Maria Leite Faria **Instructions and object play**

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Universidade do Minho
Escola de Psicologia

Maria Sanches Leite de Faria

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outubro de 2023

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Instructions during object play

Dissertação de Mestrado
Mestrado em Psicologia em Cognição Humana

Trabalho efetuado sob a orientação do
Professor Doutor Carlos Pinto

outubro de 2023

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

(Maria Sanches Leite de Faria)

Instruções e Manipulação Lúdica de Objetos

Resumo

O conceito de aprendizagem lúdica implica que as crianças participem ativamente no que as rodeia, o que ajuda a alimentar a curiosidade, criatividade e capacidade de resolver problemas. Esta abordagem é crucial nas fases iniciais da educação das crianças pequenas e acredita-se que tem um impacto considerável no seu crescimento cognitivo, social e emocional. No entanto, a análise do modo como a aprendizagem lúdica influência o desenvolvimento da criança tem-se deparado com dificuldades metodológicas, tornando a interpretação dos resultados complexa. Nesta investigação, analisámos novamente a forma como o treino pode influenciar as capacidades de resolução de problemas das crianças no futuro. Comparámos duas variações do paradigma da tarefa de construção LEGO: Para a realização das tarefas, numa versão as crianças tinham as instruções de construção permanentemente disponíveis noutra, após um período de estudo das instruções, as instruções eram removidas e só depois dadas as peças. A fase de treino, uma fase prévia às tarefas, também possui duas variações do treino: ou as instruções eram explicandas com os seus componentes ou explicadas sem eles. Revisitámos a discussão sobre a forma como o treino pode afetar o desempenho posterior na resolução de problemas. No final, o desempenho tendeu a ser melhor quando a criança pôde fazer uso da instrução durante a construção, e inesperadamente o resultado do treino sem os componentes foi melhor durante a resolução das tarefas com instruções presentes.

Palavras-Chave:

Treino; Instruções; Resulução de Problemas; Construções LEGO; Sucesso

Instructions and Object Play

Abstract

The concept of learning through play involves children actively participating in their surroundings, which helps nurture their curiosity, creativity, and ability to solve problems. This approach is crucial in the initial stages of education for young children and is believed to have a considerable impact on their cognitive, social, and emotional growth. However, the examination of how play influences child development has encountered difficulties in methodology, making the interpretation of results more complex. In this research, we took another look at how training might influence children's problem-solving abilities in the future. We contrasted two variations of the LEGO construction task paradigm: either with the building instructions permanently available or, after a period of study of the instructions, and then with the instructions removed, as well as two variations of the training: either explaining the instructions with its components or without them. We revisited the discussion on how training may affect subsequent problem-solving performance. At the end, the performance tended to be better when a child could make use of the instruction during the construction, and unexpectedly the result of the training without the components were better during the resolution of the tasks with instructions present.

Key Words:

Training; Instructions; Problem-Solving; LEGO Constructions; Success

Index

Introduction

Learning through play, a process by which children actively engage with their environment, fostering curiosity, creativity, and problem-solving skills, is a fundamental aspect of early childhood education, and it is considered to hold significant implications for the cognitive, social, and emotional development of children (e.g., Bruner, 1972; Robinson et al., 2018; Sutton-Smith, 1975). Despite the relevance attributed to it, the study of how play impacts child development has faced methodological challenges which complicate the interpretation of findings. Diverse fields have explored the multifaceted nature of play, highlighting its role in shaping the cognitive architecture of the young, and while these investigations may offer invaluable insights, they have also been plagued by issues such as confusion between correlational and causal evidence, failure to replicate, or experimenter bias (Lillard et al., 2013; Whitebread et al., 2017).

One topic that has received considerable attention is the relation between play and problem-solving. Problem-solving has been studied via a variety of ludic tasks, such as exploring, construction, or tool using (Pellegrini & Gustafson, 2005). For instance, Sylva (1974) challenged pre-school children with a lure-retrieval task, adapted from primate research. To successfully retrieve the lure, the children had to build a tool from sticks and connector pieces. Both direct experience with the materials (non-directed free play) and simple observation of the tool being built led to subsequent successful performance of the task. Smith and Dutton (1979) extended the procedure by adding a group with direct training on how to build the tool and not only replicated the main conclusion that play improved problem solving, but also suggested that non-directed play was best at promoting innovative solutions. These conclusions were tempered by Vandenberg (1981), that compared the impact of “play” and “non-play” experiences on lure-retrieval performance in children aged 4 to 10 years and only found clear superiority of “play” for children aged 6-7 years, in one of the tasks. Additionally, as Cheyne (1982) pointed out, these experiments may have been affected by experimenter bias, putting their validity into question. To clarify this issue, Simon and Smith (1983), controlling experimenter bias, replicated Smith and Dutton (1979) and confirmed that non-directed play and directed training had similar impacts on problem-solving. However, they did not replicate the finding that non-directed play was best at promoting innovative solutions. These examples illustrate the aforementioned methodological difficulties that have plagued this topic of research, so prevalent that Lillard et al. (2013) consider they preclude proper meta-analyses that could help identify which results are robust and replicable.

More recently, Richardson et al. (2004) looked into a different type of task: construction play, in adults. To that end, they created a LEGO construction task paradigm, consisting of tasks of increasing difficulty, where participants had to follow instructions that presented an isometric view of the model to be built. On children, performance on this task has been correlated with spatial ability and mathematical performance (Richardson et al., 2014), and visuospatial and verbal working memory, non-verbal intelligence and mathematical performance (Nath & Szücs, 2014). Making use of the LEGO construction task paradigm, in this study we revisited the discussion on how training may affect subsequent problem-solving performance. We had two training conditions: to half the children, the instructions were explained and they got the chance to actually build the model. For the remaining children, no LEGO pieces were made available during the explanation of the instructions: they could only see the already-built model. Additionally, we contrasted two variations of the LEGO construction task: either with the building instructions permanently available or, after a period of study of the instructions, with the instructions removed. We were interested in seeing whether prior experience affected equally the two variations of the task.

