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Introduction to informatics in a Peruvian penitentiary using cs unplugged: from university to penitentiary

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Abstract

Within the field of social reintegration and re-education, this paper presents an educational experience carried out at the Iquitos Penitentiary Center, Lima, Peru, with the aim of providing an introduction to informatics to 25 inmates who volunteered to take part in the project. Twenty students and a teacher from the Scientific University of the South also in Peru, were responsible for initiating the transmission of knowledge from the university to inmates, with the collaboration and participation of the penitentiary coordinator. The main objectives of the case study were to validate both the suitability of the CS unplugged proposal and the adaptability of the L2T2L pedagogic strategy to the transmission of knowledge to adults, specifically penitentiary inmates. This strategy had been originally designed to transmit informatics knowledge from university to primary school. The validity and effectiveness of the experience was assessed using surveys. Results confirm that inmates achieved a good level of understanding when endeavoring to resolve most of the CS unplugged assignments designed for them. It was also seen that L2T2L is adaptable and valid for different scenarios other than those for which it was initially designed. Indeed, it was proven to be valid for transmitting knowledge to the prison population. Finally, it should be pointed out that the experience is easily replicable and that it brings an opportunity to introduce informatics into education programs in prisons, something which can contribute enormously to social reintegration and re-education, facilitating the subsequent reentry of inmates into the community once their period of imprisonment has ended.

Keywords Informatics · Computer Science unplugged · Learning in penitentiaries · Rehabilitation programs · Learning by teaching

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1 Introduction

Social reintegration and re-education efforts made in penitentiaries are often overlooked by most of society. Given that education is a fundamental right of every human being, incarceration should not preclude access to education for the imprisoned population. The Doha Declaration (2015), adopted at the 13th United Nations Congress on Crime Prevention and Criminal Justice (UNODC), highlights the importance of adopting measures to support the rehabilitation of inmates and their social reintegration into the community. UNODC supports Member States which endeavor to break the cycle of recidivism, providing prison administrations with technical guidance on how to initiate and/or improve rehabilitation programs, in close coordination with other governmental and non-governmental actors, including civil society and the private sector.

As reflected in most of the regulations and interventions existing worldwide in the prison environment, rehabilitation is a key factor in enabling the social reintegration of inmates once they are released. And education, a right which was recognized for everyone in the United Nations General Assembly in Paris on 10 December 1948 –*Article 26: Everyone has the right to education* (United Nations, 2015)– is considered as one of the most appropriate tools to achieve this rehabilitation, producing changes in both the behaviour and attitudes of people in prison.

Although there are experiences that endorse this statement (Lipsey & Cullen, 2007; Behan, 2014, 2021), it is also true that the prison environment is a complicated arena in which to achieve educational objectives. Even more so when the teaching is focused on certain areas in particular, such as the case of the teaching of informatics –computer science–, where it is usually assumed that the use of computers and the availability of internet access are a necessity.

Throughout the world, there is a vast diversity in terms of infrastructure and living conditions in prisons. From the so-called *"luxury prisons"* to prisons in which inmates are treated in an inhumane manner. From the Halden Prison in Norway, established in 2010 with a total focus on rehabilitation and considered as one of the world's most humane prisons, where the inmates interact with unarmed staff in all kinds of activities, simulating life outside the prison in a specially-equipped space and with an architectural design that is both practical and aesthetically pleasing (Hacler, 2016) to overpopulated prisons with precarious infrastructure that makes it extremely difficult to even think about carrying out rehabilitation tasks.

In the case of Peru, according to the report prepared by the National Penitentiary Institute (INPE, 2021), the country has 69 penitentiary establishments with a capacity to accommodate 41,123 people. However, as of May 2021 the prison population numbered 87,131 reflecting a level of prison overcrowding of 239%. The situation is not new, for example, in November 2019, a cell built to sleep 4 people, would sleep 9.5 people on average. Currently, there are many who point out that Peruvian prisons, due to their overcrowding, their precarious infrastructure, their inhumane hygiene conditions, the poor diet of the inmates and the spread of diseases, are more schools for crime than rehabilitation centers. From the same report (INPE, 2021), and with regard to the characteristics of the prison population in Peru, it can be seen that the vast majority of inmates (95%) are male. According to age ranges, there are a great

number of young people incarcerated in Peruvian prisons, almost 30% of the inmates are between 18 and 29 years old, and 38% between 30 and 50 years old. Focusing on the level of education, just over 68% of the population finished secondary education and more than 20% only managed to finish basic or primary education.

However, despite all the existing difficulties, inmates in Peru are able to participate in different programs, which help them to obtain some benefits. For example, in prisons not considered as high-security centers, but rather as minor offence centers, inmates who take part in these programs receive a double benefit. Not only are they are provided with training that facilitates their reentry into society but they also get a reduction in their sentence, up to a maximum of 30%. In this regard, with informatics being one of the areas that offer the greatest job opportunities, a new program focusing on computer education would appear to be a logical inclusion.

Given the impossibility of having the necessary technological infrastructure to work with computers in Peruvian penitentiaries, the only way to teach to inmates the fundamentals of informatics is through the Computer Science Unplugged initiative (CS Unplugged, 2023). CS Unplugged does not use computers to transmit the concepts of informatics; it uses games and exercises, but to date it has been only used in a practical fashion with non-adult populations (Battal et al., 2021).

In Larraza-Mendiluze and colleagues (2020), L2T2L, a pedagogical strategy to transmit knowledge about informatics topics from university to primary education using CS unplugged activities was presented. University students and teachers, and primary and secondary students and teachers participated in the proposal. Using a variant of L2T2L to transmit informatics knowledge to inmates seemed to present both an opportunity and a challenge.

In this context, the main objectives of the work presented here are twofold:

- To validate the suitability of using CS unplugged activities to transmit informatics to an adult population, specifically to inmates.
- To validate the adaptability of the L2T2L pedagogical strategy to transmit informatics knowledge from university students to inmates.

