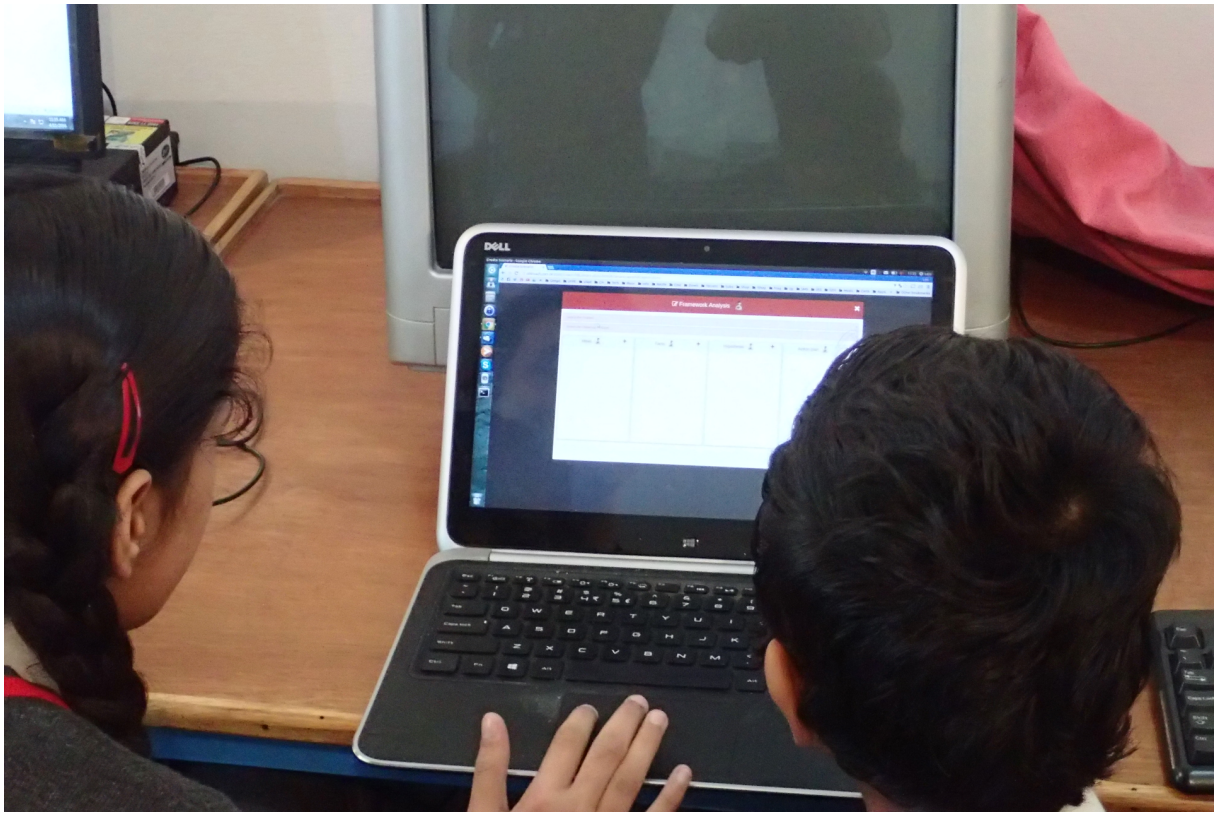
Kasol, Himachal Pradesh. Source: Laio Fonseca

Tosh, Himachal Pradesh. Source: Laio Fonseca

Manikaran, Himachal Pradesh. Source: Laio Fonseca

Raison, Himachal Pradesh. Source: Laio Fonseca

Tara International School, Himachal Pradesh. Source: Laio Fonseca



Tara International School, Himachal Pradesh. Source: Laio Fonseca

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