Method

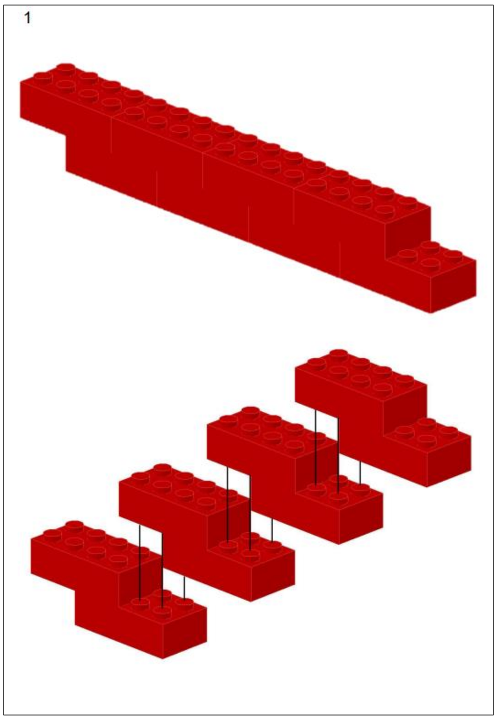
Participants

Fifty children (27 girls, 23 boys) aged 6-7 years, participated in the study. All children were enrolled in Colégio Nossa Senhora do Rosário. To participate, informed consent was obtained from each child's guardians (see Appendix 1). The study obtained approval from the ethics committee. The participants did not present hearing difficulties or used hearing aids, did not present visual difficulties that could compromise the performance of the tasks, and did not have a diagnosis of neurodevelopmental disorders. After completing the experimental tasks, the children received a sticker as a reward.

Materials

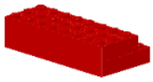
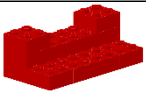
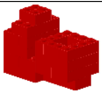
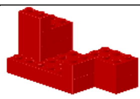
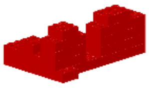
We used the Lego building paradigm developed by Richardson et al. (2004) which, by combining the number of unique assemblies, the number of pieces that constitute each assembly, and the number of pieces available for selection, consists of seven tasks of increasing difficulty (see Table 1). For the present study, similarly to Nath and Szücs (2014), only the required parts were provided for each task, along with an instruction sheet. The instructions for each task (provided by Miles Richardson) were presented on individual, laminated, sheets. Each instruction sheet shows how the final assembly should look and an exploded view of how the components, in space, via guides, should be put together. See Figure 1 for an example, and Appendix 2 for the full set of instructions. Only red LEGO pieces were used, in all tasks.

Figure1. Instruction sheet for one of the LEGO assembly tasks.



The number of components that comprised each model (rightmost column of Table 1) did not correspond necessarily to a single LEGO piece. In some cases, it did, in other cases it was a sub-assembly comprised of two or more pieces: For instance, the model depicted in Figure 1 ("Training 1"), is composed of 4 components, each component made of two LEGO pieces glued together, so that the children could not separate them. It was these four components that the child had to put together.

Table 1. Lego models in order of task difficulty.

Designation	Model	Components
Training 1		4
Training 2		5
T1		7
T2		5
T3		6
T4		9
T5		8

Procedure

The experiment was run in a room of the children's school, where only the researcher and child were present. They sat at a table, facing each other. The researcher introduced herself and had a brief conversation before starting with the task proper. The two easiest tasks from the set of seven tasks, named "Training 1" and "Training 2" were used for the training. The first step was outlining the steps involved in the task, emphasizing the importance of following the instructions carefully, and answering any questions the child may have. With the help of the instruction sheet for Task "Training 1" the researcher explained, by drawing on the sheet, where the components were located in the assembled figure, and how the exploded view worked, by indicating where each part was located in the assembled figure. A similar process was followed with task "Training 2". This stage did not take longer than 5 minutes.

There were two training conditions: with pieces and without pieces. On the one hand, in training with pieces, besides the instruction sheet, the children were also given the components required to build it. That is, they could actually practice building the LEGO construction. On the other hand, in training without pieces, the children could study the instruction but without access to the LEGO pieces. They were only allowed to see the final product, already built, on the hands of the researcher. Half of the children were allocated to each of the training conditions.

Within each training condition, the children were further divided in two test conditions: building with instructions available or not. Given the difficulty in obtaining participants, more children (18) were allocated to the condition with instructions than to the condition without instructions (7). Since building without the instructions was expected to be significantly harder, there was a risk of a floor effect obscuring potentially interesting results. Thus, we allocated more children to the conditions with instructions, as an attempt to maximize the potential of the study findings. This decision was made in the hopes that more data would be collected at a later moment to bring all conditions to equal footing.

The test consisted in solving the remaining five LEGO construction tasks, named T1 to T5, which were presented in order of increasing difficulty. For the condition with instructions, the children were given, simultaneously, the instruction sheet and the pieces required to complete the task and could make use of the instructions while building. For the building condition without instructions, the children were first given the instructions to study, for a maximum of three minutes. Then, the instructions were removed and the LEGO pieces given: the construction had to be completed from memory. To prevent providing any hints or assistance unwillingly, the researcher remained silent for the duration of the construction time, speaking only if the child gave up or claimed to have completed the task. For both conditions, each task had to be completed within four minutes. Any extension beyond this time frame was considered a failure. Between tasks, the researcher quickly checked in with the child, by asking questions such as "How do you think it went?" or "Are you ready for one more?” Overall, the whole session lasted around 30 minutes.