The case study presented in this article was carried out in the prison of Iquitos, Lima, Peru, in 2022 with 25 inmate volunteers. Through CS unplugged exercises designed or adapted by students of the Scientific University of South, Peru, and based on games or recreational activities for the transmission of computer concepts without using computers, the inmates worked on certain topics associated with informatics. The study has made it possible to identify not only the positive attitude of inmates towards informatics, but also the suitability of combining CS unplugged and L2T2L to transmit informatics knowledge from university to penitentiary.

Initiatives such as the one presented in this work can contribute significantly to social reintegration and re-education, facilitating the subsequent reentry of inmates into the community once their imprisonment period has ended.

This article is structured as follows. Section 2 presents a literature review about the teaching of informatics in prison together with an introduction to CS Unplugged. Section 3 summarizes the methodology used to transmit the knowledge associated with certain informatics topics from the university to the prison. Section 4 describes

how the project was introduced in the prison of Iquitos, Lima. Section 5 summarizes the results obtained. Finally, in Section 6 some conclusions and future research lines are indicated.

2 Literature review

In this section, two main issues are reviewed: first, how informatics education has been addressed in prisons and then, an introduction to CS unplugged is presented.

2.1 Informatics education in prison

There are several reasons behind advocating the incorporation of digital technology in prisons: improving and sustaining family relationships, improving educational and employment opportunities, delivery of emotional and psychological support to address mental health issues, wellbeing and addiction support or providing benefits to prisoner and staff wellbeing and relations by means of improvements in prisoner behavior (CSJ, 2021).

With regard to education, it is true that with the incorporation of computers in prisons it has been possible to address the teaching/learning process of certain subjects. And in this vein, some works that present different studies and experiences carried out across the world with different objectives have been published: to pass the General Education Development test in the USA (Stuart Batchelder & Rachal, 2000), to explore ways to securely and cost-effectively increase access to educational technology (ETC2015), to debate the function of technology-based education in prison (Jay, 2008), and to compare traditional in-person and computer-based instruction (Tanaka & Cooper, 2020); to analyze the education needs of inmates in Australia and evaluate their current access to education, information technology and the internet (Garner, 2017); in Franganillo and colleagues (2006), the experience carried out since 2016 in Barcelona to foment digital literacy is presented; in CSJ (2021) and McFarlene and Whyte (2019) some examples of the use of digital technology for prison education in the UK and around the world are reported. However, in areas such as Africa, Asia or Latin America, prisons are overcrowded and computers, rather than for educational purposes, are generally only used by prison staff to facilitate management tasks (Mbatha et al., 2020; Saputra et al., 2020).

The above mentioned attempts are mainly oriented both to providing the imprisoned population with some digital literacy and to aiding them in the teaching/learning process. However, our main objective in this section is to focus on reviewing how informatics education has been approached in prisons, understanding informatics as a science, and not just as mere technology or as an auxiliary tool for edition, entertainment or communication purposes. Next, some initiatives carried out around the world to teach informatics in prison are presented.

In the case of North America, a number of programs have been developed to introduce informatics topics to inmates. The first three are accessible to only a fraction of America's prison population while the fourth one is accessible to any imprisoned North American citizen.

- *The Last Mile* (https://thelastmile.org/): Since 2010, this program has provided software development training in two-6 month courses about Web Development Fundamentals and MERN Development with an approach based on the premise that re-entry transitioning must begin during incarceration and continue post-release with the end result of providing employment. Currently, the program has 19 prison classrooms and 577 students, 70 successfully returned citizens positioned in higher education or employed, and a 0% recidivism rate for program participants. During the prison period, people learn to code without having access to the internet, although they do have access to computers.
- *Unloop* (https://www.un-loop.org/programs/educate/): This initiative started in 2015 in Seattle, it aims to build a pathway to living wage careers in software development for people with criminal records. The pathway includes a year-long certificate course in web development from a college partner while in prison, followed by an immersive, six-month, full stack software development boot camp upon release. Again, during the prison period people have access to computers but not to the internet.
- *Brave Behind Bars* program (https://www.csail.mit.edu/news/prison-education-program-focusing-computing-skills-women): A prison education initiative in computing, based on The Educational Justice Institute at MIT and founded in 2020, which pursues the introduction of a computer science and career-readiness program for incarcerated people. Starting in the summer of 2021 with 25 women from four correctional centers across New England it expanded in 2022 to include 40 men and women from six correctional centers across the United States. The program includes three main parts –core technical skills, career-readiness, and the capstone project–, that are taught both online and in-person under different security constraints, some inmates have access to Wi-Fi, some not, some have personal laptops most of the day, some only during class hours (Gordon, 2022).
- *Level* (Wright, 2020): Initiative carried out in North America with the aim of creating free educational content for people in prison: *"At Level, we send small booklets directly to people in prison through the US Mail. Doing so, we can reach even incarcerated Americans in solitary confinement and maximum security — inmates who would never be allowed in a prison education or job training class. So the thing we have to work with is printed paper."*

Some of the programs implemented in Europe are:

- *Code4000* (https://code4000.wordpress.com/): Inspired in The Last Mile project, Code4000 was founded in 2016 with the aim of reducing reoffending through teaching incarcerated people in the UK how to code and to prepare them for employment in the information technology sector.
- *Coding OUT* (https://prisonsystems.eu/coding-out-project-for-inmates-gets-eu-support/): Promoted by the Association of Electronic and Information Technologies in the Basque Country in collaboration with other institutions, the program aims to empower inmates with marketable skills, developing a training program focused on programming skills (basics of Android and iOS programming and JavaScript).

- *Free to Code* (F2C Report, 2020): Initiative to be delivered to inmates incarcerated in different European countries that endeavors to provide training in coding skills.

In countries such as Finland, beyond the use of computers, there are initiatives in which inmates have access to the most advanced technologies, e.g., Augmented Reality to learn the basics of Artificial Intelligence.

However, when moving from those countries understood to be developed countries, and focusing on impoverished countries, it is not easy to find programs with the aim of promoting the teaching of informatics topics to inmates. It is evident that the digital divide between developed and impoverished countries directly affects the teaching of informatics in prisons.