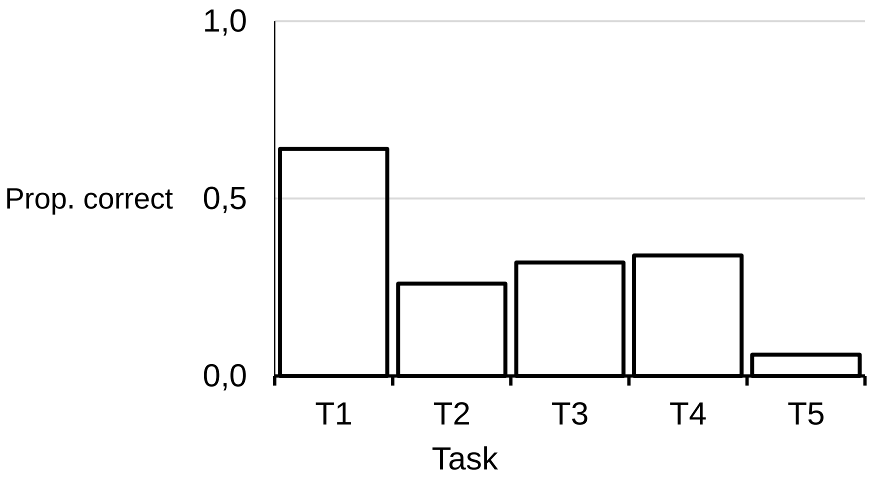
Data Analysis

We analyzed whether the LEGO construction tasks were completed successfully, (i.e., matching the instructions). Performance as a function of task was modeled with a mixed logistic regression model (Gallucci, 2019), with post-hoc comparisons to compare performance in the five tasks, using the jamovi software for Windows (version 2.3.21). To compare conditions, we combined performance on all levels of difficulty and calculated the proportion of successful completion for each child. A between-subject ANOVA with condition as a factor (four levels) was conducted to assess if and how type of training and access to instructions affected performance, with post-hoc comparisons with Tukey correction. Conditions with instructions available were combined and compared with the conditions where instructions were unavailable, via an independent samples Welch’s t-test (given the unequal sample sizes). As measures of effect size, we used the generalized eta square for the ANOVA and (η_G^2, e.g., Bakeman, 2005; Olejnik & Algina, 2003) and the standardized mean difference effect size for the t test (d_z, e.g., Cohen, 1988, p. 48; Lakens, 2013).

Results

Figure 2 shows the proportion of correct constructions for each of the five test tasks, for all children combined.

Figure 2. Overall proportion of correct constructions of the five LEGO construction test tasks.



Task T1 had the most successes (proportion = .64), significantly higher than all other tasks (vs. T2: $z = 4.26$, $p < .001$; vs. T3: $z = 3.72$, $p = .002$; vs. T4: $z = 3.53$, $p = .004$; vs. T5: $z = 5.46$, $p < .001$). On the opposite end of the spectrum, T5 was solved correctly the least amount of times (average = .06), significantly lower than all other tasks (vs. T2: $z = 2.94$, $p = .033$; vs. T3: $z = 3.48$, $p = .005$; vs. T4: $z = 3.64$, $p = .003$). Performance was similar for tasks T2 (.26), T3 (.32) and T4 (.34), with no statistically-significant differences between them.

Figure 3. Proportion of correct constructions as a function of training (with and without pieces) and test (with and without instructions) conditions

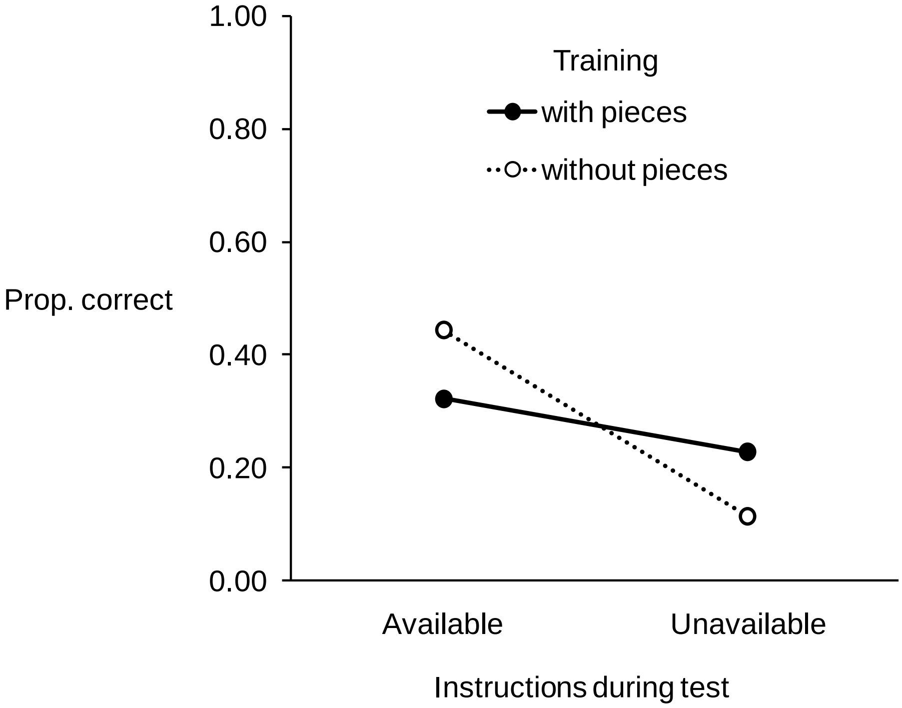


Figure 3 shows the proportion of successful completions as a function of training (with or without pieces) and test (with or without instructions). There was a significant main effect of condition, $F(3, 46) = 2.82$, $p = .049$, $\eta^2_G = 0.16$, and post-hoc comparisons revealed that, when there was no access to pieces in training (dotted line), there was a significant performance difference when instructions were available ($M = .44$, $SD = .30$) and not ($M = .11$, $SD = .20$), $t = 2.71$, $p = .045$. When training had pieces available (filled line), performance was not significantly difference whether instructions were available ($M = .32$, $SD = .28$) or not ($M = .23$, $SD = .24$), $t = 0.77$, $p = .868$. Performance with instructions available (left data points, $M = .38$, $SD = .29$) was significantly higher than when instructions were unavailable (right data points, $M = .17$, $SD = .22$), $t(31.48) = 2.78$, $p = .009$, $d_z = 0.82$

Discussion

Starting with overall performance, all test tasks posed a reasonable challenge to the children, and even for the first test level (T1), the proportion of success was not very high (.64). That first level was, as expected, the one with the most successes, and the last (T5) the one with the least (.06). Performance on the three intermediate levels was similar, with no negative gradation as level increased, which was not expected to happen (given the assumption of increasing task difficulty with each level).

We do not have the proportion of success for each task individually from Nath and Szücs, (2014), the study closest to the present study, but we do have the average maximum level that their participants managed to solve: 4.12. Given that we used the first two levels of difficulty as training tasks, we cannot make a direct comparison with this metric: some children failed all of our test levels - levels 3 to 7 in Nath and Szücs, (2014) - so we cannot ascertain if the maximum level of these children would be 0, 1, or 2. With that caveat, we can still compute the maximum level for the children that did manage at least one success to get a sense of how performance in the experiments compare. Our overall maximum level was slightly higher, 4.97, but again, it may not necessarily represent an actual difference in performance. One interesting comparison that suggests such a difference is that, while in Nath and Szücs (2014) no child managed to solve the most difficult task (what we called “T5”), a very small proportion of our participants (three out of 50) did manage to solve it. This difference could be due to the more extensive training in our procedure – in Nath and Szücs (2014) the children started building by themselves immediately from the first level (what we called “Training 1” in our study).

Unsurprisingly, performance tended to be better when a child could make use of the instructions during the construction. What was more interesting was finding that the presence/absence of instructions affected the two training conditions differently: whereas the presence of instructions appeared to be of little benefit to the children that trained with LEGO pieces, for the children that had no pieces during training there was a clear difference when instructions were available and not.

One possibility for this group discrepancy is that, given our limits in attentional capacity (e.g., Pashler, 1998), the presence of pieces during the explanation of the task was distractive, and thus counterproductive to learning how to read the instructions. Conversely, the children who trained without the potential distraction of the pieces could focus more on the explanation of the instructions, understanding them better. Consequently, these children were able to take better advantage of the instructions when they were available (this group was the one that performed at the highest level).

According to this possibility, we would expect performance for the "training without pieces" conditions (Figure 3, white data points) to always be superior to the "training with pieces" conditions (black data points), which was not the case: both when instructions were available and not, there was no statistically-significant difference between the two training conditions. Perhaps training without pieces led to both better performance with instructions and poorer performance without instructions, and these two tendencies together yield the difference we found.

It has been found that materials' manipulation can improve subsequent problem-solving performance (e.g., Simon & Smith, 1983; Smith & Dutton, 1979), so an obvious question that stems from the previous discussion is why would the manipulation of the pieces be counterproductive in our case. In previous tasks, there is less competition between instructions and materials: learning how to solve a task happens directly through the manipulation of the materials. In our case, the instructions and materials were clearly separated – hence the possibility of competition between them, as we advanced in the previous paragraph.

In closing, given the size of the samples we were able to collect, as well as the sample size difference between the task with and without instructions, our conclusions are only tentative; even when significant differences emerged, their effect sizes were relatively small, further suggesting the need of additional data collection. Nonetheless, our results suggest interesting effects of how the way a task is learned may affect subsequent performance, which warrant not only wider data collection but also further experiments.

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Appendix

Appendix 1 – Informed consent form

Declaração de Consentimento Informado, Livre e Esclarecido

Neste documento encontra-se informação relativa ao estudo "Problem-solving and object play" e à divulgação e confidencialidade dos dados que a partir dele se produzirem, para esclarecimento do participante. É necessário que leia com atenção a informação a seguir apresentada com o intuito de compreender os detalhes inerentes à participação do seu educando e proceder à assinatura deste consentimento.

1. **Objetivo do estudo**

O objetivo principal deste estudo é perceber se o tipo de treino que a criança passa antes da tarefa afeta, ou não, a funcionalidade e a importância do papel com as instruções.

2. **Descrição do estudo, tarefas e duração**

A participação será individual, sendo feita numa sala apenas com o experimentador e o educando. A tarefa consiste na construção de figuras em Lego seguindo diferentes instruções, presentes ou não presentes, sendo que todas começam com uma fase de treino onde se procura explicar e esclarecer à criança como se lê e interpreta as instruções, existindo ou não peças para ajudar.

3. Riscos associados à sua participação nesta investigação

Não é antecipável, que os participantes possam incorrer em qualquer tipo de risco ou desconforto associado ao procedimento do estudo, seja ele físico, psicológico, económico ou social.

4. **Uso dos resultados de investigação e confidencialidade**

Os dados recolhidos apenas serão usados no âmbito da apresentação de uma dissertação de Mestrado e para fins de investigação (i.e., apresentações em encontros científicos e a sua publicação em revistas científicas). O anonimato e a confidencialidade dos dados serão assegurados pelas normas de proteção de dados em vigor na Universidade do Minho. Nunca será estabelecida qualquer relação entre o participante e os dados do estudo.

5. Direitos do participante da investigação

A participação no estudo é voluntária e o participante pode desistir a qualquer momento e abandonar a experiência sem que isso envolva qualquer prejuízo para ele.

Caso pretenda notificar algum aspeto relativo à proteção dos seus dados, deverá fazê-lo, por escrito, dirigindo notificação ao Encarregado de Proteção de Dados da Universidade do Minho (protecaodados@uminho.pt).

Obrigado pelo tempo que despendeu a ler esta informação e a ponderar a sua participação neste estudo. Se desejar participar, deve assinar e datar o Consentimento Informado.

Consentimento (1ª cópia para o Encarregado de Educação)

(Para esclarecimento ou questões sobre a informação presente neste documento, por favor contactar através deste email: Maria Leite Faria (pg45628@alunos.uminho.pt) ou Carlos Pinto (cpinto@psi.uminho.pt).

Eu, ____ (nome completo encarregado de educação) compreendi a informação que me foi fornecida sobre a investigação que se tenciona realizar, bem como o estudo em que o meu educando ____ irá participar. Foi-me disponibilizado tempo para refletir sobre a participação, assim como, colocar todas as minhas dúvidas acerca do estudo.