2.2 CS unplugged

The CS unplugged initiative aims to teach CS concepts and computational thinking skills without employing any digital tools. It proposes exercises and games to introduce Informatics without the use of computers (CS Unplugged, 2023). The initiative, originally designed in the 1990s, has already proved to be a suitable approach for teaching the fundamentals of informatics and computational thinking in different educational settings (Battal et al., 2021) –from scenarios in which, given the possibility of using computers, it was decided not to do so, to scenarios where computers were not available, even including hybrid approaches where unplugged and plugged activities where linked (Akiba, 2022). CS unplugged can be easy to implement in terms of time and/or resource limitations (Bell, 2009). In addition, in recent years, other projects are contributing to the creation of additional unplugged activities to introduce Informatics: Computer Science For Fun (CS4FN, 2023), code.org unplugged (Code.org, 2023) or Bebras (2023), among others.

Literature reviews reveal that most studies on CS unplugged have been conducted in primary and secondary education (Battal et al., 2021; Chen et al., 2023; Shehzad et al., 2023). However, as Battal and colleagues pointed out, additional research is needed to ascertain whether the CS unplugged approach is suitable for individuals of all ages. To the extent of our knowledge, efforts to introduce CS unplugged in the adult population have mainly been limited to teachers of basic educational levels (Cakir et al., 2022).

As a summary of the literature review, it can be concluded that most of the proposals published on the teaching/learning of informatics in prisons present experiences carried out in prisons where computers are available to inmates, and not experiences based on the use of the CS unplugged approach. The CS unplugged approach, although seldom used in prisons to teach informatics has, in other scenarios, proven to be an accessible form of education for anyone, regardless of whether or not computers or internet access are available or not. Despite having access to computers or to the internet, some prisons may decide to eschew their use for security reasons (Behan, 2021), and in these cases CS unplugged could present an opportunity.

3 Methodology

The work presented in this paper tests a variant of the L2T2T pedagogical strategy to transmit informatics knowledge through a case study. In addition, it collects data, mainly through surveys, and analyses the results obtained from a statistical point of view.

Regarding the pedagogical strategy for transmitting informatics knowledge from university to prison, an adaptation of the L2T2L methodology is used. The L2T2L methodology *–Learn to Teach to Learn–* (Larraza-Mendiluze et al., 2020), enables a multistage sequencing knowledge transmission and was first proposed and used to transmit informatics knowledge through CS unplugged activities from university to schools *–from university education to secondary education and then, from secondary education to primary education–* in the Basque Country, a technologically developed country. Later, an adaptation of the methodology was used to transmit informatics knowledge from university to school in a technologically disadvantaged area of Lima, during the COVID-19 pandemic (Díaz-León et al., 2023).

This new variant of the L2T2L methodology (see Fig. 1) transmits informatics knowledge from university to penitentiary *–from university education to penitentiary coordinators and then, from penitentiary coordinators to the imprisoned population.* Given the complexity of the structures involved in the current proposal, it was the university teaching staff *(Group2)* who were responsible for transmitting the informatics knowledge to the penitentiary coordinators *(Group3)*, and not the university students *(Group1)*. To carry out their task, the university teachers *(Group2)* use the information prepared and provided by the university students *(Group1)*.

3.1 Data collection and analysis instruments

As has been pointed out above, this case study intends to analyze if the methodology used in JolasMATIKA in the Basque Country (Larraza et al., 2020) and in Lima during pandemics (Díaz-León et al., 2023) is also effective for teaching informatics concepts to prison inmates. In this context, in addition to implementing a similar methodology, various survey-based analyses were carried out.

In order to analyze whether the previously used proposals were valid for a type of scenario other than schools, the authors considered that the best option was to use

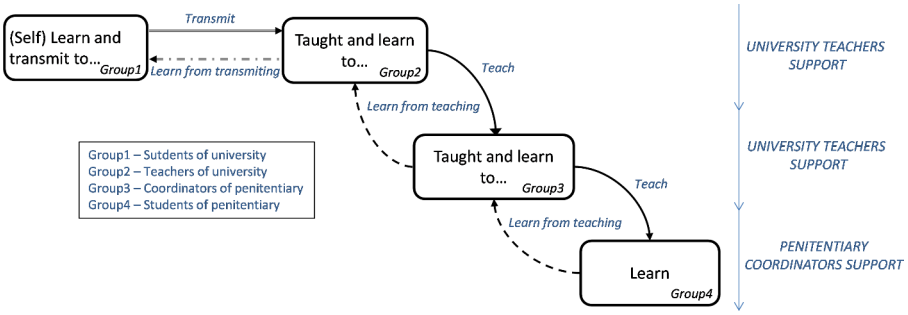

Fig. 1 Pedagogic strategy

the survey shown in Table 1 (a slight modification of the one used in the initial scenario), which was based on the research of Taub et al. (2012) to answer the following research question: *"What is the effect of CS unplugged on the perspective, attitudes and intentions of seventh grade students with respect to computer science?"*. The survey consists of 23 closed-ended statements with five values on a Likert scale of 1–5 (1 – total disagreement; 5 – total agreement) and three open-ended questions: Is informatics interesting? Why? How do you think knowledge on informatics can help you? In this new project, of the 23 original closed-ended statements three (11, 12 and 15) were modified to be addressed to adult people (see Table 1 where the modified statements appear marked in bold). Information based on the survey was gathered before the start of the process (named pre-test) and after its finish (named post-test).

Student's t-test was used to determine the existence of statistical differences between the two samples and the size of the effect was calculated using Cohen's D (Cohen, 1988). The results have also been compared to those obtained for Peruvian rural area students during the pandemic (Díaz-León et al 2023) using the same methodology. The reliability of the data collected in each questionnaire was calculated using Cronbach' s Alpha (Lukas, 1998; Nunnally, 1978).