Tomei conhecimento de que, de acordo com as recomendações da Declaração de Helsínquia, a informação ou explicação que me foi prestada abordou os objetivos, os métodos, os benefícios previstos, os riscos potenciais e o eventual desconforto provocado pela participação neste procedimento.

Compreendo que a participação é voluntária e que a criança pode desistir a qualquer momento sem dar qualquer justificação, sem que daí possa ocorrer qualquer prejuízo para a mesma.

Deste modo, consinto que o meu educando participe no procedimento de investigação proposto pelos investigadores e autorizo que os dados sejam apresentados de forma completamente anónima e confidencial em apresentações públicas, congressos científicos e publicações.

Data: _____ / __________________ / 20_____

Eu, ____ (nome do encarregado de educação) autorizo o meu educando _____________________ ____ a participar neste estudo experimental

Assinatura: ____

A investigadora responsável,

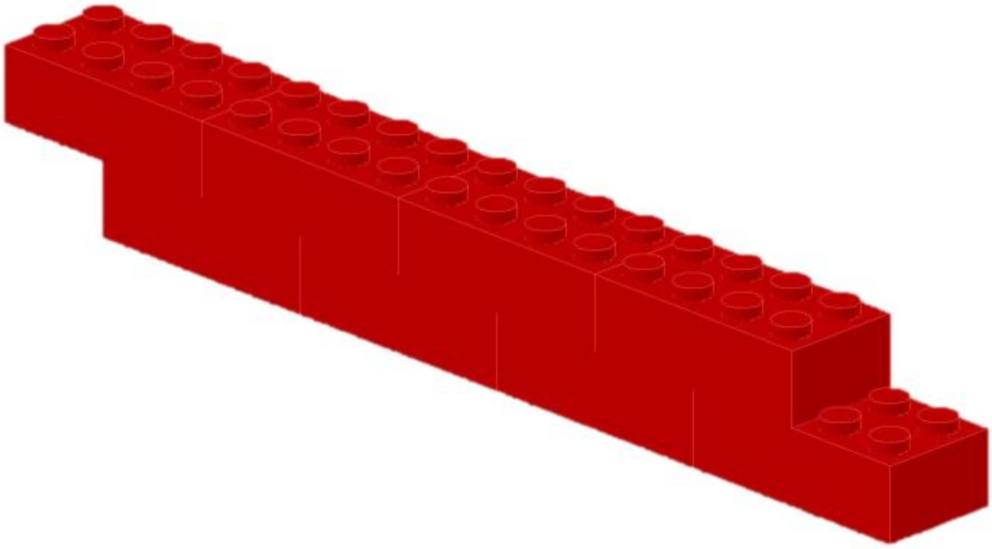
Nome: Maria Sanches Leite Faria.

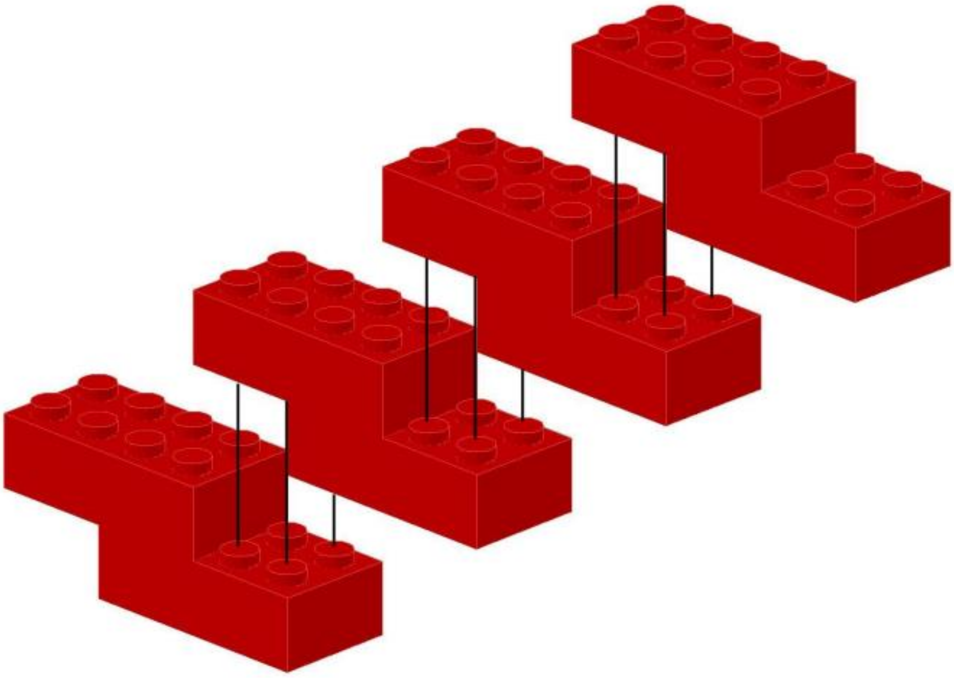
Assinatura: ____

(Para esclarecimento ou questões sobre a informação presente neste documento, por favor contactar através deste email: Maria Leite Faria (pg45628@alunos.uminho.pt) ou Carlos Pinto (cpinto@psi.uminho.pt).

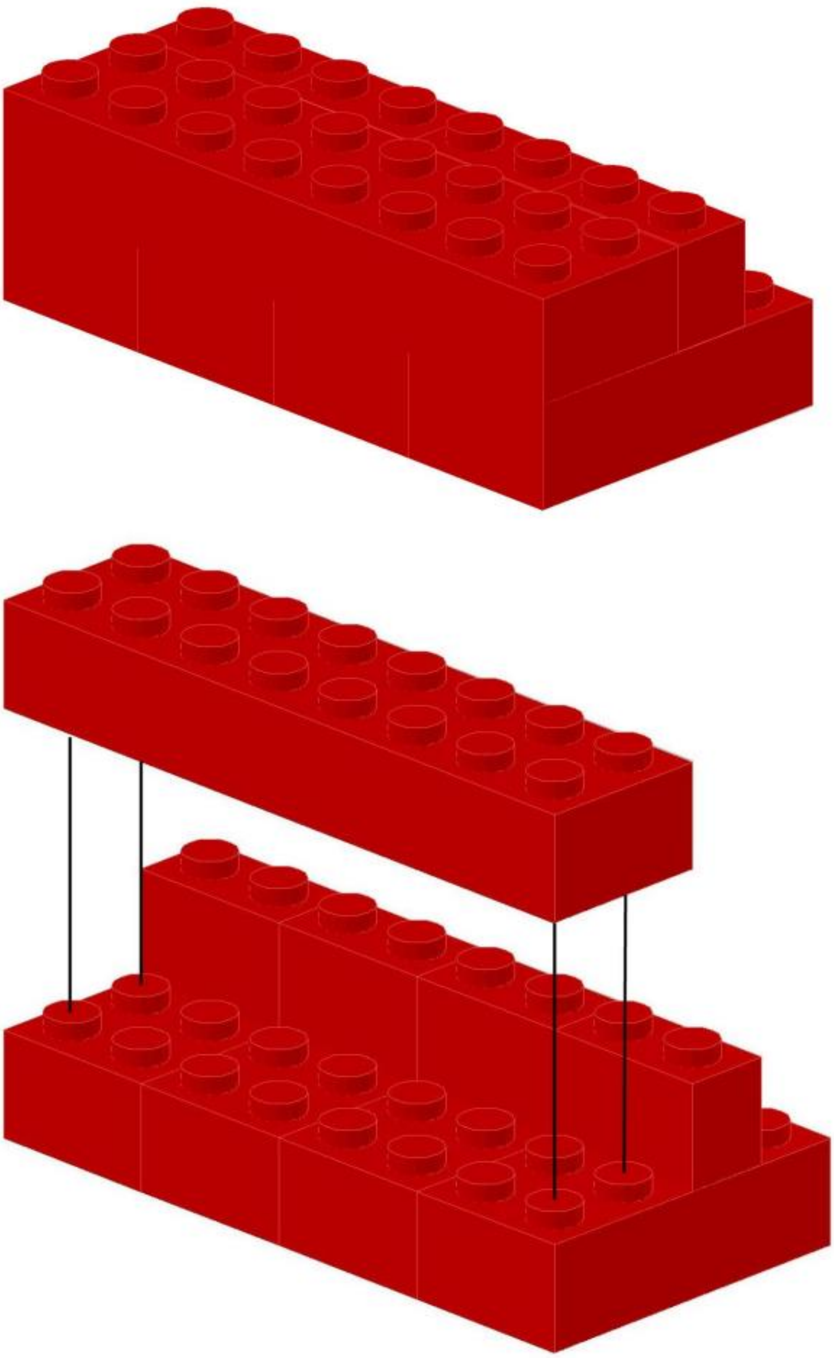
Appendix 2 – Building Instructions

Training 1

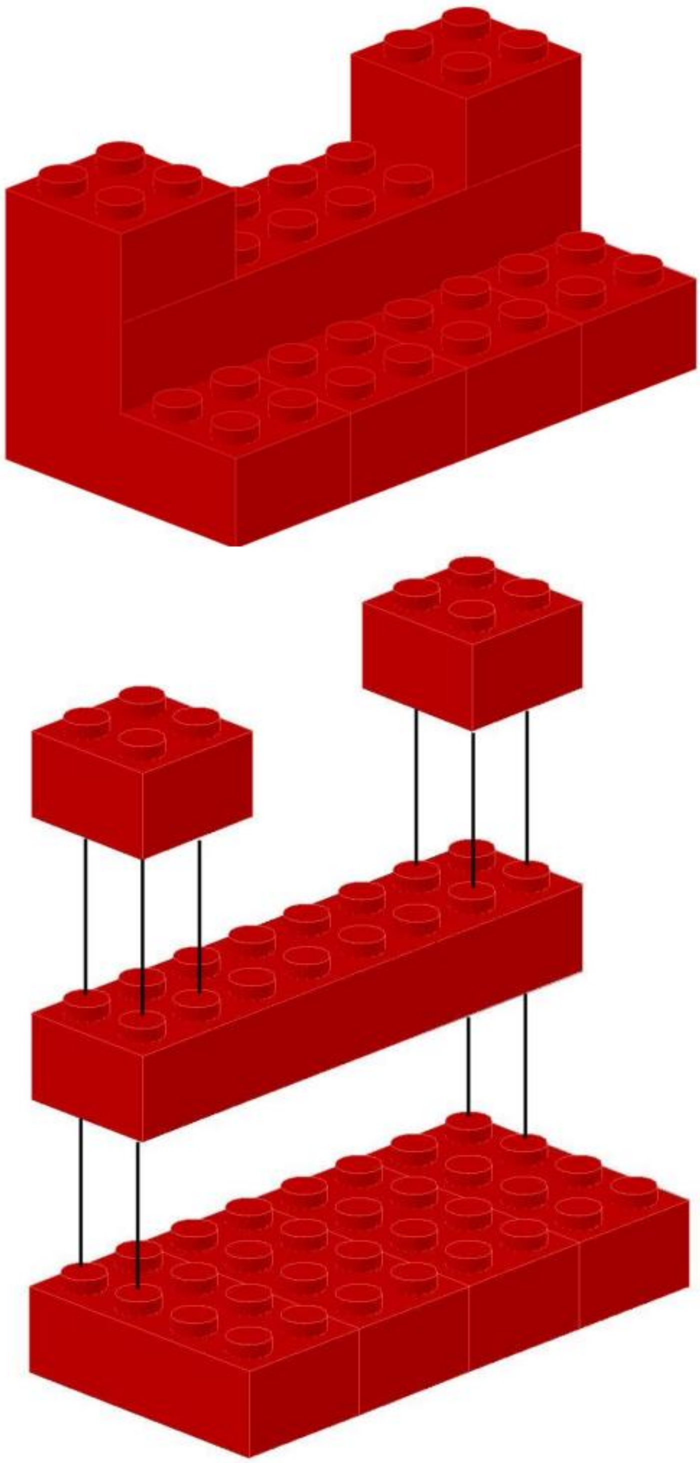