The study also includes an analysis of a survey (Table 2) used to assess the difficulty and rate of completion of the exercises by the inmates. After each exercise, they

Table 1 List of the closed statements included in the survey

Item	Statement
1	Using the Internet is central to informatics
2	Using text editors (Google Docs, Word…) is central to informatics
3	Installing software/programs is central to informatics
4	Programming is central to informatics
5	Being able to solve different problems is central to informatics
6	I think I am capable of studying informatics
7	Informatics is an area related to math
8	I am good at science
9	The computer scientist should be good at cooperation
10	The computer scientist is a nerd
11	**In future, if possible**, I want to work in informatics
12	**Men are better than women** at studying informatics
13	The computer scientist should have a mathematical way of thinking
14	Work in informatics requires long hours
15	**In future, if possible**, I want to study informatics
16	Working in informatics is fun
17	Computer science workers earn a lot of money
18	I am good at math
19	Work in informatics can be done without a computer
20	Informatics is a boring subject
21	Informatics is used in almost all professions
22	People who work in informatics should use their creativity
23	In general, I like informatics

Table 2 List of short questions to assess exercise completion and understanding

Item	Statement
1	Where you able to complete the exercise?
2	How many exercises were difficult for you?
3	Do you think you understood the concept?

filled out a short survey of three questions about their understanding and their task completion level. The three generic questions shown in Table 2 are adapted to each specific exercise. Each question was answered within a Likert scale of 1–5 (1 – none/nothing; 5 – all/a lot).

In addition, communications with the coordinator were carried out periodically, both to exchange impressions about the difficulty of the exercises and concepts and to analyse the results. All the data generated during the current study are available from the corresponding author on reasonable request.

4 Implementation

The case study presented in this paper was carried out in 2022 in Lima, Peru, in collaboration with members of the Iquitos Penitentiary Center and the Scientific University of the South. On behalf of the penitentiary center, 25 inmate volunteers, between 30 and 40 years old, and the coordinator of the penitentiary activities took part; on behalf of the university, 20 students and a Senior lecturer within the subject *Management of Economic and Social Projects* of the *Economic and Business Engineering Degree* were involved in the project. Inmates who took part in the experience were inmates charged with minor offences, so in addition to gaining informatics literacy, they were able to obtain a reduction in their sentence, up to a maximum of 30%. Although the type of crime committed by those inmates and their type of imprisonment is confidential information, it should be mentioned that the prison of Iquitos is not a high-security prison but a prison for minor offences.

As in the JolasMATIKA project (Larraza-Mendiluze et al., 2020), in the current experience the same three teaching and learning topics were chosen to convey computer science concepts to students:

1. Introduction to computational thinking. Introduction to problem solving strategies and the abstract concepts used in computational thinking.
2. Information representation in computers. Binary system and image representation in computers.
3. The basics of programming and algorithm. Algorithms with loops, instruction sequences, conditions.

Specifically, the exercises and activities described in Larraza-Mendiluze and colleagues (Larraza-Mendiluze et al., 2017) and based on CSUnplugged (http://csunplugged.org/), ComputerScience for Fun (http://www.cs4fn.org/), code.org (https://code.org/), Scratch (https://scratch.mit.edu/), Bebras (http://bebras.org) were worked on, albeit slightly modified and adapted for an adult target population rather than for children.

The university students, separated into four groups of five students, were in charge of making the pertinent modifications.

Once the exercises were prepared, the following work flow was implemented:

1. Each exercise along with the content and instructions was sent by the senior lecturers via computer to the coordinator of the penitentiary center. When necessary, explanations were provided via zoom.
2. The coordinator of the penitentiary center printed and delivered the exercises, on paper, to the students. Since the students had no recourse to external communication, the coordinator was responsible for resolving any doubts or questions.
3. The completed exercises were returned to the penitentiary coordinator who scanned and sent them to the university coordinator via email. The university coordinator then referred them to the university students for their review and evaluation, and the results were centralized on a shared drive.

5 Results analysis

This section presents and discusses the results obtained in both types of questionnaires completed by the inmates, the one analyzing their vision of informatics, and the one about their comprehension level. Specifically, the section includes:

- An analysis of the conception the inmates had about informatics before the educational sessions.
- An analysis of how their view about informatics changes after the experience, including the comparison of pre-tests and post-tests carried out by the inmates.
- A comparison between the attitude of inmates and the attitude of younger rural area students during the pandemic (Díaz-León et al. 2023).
- An analysis of the achievement level and comprehension of the assignments carried out by the inmates.
- In the data collected for the first two analyses the reliability of the data collected in each questionnaire, calculated using Cronbach' s Alpha was over 0.9, which is considered more than acceptable in this type of questionnaire (Lukas, 1998; Nunnally, 1978).

5.1 Inmates' perception about informatics before the experience

In overall terms, the results of the pre-test indicate that 88% of the inmates consider they have the capacity to study computer science. 80% of the inmates have the desire to work in this field, probably because 72% of them are aware that with these studies they can find work in various professions. Indeed, to have computer science knowledge opens a window that will help them to get a job and they presume that with this profession they could have an opportunity to reintegrate into society.

5.2 Effect of the experience on the opinion inmates have about informatics

Table 3 shows average values obtained for the pre-test (column pre-test) and post-test (column post-test) questionnaires in the 23 close-ended statements, the existence or not of significant differences between them according to Student's t test, and the meaningfulness of their difference given with Cohen's D (Cohen, 1988).

Before the experience, the majority of answers tended to be near 5, although there were some statements with a lower score. In general, the answers coincided with reality but some of the answers were not aligned with the desired ones.