Training 2



T1



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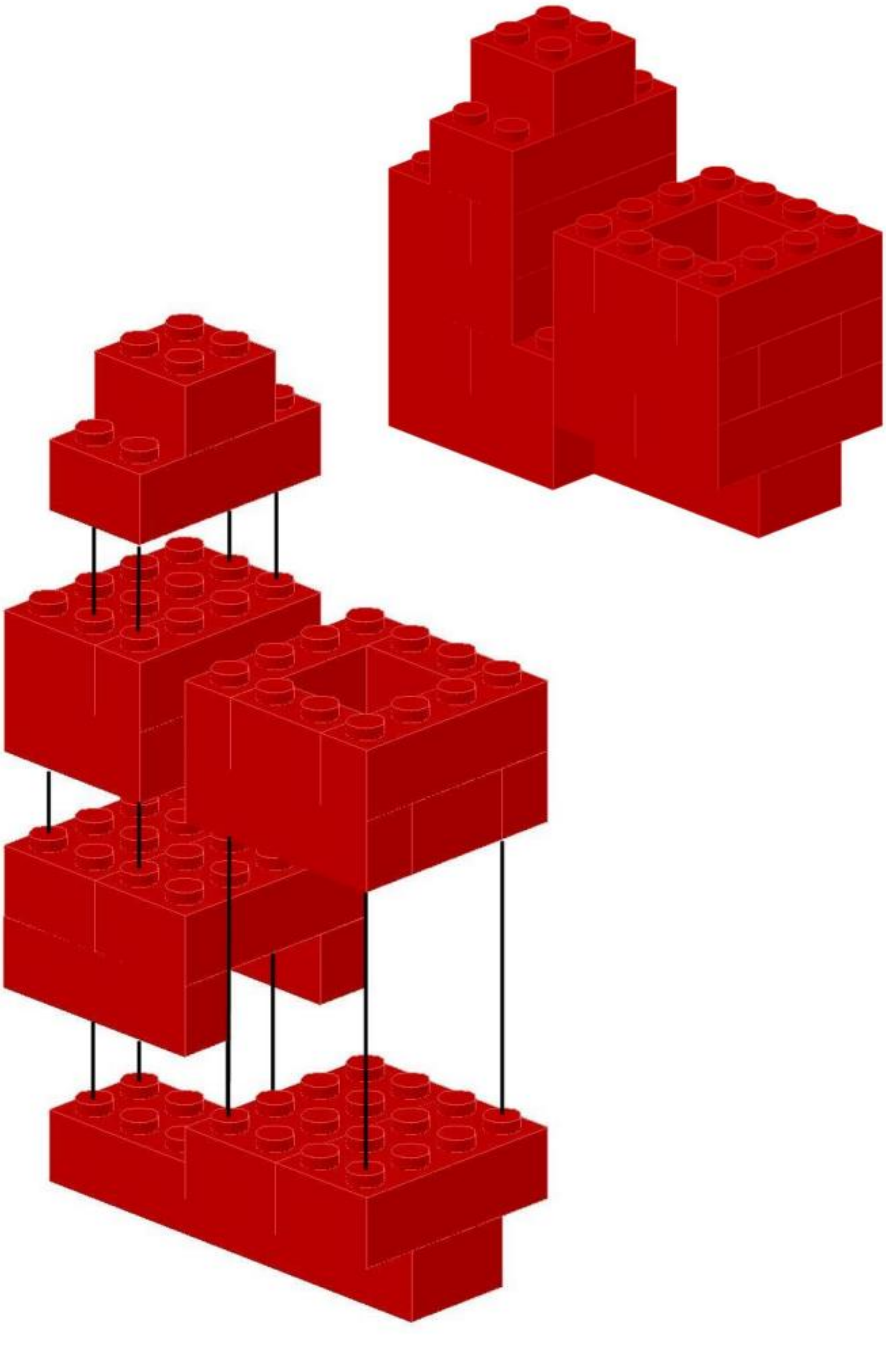