For example, the majority of inmates were aware that informatics is used in almost all professions (Statement 21) or that people who work in informatics should use their creativity (22). Some of the low scores such as, for instance, men are better than women at studying informatics (12) or informatics is a boring subject (20), denote correct ideas of the inmates about informatics; desirable outputs. On the other hand, although not in the majority, some other answers show that the inmates have mistaken ideas. For instance, among the high scores it can be seen that the majority of

Table 3 Comparison between initial test and final test results for inmates

Statement	Item	pre-test	post-test	cohensD
Using the Internet is central to informatics	1	4.24	2.14**	**1.53**
Using text editors (Google Docs. Word…) is central to informatics	2	3.96	2.57**	**1.20**
Installing software/programs is central to informatics	3	4.44	3.57*	**1.06**
Programming is central to informatics	4	4.36	4.43	-0.08
Being able to solve different problems is central to informatics	5	3.80	4.14	-0.32
I think I am capable of studying informatics	6	4.72	4.57	0.21
Informatics is an area related to math	7	4.08	4.71*	*-0.65*
I am good at science	8	3.64	3.14	0.48
The computer scientist should be good at cooperation	9	4.28	3.86	0.44
The computer scientist is a nerd	10	3.88	1.14**	**2.61**
In future, if possible, I want to work in informatics	11	4.60	3.29**	**1.87**
Men are better than women at studying informatics	12	1.68	1.43	0.25
The computer scientist should have a mathematical way of thinking	13	2.68	2.00	*0.61*
Work in informatics requires long hours	14	3.12	2.86	0.27
In future, if possible, I want to study informatics	15	4.60	3.71**	**1.16**
Working in informatics is fun	16	4.16	4.00	0.16
Computer science workers earn a lot of money	17	3.44	3.71	-0.33
I am good at math	18	3.44	3.29	0.16
Work in informatics can be done without a computer	19	2.16	2.14	0.01
Informatics is a boring subject	20	2.16	1.29*	*0.72*
Informatics is used in almost all professions	21	4.52	4.86	-0.43
People who work in informatics should use their creativity	22	4.80	4.71	0.28
In general, I like informatics	23	4.56	4.57	-0.02

*Note: Marked with ** when significant differences existed at significance level alpha=0.01 and with * when significance level was alpha=0.05. In addition, medium impact differences are marked in italics and big impact differences in bold.*

inmates think that using the Internet is central to informatics (1), using text editors (Google Docs, Word…) is central to informatics (2) or installing software/programs is central to informatics (3), or that computer scientists are nerds (10). Among the low scores, they do not tend to think (they give low values) that the computer scientist should have a mathematical way of thinking (13), which is opposite to their answer in Statement 7, where they affirm that informatics is related to mathematics. In addition, they do not think that work in informatics can be done without a computer (19). With regard to the set of statements relating more to whether they like computer science, inmates state they would like to study or work in informatics in the future if possible (11/15), and that they do like informatics and they think it is fun (16/23).

When analyzing the variability in responses, in general terms, it was found that inmates had varied opinions regarding Statement 19 ("It is possible to work in informatics without using a computer") and in Statement 20 ("Computer science is a boring subject"), since they have a greater deviation compared to the other statements (1.51 for both statements). This reflects that there exists variability in interpreting informatics as being related to the use of computers more than working without them and that they have different opinions regarding how boring computer science is.

The opposite was the case with Statement 22 ("Should people working in IT use their creativity?"), where the smallest deviation was obtained, thus inferring a close unanimity in the answer (0.40).

Changes in the post-test will show how the methodology and the experience carried out affected the perception the inmates had about informatics. When the differences in the answers given to the questions were statistically significant, the effect of the size of the change was calculated using Cohens'D (Cohen, 1988). The effect of the magnitude is considered small when d=0.2–0.3, medium when d=0.5–0.8 and big when d>=0.8. Medium (marked in red in Table 3) and big (marked in bold in Table 3) effects are marked in Table 3.

Comparing the changes between the pre- and post-tests it can be concluded that the intervention had a clear effect on the inmates; differences where significant in 8 out of 23 questions. Changes that can be considered big or medium are seen for many of the statements and, in most of the cases, they denote a better understanding of what computer science is. The biggest change corresponds to Statement 11 where the consideration of computer scientists as nerds descends drastically. Considerable changes can also be noticed in Statements 1, 2 and 3, where the view about the centrality of the Internet, text editors and software programs in informatics decreases substantially. In addition, a medium effect change in Statement 7 (Informatics is an area related to math) also denotes an improvement in comprehension. The intervention seems also to have had an effect on whether the inmates like informatics since they consider informatics less boring after the intervention.

5.3 Comparison between the attitude of inmates and the attitude of younger rural area students during the pandemic

In an effort to analyse whether the adapted pedagogical strategy to transmit knowledge about informatics works in a completely different environment such as prisons, the results of the pre- and post-tests were compared to the results obtained in a pre-

vious experience carried out to introduce informatics from an early age to students living in disadvantaged areas in Peru during the pandemic (Díaz-Leon et al. 2023). Specifically the answers given by inmates were compared to the answers given by secondary education students; students from secondary education were considered more mature than students from primary education, and therefore, closer to the target population. Table 4 shows results and comparisons for pre- and post-tests.

The analysis of the differences in the pre-tests shows the existence of discrepancies in the perception of informatics among young students in rural areas and among inmates prior to taking part in the program. Significant differences appeared in 11 questions out of 23 with the biggest differences in Statement 15 (willingness to study informatics), Statement 11 (willingness to work in informatics in the future) and Statement 6 (perception of own capability to study informatics), in which inmates returned higher values in all cases. There are many other statements with a medium effect in the change with, in the majority of cases, there being higher average value for inmates than for students. For instance, in Statements 3 and 4, where inmates seem to find programming and software more central to informatics; Statement 7, indicating that inmates are more aware of the relationship between informatics and math; Statement 16, where informatics seems more fun to inmates: Statements 21

Table 4 Comparison between pre-test and post-test results for secondary education students and inmates