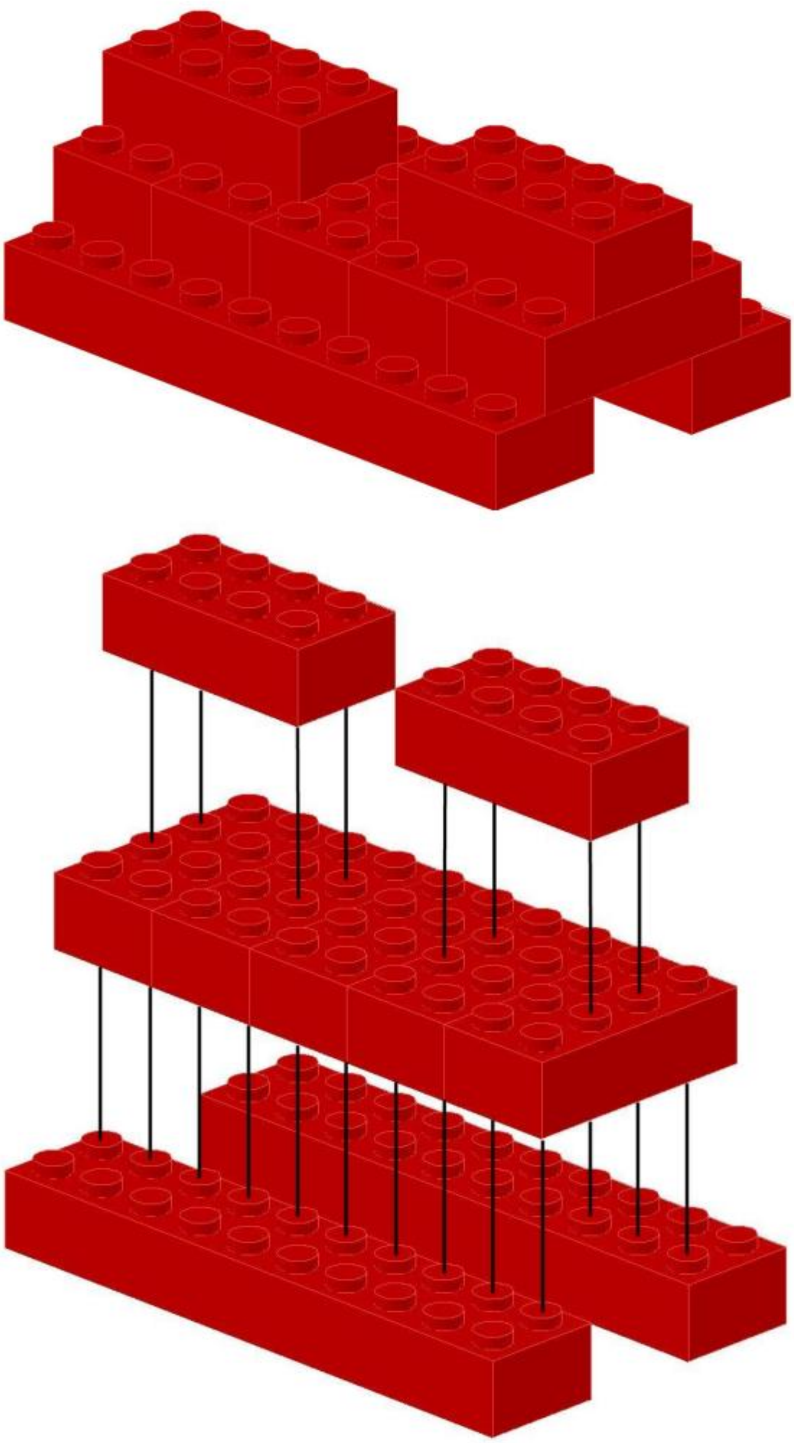
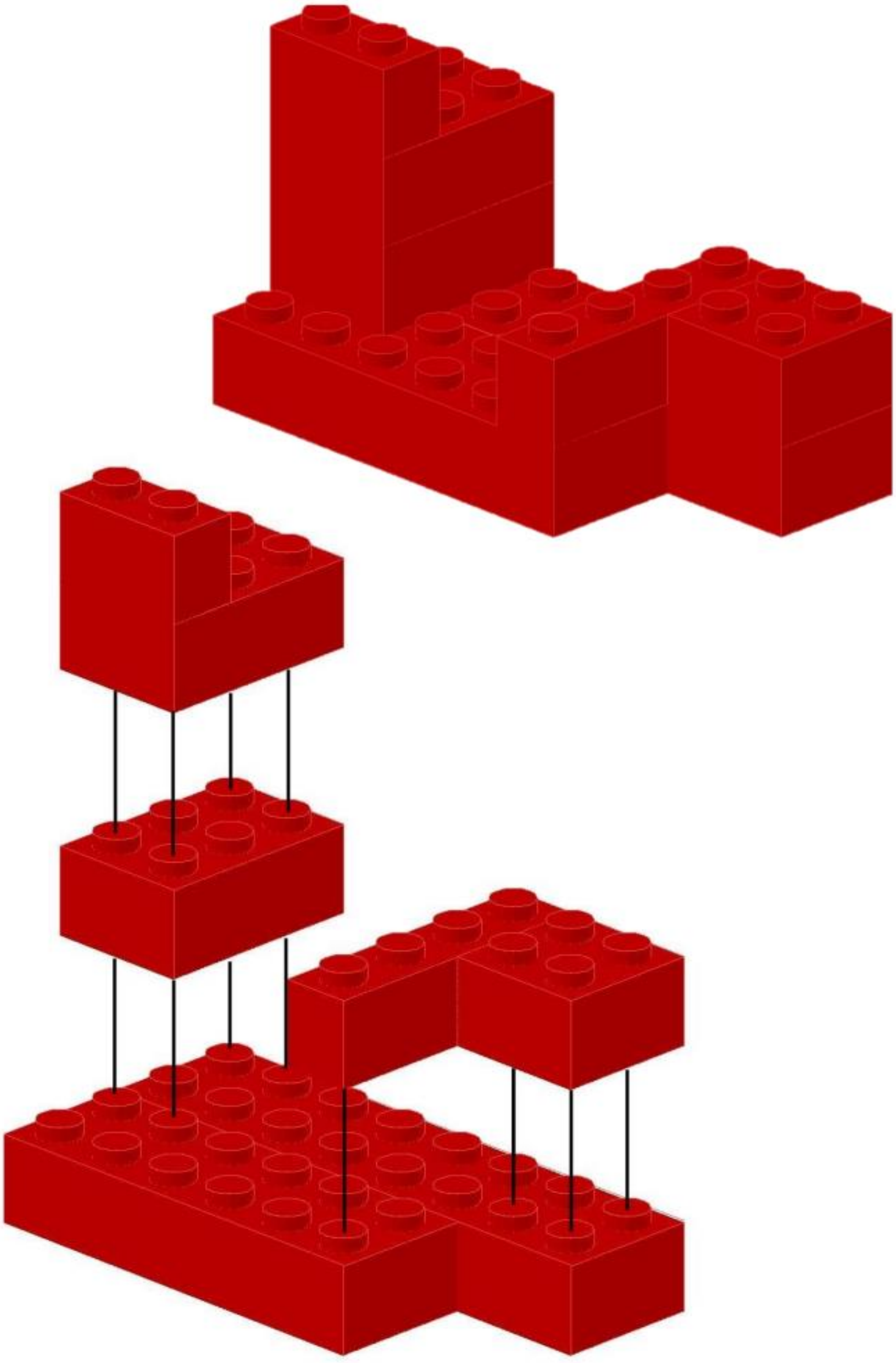


T3



T4



T5