Item	pre-test			post-test		
	Inmates	Second.	cohensD	Inmates	Second.	cohensD
1	4.24	4.07	0.15	2.14	4.02**	**-1.51**
2	3.96	4.23	-0.22	2.57	4.19**	**-1.36**
3	4.44	3.56**	*0.78*	3.57	3.51	0.06
4	4.36	3.47**	*0.74*	4.43	3.75**	*0.70*
5	3.80	3.72	0.06	4.14	3.83	0.32
6	4.72	3.84**	**0.86**	4.57	3.38**	**1.15**
7	4.08	3.26**	*0.65*	4.71	3.49**	**1.15**
8	3.64	3.49	0.12	3.14	3.21	-0.06
9	4.28	4.16	0.10	3.86	4.13	-0.23
10	3.88	3.72	0.11	1.14	3.66**	**-1.93**
11	4.60	2.51**	**1.72**	3.29	2.468*	*0.70*
12	1.68	2.12	-0.33	1.43	1.851	-0.37
13	2.68	2.95	-0.20	2.00	3.043*	*-0.71*
14	3.12	3.95**	*-0.66*	2.86	3.809*	*-0.67*
15	4.60	3.05**	**1.28**	3.71	2.979*	*0.63*
16	4.16	3.49*	*0.50*	4.00	3.128*	*0.69*
17	3.44	3.40	0.04	3.71	3.404	0.28
18	3.44	3.42	0.02	3.29	3.234	0.04
19	2.16	2.21	-0.03	2.14	2.617	-0.33
20	2.16	2.19	-0.02	1.29	2.426**	**-1.14**
21	4.52	3.79**	*0.61*	4.86	3.574**	**1.08**
22	4.80	4.26**	*0.70*	4.71	4.128**	*0.76*
23	4.56	3.58**	*0.78*	4.57	3.596**	**0.84**

*Note: Marked with ** when significant differences existed at significance level alpha=0.01 and with * when significance level was alpha=0.05. In addition, medium impact differences are marked in italics and big impact differences in bold.*

and 22, where inmates seem to have it clearer in their minds that informatics is used everywhere; and Statement 23, showing that inmates think they like informatics more than secondary students do. On the other hand, secondary students seem to think it more likely that informatics would involve working long hours (Statement 14).

The comparison of the two output tests shows that the effect of the study is not the same in the two populations, since statistically significant differences appear in more statements (15 out of 23) and with a greater impact. We can affirm that the effect the experience has on inmates is stronger than the effect it has on students. After the experience, inmates think that the use of internet (1) and text editors (2) are less central to informatics, as well as being more confident in their capability to work in informatics (6) and more sure about the connection between informatics and math (7). Also, their impression about computer scientists being nerds (10) is considerably lower, and they consider informatics to be less boring (20), they like it more (23) and they are more conscious of the general use of informatics (21).

5.4 Achievement level and comprehension of the assignments

As mentioned above, the second part of the research consisted of analyzing the level of understanding and scope of the ten computer-related exercises proposed in the learning process. These exercises were explained to the inmates by the internal coordinator of the prison and solved individually by each of them.

Figure 2 summarizes the main answers to the four questions in the ten exercises (average values of the answers given by the inmates). From these it can be concluded that, at least in the first seven assignments, inmates seem to have had no major problems in solving the problems posed to work with informatics: they were able to finish almost every assignment and found very few assignments to be difficult. Although,

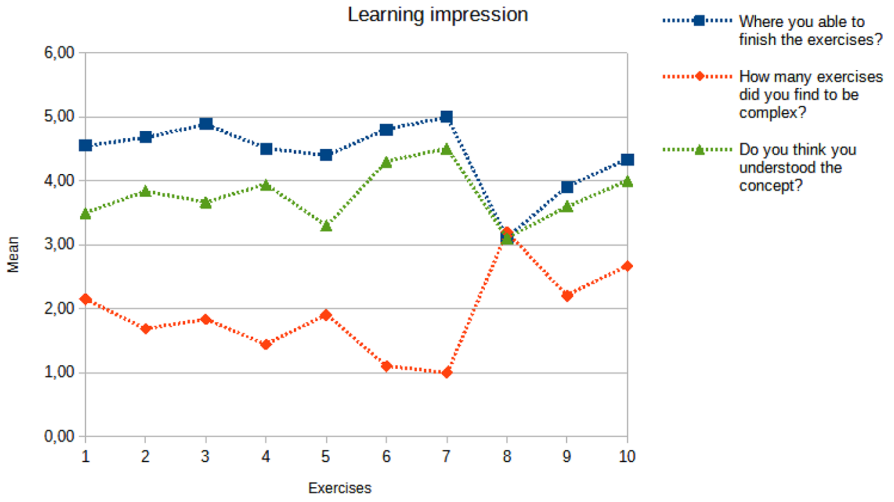

Fig. 2 Summary of comprehension and achievement level of the 10 assignments proposed in the experience

as mentioned, no major problem seemed to arise, the level of understanding of the proposed concepts seems to have been slightly lower than the level of achievement, suggesting that inmates have more difficulties in understanding than in learning the mechanics of the assignments.

Unfortunately, this trend changed during the experiment as a whole. The biggest challenge for inmates seems to be the one posed by Assignment 8 related to search; it clearly obtains the lowest achievement and understanding level. Finally, Assignments 9 and 10 seem to work slightly better but the level of achievement of the initial assignments was not reached.

The responses suggest that, although the overall level of achievement and understanding of the assignments was quite good, it would appear that additional initial support could be beneficial and enable a clearer understanding. This is yet more obvious in the last part of the experiment in which it was seen that the inmates struggled to reach desirable levels of achievement in Assignments 8, 9 and 10. It seems that some reformulation or rethinking of these assignments is necessary to help inmates to carry them out properly.

6 Conclusions and discussion

The case study reported in this article endorses the suitability of using CS unplugged activities to transmit informatics topics in an adverse environment in which the participating population are adult imprisoned males. Unplugged activities tend to be less costly and resource-intensive than those requiring computer platforms, and thus can reach larger audiences (Fees et al., 2018). To date, CS unplugged has been mainly used in schools to introduce informatics to young people. To the extent of our knowledge, the use of CS unplugged is only in its initial stages in the case of imprisoned adult populations and the work presented here is one of the first to undertake the introduction of informatics topics to this population. An experience similar to the one proposed in the present work is being carried out in collaboration with the Level organization. However, as the authors have pointed out, the goal *"is yet to be proven"* (Bell and Henderson, 2022).

The study also validates the adaptability of the L2TL2 pedagogical strategy for the transmission of informatics knowledge in chain from the university to different populations (Larraza-Mendiluze et al., 2020; Díaz-León et al., 2023). Up to now, L2T2L, or one of its variants, had been used to transmit informatics knowledge from university to secondary and primary schools, in both technologically advanced areas and technologically disadvantaged areas. On this occasion, not only has the scenario changed (school to prison) but the population also has (young students to adult inmates). In the future, the pedagogical strategy could be adapted to be used in new scenarios. Furthermore, it could be a valid pedagogical strategy to transmit knowledge in areas other than informatics.

The analysis on the data collected during the case study showed that the intervention had a clear effect on the inmates. Following the intervention numerous changes were noticed which indicated a better understanding of what computer science is. In addition, inmates seemed to have had no major problems and revealed a good level

of understanding when solving most of the assignments designed for the experiment. Moreover, at the end of the study, six inmates asked their penitentiary coordinator for further training in informatics. In this regard, the exercises which were less well understood could be improved and new material could be designed to teach more advanced informatics topics. It seems that along the lines proposed by Munasinghe and colleagues (2023), within a given teaching activity, the use of unplugged elements increases the potential semantic range for both learners and teachers, facilitating the use of both the learners' existing knowledge and concrete experience as a foundation for learning more abstract or technical concepts.

Furthermore, a comparison of the inmates' perceptions of informatics before and after the experience to the impressions of secondary students from a Peruvian rural area during the pandemic (Díaz-León et al., 2023), revealed that the change in the former was more significant. Inmates clearly showed a better understanding of what computer science is after the process. All the information derived from the study is being transmitted to both the National Penitentiary Institute (INPE) authorities and to the Ministry of Justice of Peru.

Nevertheless, several limitations can be attributed to this study. In addition to the lack of prior research studies on the topic, it is worth mentioning the small sample size used in the study, 25 inmates, and the limited access of the researchers to the final participants when collecting information about the experience carried out. The fact that the final communication with the imprisoners was done through other interlocutors, specifically through the penitentiary coordinator, has made it impossible for researchers, for example, to gather information from direct interviews with the participants. In any case, thanks to the adaptability of both the CS unplugged approach and the pedagogical strategy used for transmission, this is a proposal that can be easily replicated in other penitentiaries in Peru and even in penitentiaries of different countries, regardless of their technological facilities.

Consequently, the proposal includes an innovative approach to rehabilitation in penitentiaries, based on education, trying to provide inmates with the motivation and vision for the future necessary for their reintegration into society. By treading the path marked by Higgins (2021), it seeks a rehabilitation proposal that can offer a more person-centered approach and has the objective of showing the students participating in the project what informatics is. Inmates, despite their adverse economic, technological, social and health circumstances, were indeed able to carry out activities that introduced them to informatics.

Okike (2021) advocates in favor of the implantation of an appropriate informatics' education for imprisoned populations, especially in developing countries. The work presented in this the paper lays the foundations for implementing an informatics education program in the near future through the transmission of knowledge from the university to the penitentiary.

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Data Availability All the data generated during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

References

Akiba, D. (2022). Computational thinking and coding for young children: A hybrid approach to link unplugged and plugged activities. *Education Sciences*, *12*(793), https://doi.org/10.3390/educsci12110793.

Battal, A., Adanir, G. A., & Gülbahar, Y. (2021). Computer Science unplugged: A systematic literature review. *Journal of Educational Technology Systems*, *50*(1), 22–47. 0.1177/00472395211018801.

Bebras (2023). International challenge on informatics and computational thinking. Accessed: July 10, 2021. [Online]. Available: https://www.bebras.org/.

Behan, C. (2014). Learning to escape: Prison education, rehabilitation and the potential of transformation. *Journal of Prison Education & Reentry*, *1*(1), 20–31.

Behan, C. (2021). *Education in prison: A literature review*. UNESCO Institute for Lifelong Learning.

Bell, T., & Hendersor, T. (2022). Providing a CS unplugged experience at a distance. *Acm Inroads*, *13*(4), 26–31. https://doi.org/10.1145/3571093.

Bell, T., Jason, Al, Freeman, I., & Grimley, M. (2009). Computer science unplugged: School students doing real computing without computers. *New Zealand Journal of Applied Computing and Information Technology*, *13*(1), 20–29.

Cakir, H., Islim, O. F., Sokmaz, E., Berikan, B., & Yilmaz, F. (2022). Development and evaluation of unplugged algorithmic thinking activities training program for in-service primary school teachers. *Journal of Learning and Teaching in Digital Age*, *7*(2), 222–234. https://doi.org/10.53850/joltida.1036460.

Chen, P., Yang, D., Metwally, A. H. S., Lavonen, J., & Wang, X. (2023). Fostering computational thinking through unplugged activities: A systematic literature review and meta-analysis. *International Journal of STEM Education*, *10*(47), https://doi.org/10.1186/s40594-023-00434-7.

Code.org (2023). *CS fundamentals Unplugged*. Code.org. https://code.org/curriculum/unplugged Accessed: December 11, 2021. [Online]. Available:.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum.

CS Unplugged (2023). Comput. Sci. Educ., Univ. Canterbury, Christchurch, New Zealand. Retrieved July 10 https://www.csunplugged.org/en/.

CS4FN (2023). Computer Science For Fun Queen Mary, University of London Accessed: July 10, 2023. [Online]. Available: http://www.cs4fn.org/.

CSJ (2021). Digital technology in prisons unlocking relationships, learning and skills in UK prisonsCentre for social justice. Retrieved November 11, 2021 https://www.centreforsocialjustice.org.uk/library/digital-technology-in-prisons-unlocking-relationships-learning-and-skills-in-uk-prisons.

Diaz-León, J. A., Larraza-Mendiluze, E., Arbelaitz, O., & Arruarte, A. (2023). The challenge of introducing informatics topics from an early age in Peru during the pandemic. *IEEE Transactions on Education*. https://doi.org/10.1109/TE.2023.3260468.

Doha Declaration (2015). Thirteenth United Nations Congress on Cirme Prevention and Criminal Justice, 12–19 April, Doha. Retrieved November 11, 2022 https://www.unodc.org/documents/congress/Documentation/ACONF222_L6_e_V1502120.pdf.

ETC2015, Educational Technology in Corrections (2015). U.S. Department of Education, Office of Career, Technical, and Adult Education, Washington, DC.

F2C Report (2020). Improving digital and coding skills for inmates. Pilot Program Report. Retrieved November 14, 2022. https://eustrategies.eu/wp-content/uploads/2021/04/Annex-4-F2C-Pilot-Programme-Report_Eng.pdf.

Fees, R. E., da Rosa, A., Durkin, S. S., Murray, M. M., & Moran, A. L. (2018). Unplugged cybersecurity: An approach for bringing Computer Science into the classroom. *International Journal of Computer Science Education in Schools*, *2*(1), https://doi.org/10.21585/ijcses.v2i1.21.

Franganillo, J., Burgos, L., Gracía, A., & Tomás, C. (2006). *Alfabetización digital en la prisión: Una experiencia con jóvenes internos* (pp. 29–30). II Congreso Internacional de Alfabetización Tecnológica.

Garner, J. (2017). *The role of IT in prisoner education: A global view, ASCILITE 2017*. University of Queensland.

Gordon, R. (2022). Brave behind bars: Prison education program focuses on computing skills for women. *Mit News on Campus and around the World* Retrieved November 8, 2022 https://news.mit.edu/2022/brave-behind-bars-mit-prison-education-computing-skills-for-women-0119.

Hacler, F. (2016). Modular cell. Reducing recidivis rates through design. Swingburne Univesity. Retrieved November 11, 2022 file:///C:/Users/jiparlaa/Downloads/F_Hackler_A5.pdf.

Higgins, L. (2021). Exploring the relationship between education and rehabilitation in the prison context. *Journal of Prison Education and Reentry*, *7*(2), https://doi.org/10.25771/mcrw-yw06. 144.159.

INPE (2021). Informe estadístico del Instituto Nacional Penitenciario 2021. Retrieved November 11, 2022. https://siep.inpe.gob.pe/Archivos/2021/Informes%20estadisticos/informe_estadistico_mayo_2021.pdf

Jay, J. (2008). The effective use of technology of correctional education, Reentry Roundtable on Education, March 31 and April 1.

Larraza-Mendiluze, E., Arbelaitz, O., Arruarte, A., Garay, N., Maritxalar, M., Martín, J. I., Ruiz, T., & Lukas, J. F. (2017). Desde La Universidad Hasta primaria: Proyecto piloto de innovación docente en Informática. *ReVisión*, *10*(2), 19–31.

Larraza-Mendiluze, E., Arbelaitz, O., Arruarte, A., Lukas, J. F., & Garay-Vitoria, N. (2020). JolasMATIKA: An experience for teaching and learning computing topics from university to primary education. *IEEE Transactions on Education*, *63*(3), 136–143. https://doi.org/10.1109/TE.2019.2951568.

Lipsey, M. W., & Cullen, F. T. (2007). *The Annual Review of Law and Social Science*. https://doi.org/10.1146/annurev.lawsocsci.3.081806.112833.

Lukas, J. F. (1998). *Analisis de items y tests con ITEMAN*. Universidad del País Vasco.

Mbath, L. S., Luthuli, L. P., & Masenya, T. M. (2020). Prison breakthrough: Use of information systems in correctional facilities. *Journal of South African Society of Archivists*, *53*, 54–64. https://doi.org/10.4314/jsasa.v53i1.4.

McFarlane, R., & Whyte, D. (2019). Advantages of digital technology for prison education –a literatura review. The Open University. Retrieved Decembar 14, 2022 https://www.dwrm.org.uk/wp-content/uploads/2021/03/Literature-Review-benefits-of-digital-study-in-prison.pdf.

Munasinghe, B., Bell, T., & Robins, A. (2023). Unplugged activities as a catalyst when teaching introductory programming Bhagya Munasinghe, Tim Bell and Anthony Robins. *Journal of Pedagogical Research*, *7*(2). https://doi.org/10.33902/JPR.202318546.

Nunnally, J. C. (1978). *Psycohometric theory* (2nd ed.). McGraw-Hill.

Okike, E. U. (2021). Computer Science and prison education. *IGI Global*. https://doi.org/10.4018/978-1-7998-3016-0.ch074.

Saputra, D. E. E., Eliyana, A., Hamidah, Sariwulan, T., & Buchdadi, A. D. (2020). The use of information technology in correctional services to improve service quality and service satisfaction: A theory approach. *Systematic Reviews in Pharmacy*, *11*(8), 245–253.

Shehzad, U., Recker, M., & Clarke-Midura, J. (2023). A literature review examining broadening participation in upper elementary CS education. *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V 1 (SIGCSE 2023)*. https://doi.org/10.1145/3545945.3569873.

Stuart Batchelder, J., & Rachal, J. R. (2000). Efficacy of a computer-assisted instruction program in a prison setting: An experimental study. *Adult Education Quarterly*, *50*(2), 120–1133. https://doi.org/10.1177/07417130022086946.

Tanaka, K., & Cooper, D. (2020). Advancing technological equity for incarcerated college students. Examining the opportunities and risks. Report ITHAKA S + R. https://doi.org/10.18665/sr.313202.

Taub, R., Armoni, M., & Ben-Ari, M. (2012). Cs unplugged and middle-school students' views, attitudes, and intentions regarding CS. *ACM Transactions on Computing Education (TOCE)*, *12*(2), 1–29.

United Nations (2015). Universal declaration of human rights. Retrieved November 11, 2022 https://www.un.org/en/udhrbook/pdf/udhr_booklet_en_web.pdf.

Wright, A. (2020). How to teach programming to people in prison (without computers). *Towards Data Science* Retrieved December 14, 2022 https://towardsdatascience.com/how-to-teach-programming-to-people-in-prison-without-computers-c455baca7f19.

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